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Potential for New Export-oriented Production for Large Cities with a High Quality of Life – Focus on North America

Alexander Daminger, Peter Huber, Peter Mayerhofer, Anja Sebbesen (WIFO), Timothy Sturgeon, Amy Glasmeier (MIT), Peter V. Schaeffer, Randall Jackson (WVU), Mario Polèse (INRS)

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This study explores what lessons can be learned from the experience of North American cities with respect to the development of new opportunities for export-oriented production that are compatible with a high quality of life in metropolitan regions. To this end, six case studies on North American metropolitan regions marked by a high level of economic development and a high quality of life were conducted. These case study metropolitan regions were Atlanta, Boston, Montreal, Pittsburgh, San Francisco and Seattle. The current report synthesises these case studies, provides a data-based comparison of the respective case study metropolitan regions with the Vienna metropolitan region and discusses a number of experiences from which the city of Vienna could potentially learn.

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Overview

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Synthesis Report

Alexander Daminger, Peter Huber, Peter Mayerhofer, Anja Sebbesen

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Kurzfassung

Hintergrund und Ziele

Diese Studie untersucht die exportorientierte Produktion in Großstädten anhand eines Vergleichs von sechs nordamerikanischen Metropolregionen – Atlanta, Boston, Montreal, Pittsburgh, San Francisco und Seattle – mit Wien, deren Gemeinsamkeit in einer Kombination aus hoher wirtschaftlicher Dynamik und einer hohen Platzierung in Rankings zur Lebensqualität besteht. Methodisch stützt sich die Studie dabei auf eine Kombination aus Fallstudien zu den einzelnen Metropolregionen sowie auf eine quantitative Datenanalyse. In den Fallstudien werden die Wirtschaftsgeschichte, Veränderungen im Wirtschaftsgefüge, Wachstumssektoren und strategische Initiativen in den Metropolregionen untersucht. Die Datenanalyse vergleicht Indikatoren zur Demografie, Flächennutzung, Wirtschaftsleistung, Entwicklung des verarbeitenden Sektors und Innovationssystemen. Auf diese Weise werden sowohl allgemeine (in allen Städten spürbare) Trends als auch standortspezifische Bedingungen, die die exportorientierte Produktion beeinflussen, untersucht.

Die Studie stellt Wien, das im europäischen Städtevergleich durchgehend mindestens eine Position im oberen Mittelfeld in Bezug auf wirtschaftliche Entwicklungsindikatoren einnimmt, einigen der führenden Weltmetropolen gegenüber. Letztere verfügen nicht zuletzt aufgrund ihrer meist wesentlich größeren Fläche und höheren Bevölkerungszahl über ungleich größere wirtschaftliche und technologische Kapazitäten als Wien. Zusätzlich bringen erhebliche institutionelle Unterschiede zwischen den nationalen und regionalen Regulierungssystemen Nordamerikas und Europas – unter anderem hinsichtlich der Daseinsvorsorge, der Raumplanung oder der Forschungsfinanzierung – verschiedenartige sozial- und wirtschaftspolitische Herausforderungen mit sich. Dies begründet, weshalb die Erfahrungen dieser Metropolen nicht ohne Weiteres auf Wien übertragbar sind.

Ziel der vorliegenden Pilotstudie war es daher nicht, direkt übertragbare Maßnahmen zu identifizieren. Stattdessen zielte die Analyse darauf ab, auf einer grundlegenderen Ebene zu untersuchen: Erstens, welche Lehren aus den gemeinsamen Erfahrungen und Strategien dieser weltweit führenden Metropolregionen für Wien gewonnen werden können; und zweitens, inwiefern und auf welche Weise diese Erfahrungen – nach einer sorgfältigen Prüfung kontextspezifischer Erfolgsfaktoren – in politische Maßnahmen einfließen könnten, die neue, mit einer hohen Lebensqualität in Einklang stehende Exportaktivitäten in Wien fördern.

Hauptergebnisse

Die Fallstudien zeigen, dass in allen nordamerikanischen Metropolregionen seit den 1970er-Jahren eine ausgeprägte Deindustrialisierung stattgefunden hat und anschließend neue Exportaktivitäten, hauptsächlich im Dienstleistungsbereich, entstanden sind. Art und Ausmaß dieser Veränderungen unterschieden sich jedoch je nach wirtschaftlicher Spezialisierung, Technologien und Initiativen in den einzelnen Metropolen.

Die quantitative Analyse zeigt, dass die nordamerikanischen Metropolregionen in den vergangenen zwei Jahrzehnten ein deutlich höheres Wirtschaftswachstum als Wien verzeichneten.

Von 2002 bis 2019 wuchs das reale Bruttoinlandsprodukt pro Kopf in diesen Metropolregionen um durchschnittlich 10% bis 68%, verglichen mit nur 5% in Wien. Die nordamerikanischen Metropolregionen übertrafen Wien auch beim Produktivitätswachstum in diesem Zeitraum. Das geringe Wirtschaftswachstum Wiens erfolgte trotz eines starken Bevölkerungswachstums, was auf Herausforderungen bei der vollständigen Integration des erweiterten Arbeitskräfteangebots hindeutet.

Eine Analyse der Entwicklung des verarbeitenden Sektors legt nahe, dass Produktivitätssteigerungen den Großteil des Beschäftigungsrückgangs im verarbeitenden Sektor der nordamerikanischen Metropolregionen verursachten. In Wien spielte eine echte Deindustrialisierung – ein über die Produktivitätseffekte hinausgehender Produktionsrückgang – neben dem schleppenden allgemeinen Wirtschaftswachstum eine größere Rolle. Dies deutet, im Vergleich mit den nordamerikanischen Metropolen, auf eine Schwäche Wiens im Aufbau neuer Aktivitäten mit hoher Wertschöpfung hin.

Die Untersuchung wachsender Sektoren zeigt, dass lokale Dienstleistungen wie das Gesundheitswesen, das Bildungswesen, das Gastgewerbe und das Baugewerbe in allen Städten wichtige Beschäftigungstreiber sind. Diese Sektoren bedienen jedoch weitgehend die lokale Nachfrage und bieten nur ein begrenztes Exportpotenzial. Zu den stärker handelbaren Wachstumsbranchen gehören internetbasierte Dienstleistungen, unternehmensorientierte Dienstleistungen, Konsumgüter wie Lebensmittel und Getränke und spezialisierte Aktivitäten im verarbeitenden Sektor. Eine Analyse von Risikokapitalflüssen an Start-ups zeigt auch Wachstum in handelbaren Bereichen wie Software, Biotechnologie, Ingenieurwesen und künstlicher Intelligenz.

Die Studie kommt zu dem Schluss, dass die Exportbasis in dicht besiedelten städtischen Gebieten stark aus

- hochtechnologischer, forschungsbasierter Produktion, die die räumliche Nähe zu Innovationsquellen erfordert,
- handelbaren Dienstleistungen, insbesondere wissensintensiven und digitalen Dienstleistungen,
- "smarter" Produktion, ermöglicht durch neue Technologien und Automatisierung und
- individuell angepasster Herstellung von Waren in kleinen Stückzahlen, die auf die Nachfrage städtischer Konsumenten und Konsumentinnen zugeschnitten ist,

besteht.

Sie betont auch die entscheidende Rolle von Universitäten, unternehmerischen Ökosystemen und koordinierten Entwicklungsstrategien, die auf die gesamte Metropolregion abgestimmt sind.

Politikempfehlungen für Wien

Basierend auf den Studienergebnissen sollten Politikmaßnahmen zur Förderung einer, im Einklang mit hoher Lebensqualität stehenden, Exportbasis in Wien, folgende Schwerpunkte setzen:

1. Verbesserung von Produktivität und Wirtschaftswachstum

- Unterstützung von Innovation, Unternehmertum und Exportorientierung in allen handelbaren Sektoren, um neue wertschöpfende Aktivitäten zu fördern
- Umsetzung von aktiven arbeitsmarktpolitischen und qualifikationsfördernden Maßnahmen, die auf die Integration von Migrantinnen und Migranten und die Förderung von gering qualifizierten Arbeitnehmerinnen und Arbeitnehmern zugeschnitten sind
- Weiterentwicklung und Verbesserung eines Ökosystems für Start-ups, das vielfältige Unterstützung in allen Wachstumsphasen und Branchen bietet
- Förderung einer unternehmerischen Kultur, auch durch und über das Bildungssystem
- Verbesserung des Zugangs zu Wachstumsfinanzierung für junge Unternehmen

2. Stärkung des regionalen Innovationssystems

- Konzentration der Ressourcen auf spezialisierte Forschungsschwerpunkte wie Biotechnologie, IKT, Quantentechnologie und grüne Technologien
- Förderung der Zusammenarbeit zwischen Universitäten und Unternehmen durch Programme zur kommerziellen Verwertung von Forschungsergebnissen und für gemeinsam genutzte Einrichtungen und Anlagen
- Finanzierung von Initiativen zur Gewinnung von Talenten aus aller Welt und zur Stärkung internationaler Verflechtungen
- Ausrichtung der akademischen Forschungsagenden auf die wirtschaftlichen Prioritäten der digitalen und ökologischen Transformation

3. Förderung der handelbaren Dienstleistungen

- Zuschnitt von Förderprogrammen auf die Bedürfnisse wissensintensiver Unternehmensdienstleistungen und digitaler Dienstleistungen
- Unterstützung von Dienstleistungsunternehmen bei der Expansion ins Ausland durch Beratung und Vernetzung
- Sicherstellung eines für dienstleistungsorientierte Unternehmen und Geschäftsmodelle zugänglichen Fördersystems

4. Förderung hochwertiger Produktion in Marktnischen

- Unterstützung innovationsintensiver, forschungsbezogener Produktionstätigkeiten durch Cluster und Netzwerke
- Unterstützung einer auf Kundenwünsche zugeschnittenen Produktion in kleinen Stückzahlen, die an die Präferenzen städtischer Konsumenten und Konsumentinnen anknüpft
- Verbesserung der Produktion durch Initiativen zur Einführung intelligenter Produktionstechnologien

5. Stärkung kooperativer Entwicklungsstrategien auf metropolitaner Ebene

- Bessere Koordinierung von Wirtschaftsförderung und Regionalplanung
- Aktivierung ungenutzter Flächen für kommerzielle Zwecke
- Umsetzung von Initiativen auf Ebene der Metropolregion zur Nutzung komplementärer Stärken

- Partizipative Prioritätensetzung zur Schaffung von Konsens und Engagement
- Kommunikation und Aufzeigen der positiven Effekte von Offenheit und Vielfalt auf die wirtschaftliche Dynamik

Die Studie zeigt, dass Wien bei der Betonung dieser politischen Prioritäten hinter den nordamerikanischen Städten zurückbleibt. Ein strategischer Fokus auf die Verbesserung der Produktivität, die Stärkung der Innovationskraft, die Unterstützung von Start-ups und handelbaren Dienstleistungen, die Entwicklung hochwertiger Produktionsnischen und die Verfolgung kooperativer Strategien für die gesamte Metropolregion können Wien dabei helfen, exportorientierte Produktion, die im Einklang mit hoher Lebensqualität steht, zu fördern. Auch wenn spezifische Initiativen den lokalen Kontext berücksichtigen müssen, liefert der Vergleich mit Metropolregionen in Nordamerika wertvolle Erkenntnisse zur politischen Stoßrichtung.

Executive summary

Background and objectives

This study examines export-oriented production in major cities through a comparison of six North American metropolitan regions – Atlanta, Boston, Montreal, Pittsburgh, San Francisco, and Seattle – with Vienna. These cities share a combination of high economic dynamism and high rankings in quality-of-life indices. Methodologically, the study relies on a combination of case studies of individual metropolitan regions and quantitative data analysis. The case studies explore the economic history, changes in economic structure, growth sectors, and strategic initiatives in the metropolitan regions. The data analysis compares indicators of demographics, land use, economic performance, manufacturing sector development, and innovation systems. This approach allows for the examination of both general trends observable in all cities and site-specific conditions influencing export-oriented production.

The study compares Vienna, that consistently ranks in the upper middle range among European cities in terms of economic development indicators, with some of the leading global metropolises. The latter, primarily due to their often significantly larger area and higher population, possess substantially greater economic and technological capacities than Vienna. Additionally, significant institutional differences between the national and regional regulatory systems of North America and Europe – including provisions for public services, spatial planning, and research funding – bring about diverse socio-economic policy challenges. This explains why the experiences of these metropolises cannot be directly applied to Vienna.

The aim of this pilot study was not to identify directly transferable measures. Instead, the analysis aimed to examine on a more fundamental level: firstly, what lessons can be drawn from the shared experiences and strategies of these globally leading metropolitan regions for Vienna; and secondly, to what extent and in what manner these experiences – after a careful consideration of context-specific success factors – could inform policies that promote new export activities in Vienna that are in line with a high quality of life.

Key Findings

The case studies highlight pronounced deindustrialization across all North American metros since the 1970s, with the subsequent emergence of new export activities, largely in services. However, the nature and extent of these industrial shifts differed based on economic specializations, technologies, and initiatives in each metropolis.

Quantitative data indicates the North American metros significantly outpaced Vienna in economic growth over the past two decades. They averaged 10-68% real GDP per capita growth from 2002 to 2019 compared to only 5% in Vienna. The metros also exceeded Vienna in labor productivity growth over this period. Vienna's meager economic expansion occurred despite strong demographic growth, pointing to challenges in fully integrating the expanded labor supply.

An analysis of manufacturing evolutions suggests productivity gains drove most of the employment declines in the North American metros' manufacturing sectors. In Vienna, genuine deindustrialization – output contraction beyond productivity impacts – played a greater role alongside sluggish metropolitan growth. This implies a comparative weakness in Vienna in fostering new value-added activities.

Examining growing sectors points to local services like health, education, hospitality, and construction as major employment drivers across all cities. However, these sectors largely serve local demand and provide limited export potential. More tradable growth industries include internet-based services, professional services, consumer goods like food and beverages, and niche manufacturing activities. Analysis of venture capital flows to startups also reveals concentrations in tradable fields like software, biotech, engineering, and artificial intelligence.

The study concludes that the export bases in dense urban environments will likely depend on:

- High-tech, research-based manufacturing activities requiring proximity to innovation sources
- Tradable services, especially knowledge-intensive and digital services
- "Smart" production enabled by new technologies and automation
- Small-scale, customized manufacturing meeting urban consumer preferences

It also emphasizes the vital role of universities, entrepreneurial ecosystems, and coordinated development strategies aligned across metro sub-regions.

Policy recommendations for Vienna

Based on the study findings, policies to advance Vienna's export base in line with continued urban quality of life should focus on:

1. **Improving productivity and growth**

- Support innovation, entrepreneurship, and export orientation in all tradable sectors to foster new value-added activities
- Implement education and active labor market policies tailored to integrate immigrant and low-skilled workers
- Develop a stronger startup ecosystem with diverse support across stages and industries
- Encourage entrepreneurial culture, including through the education system
- Improve access to growth financing for young firms

2. **Strengthening the regional innovation system**

- Concentrate resources on specialized research strengths like biotech, ICT, quantum technologies and green tech
- Increase university collaboration with business through research commercialization programs and shared facilities
- Fund initiatives to attract global talent and strengthen international linkages
- Steer academic research agendas toward economic priorities of digital and ecological transformation

3. **Supporting tradable services**

- Tailor assistance programs to the needs of knowledge-intensive business services and digital services
- Help service firms expand abroad through consulting and networking
- Ensure support system accessible to service-oriented companies and business models

4. **Developing high-value manufacturing niches**

- Support innovation-intensive, research-linked manufacturing activities through clusters and networks
- Assist small-scale, customized production linking to urban cultural assets and consumer preferences
- Upgrade manufacturing through initiatives to adopt smart production technologies

5. **Pursuing collaborative development strategies at the metro level**

- Improve coordination of economic development and land use planning
- Activate underutilized land for commercial uses through partnerships
- Implement initiatives across the metro region to leverage complementary strengths
- Use participatory priority-setting to build consensus and commitment
- Communicate and showcase the benefits of openness and diversity for economic vibrancy

The study indicates Vienna lags the North American cities in emphasizing these policy priorities. A strategic focus on improving productivity, strengthening innovation assets, supporting startups and tradable services, developing high-value manufacturing niches, and pursuing collaborative metro-wide strategies can help Vienna advance export-oriented production consistent with urban quality of life. While specific initiatives must consider local contexts, the comparative cases in North America provide valuable insights into policy directions.

1. Introduction

In the past decades, there has been a significant decline in the importance of manufacturing in highly developed countries. This "deindustrialization" has been most evident in urban areas, particularly regarding employment. For instance, the European Union's (EU) metropolitan regions have experienced a 33.9% decrease in manufacturing employment since the mid-1990s, and the 58 largest metropolitan regions have seen a decline of 41.1%, compared to the EU regions' average decrease of 27.7%. The United States has witnessed even higher rates of industrial employment contraction in its 366 metropolitan statistical areas over the period of 1980 to 2011. Here, the growth disadvantage relative to the national average was –8.8 percentage points for all metro regions and –10.0 percentage points for the largest 100 metropolitan regions. The Vienna metropolitan area has followed a similar trend. Manufacturing employment has declined by approximately one-third (–33.1%) since 1995, although the deindustrialization process has weakened since the mid-2000s and is barely noticeable in recent years. Currently, only 8.3% of Vienna's regional workforce is employed in manufacturing, ranking the metro 42nd among the 58 largest EU metropoles (average: 10.2%).

Until the early 2000s, this development was considered a natural consequence of a shift towards a post-industrial, service-oriented, and knowledge-based economy. Policymakers in many metropolitan areas did not view it as a significant concern. However, the resilience of industrial regions during the 2009 financial market and economic crisis and the vulnerability of global production networks to supply chain disruptions highlighted by the COVID-19 crisis have altered the national and international discourse on this topic.

Since the early 2010s, there has been an international resurgence of concepts aiming to reverse the trend in industrial development (referred to as "re-industrialization"). In the United States, for example, President Obama made the restoration and growth of the manufacturing base a central concern during his second term in office. Subsequent U.S. administrations have also prioritized this issue. This can by exemplified by the recently ratified Infrastructure Investment and Jobs Act (IIAJ) as well as the Chips Act and the Inflation Reduction Act of 2022 of the Biden administration. These all aim to increase investments in the production sector in the US. In Europe, the EU Commission recognized the importance of a dynamic and competitive industrial sector as early as 2010, considering it a "key element in solving society's major challenges and achieving a sustainable, inclusive, and resource-efficient economy. Ambitious goals were subsequently formulated, as reflected in the Industrial Strategy 2020 and its adaptation due to the pandemic. This strategy seeks to strengthen European industry's competitiveness while simultaneously addressing the ecological and digital transformation of the economy, which is particularly crucial for urban regions.

Large urban regions, however, face specific challenges in stabilizing or reversing the decline in their manufacturing sectors as the spatial and transportation requirements of many traditional manufacturing sectors and their emission intensities as well as other environmental impacts are often considered to be incompatible with the requirements and possibilities of urban spaces. Therefore, cities must find innovative solutions to address the potential conflict between further economic development, including the manufacturing sectors, and the preservation or enhancement of the environment and quality of life at the location. This challenge is particularly pertinent for metropolitan regions like Vienna, where comparative analyses highlight the high quality of life as a central (soft) locational advantage compared to competitor regions.

Against this background, the City of Vienna commissioned the current pilot project. It aims to review and analyze the development of export-based activities, with a particular emphasis on newly emerging activities in six North American metropolitan regions: Atlanta, Boston, Pittsburgh, Montreal, San Francisco, and Seattle. From the outset, the primary objective of the study was not to focus on a set of comparable regions. Rather, the aim was to consider a set of leading agglomerations on the North American continent that combine a high level of economic development as well as a high quality of life as measured by the Economist Intelligence Unit's (EUI) ranking of the most livable metropolitan regions. Since the study was intended as a pilot project, the central research interest was to explore what lessons, if any, could be learned from the development of these metropolitan regions. In particular, the aim here was to identify new opportunities for export-oriented production in urban contexts such as in Vienna, that generate high added value and are compatible with the specific locational advantages and disadvantages of large metropolitan regions as well as with a high quality of life.

To address these issues, case studies were commissioned on each of the six North American metropolitan regions selected for the analysis. Given the resources of the project, it was anticipated that not all issues related to industrial development in these metropolitan regions could be addressed by the case studies. Therefore, the research team decided to resort to a mix of data sources for their analysis. On the one hand, the authors of the case studies were asked to provide a brief description of the development of their case study metro focusing on "soft facts" and, if possible, to identify signs of newly developing export-oriented production activities on their territory. To this end, the authors of the case studies were also asked to conduct six qualitative interviews per metro region. These were conducted with relevant actors in economic policy and relevant companies at the location. On the other hand, the research team decided to collect additional data from other sources and from the literature to augment the analysis undertaken in the case study metropolitan regions.

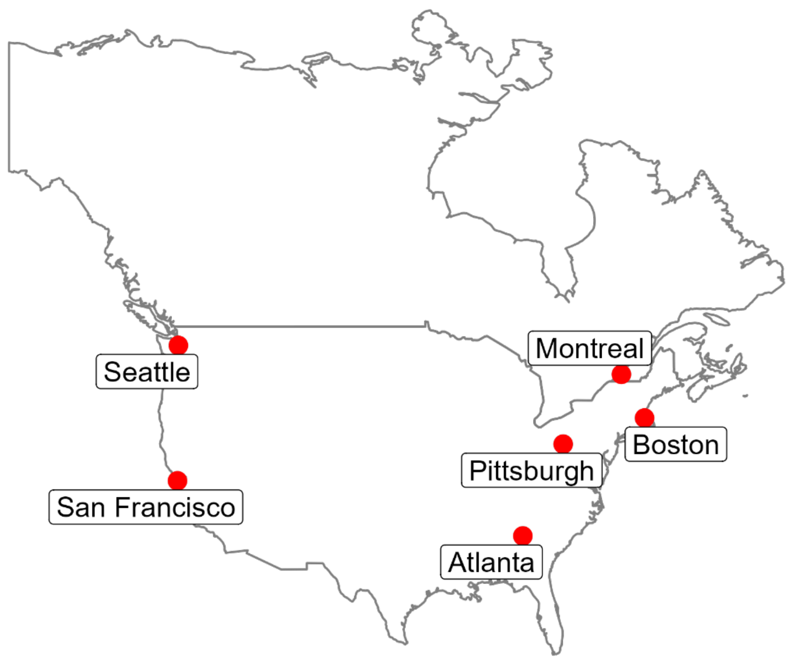
This report synthesizes the results of the case studies (appended to the report) and presents the results of the data analysis. It is organized as follows: The next chapter provides a brief discussion of the theoretical underpinnings of the study and presents some background data on the case study metropolitan regions as well as Vienna. Chapter 3 summarizes the findings of the case studies on the development of manufacturing as the sector with the largest export share and provides the results of a detailed analysis of the development of manufacturing in the case study metropolitan regions as well as Vienna. Chapter 4 provides evidence on rapidly growing and newly emerging activities in the metropolitan regions considered. Chapter 5, by contrast, considers to what degree the lessons learned from the case study metropolitan regions can be transformed into the Viennese context. Chapter 6 finally summarizes the results and provides an overview of some policy relevant lessons for policies to support newly emerging production activities in Vienna learned from the study. The individual case studies are then annexed to the study as separate texts.

2. The case study metropolitan regions

2.1 Data and regions considered

The selection of major metropolitan areas was conducted by the commissioning authority of this study and is based on the list of the "Economist Intelligence Unit's" (EIU) most livable cities. The criteria for selection included metro areas that achieved a minimum score of 90 points in the overall rating in the EIU Ranking for the year 2019. The geographical focus is on metropolitan regions located in North America. Furthermore, metropolitan regions that (from the point of view of the City of Vienna) have experienced interesting technological developments according to a preliminary screening also conducted by the commissioning authority[1], were given preference in the selection process. Thus, the case studies focus on six metropolitan regions: Atlanta, Boston, Pittsburgh, San Francisco, Seattle (USA), and Montreal (Canada)[2]. Figure 2.1 shows the geographic location of these metros.

Figure 2.1: **Location of case study metros in North America**

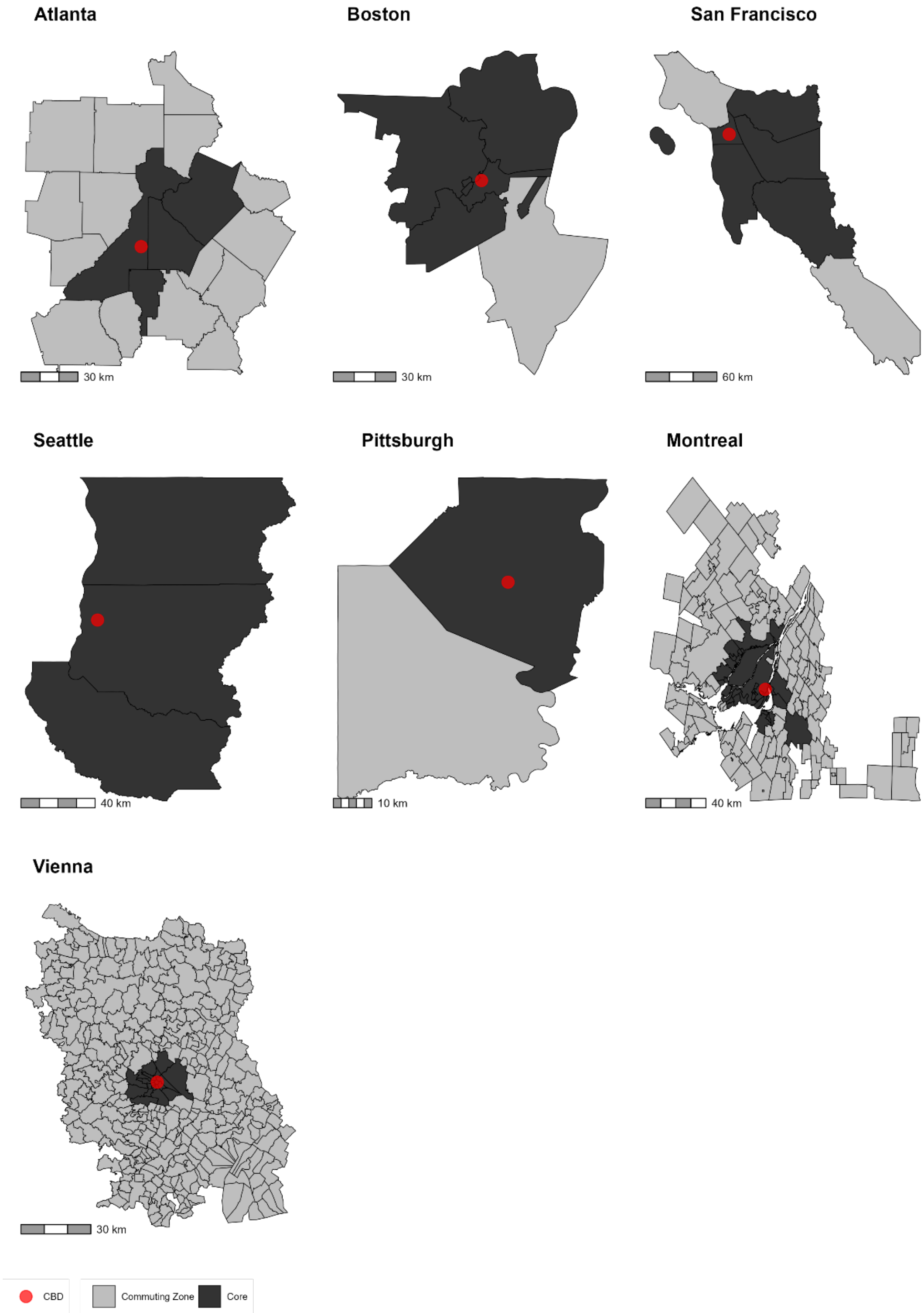


Source: R-Package "maps", WIFO illustration.

[1] During this screening the city conducted own desk research and provided a scoping report on Seattle to assess the feasibility of the envisioned research.

[2] We use the terms "metropolitan region," or "metropolitan area" interchangeably. They always refer either to the territorial delineation chosen by the respective case study authors or to the OECD definition of "Functional Urban Areas (FUAs)".

Figure 2.2: **Spatial extent and county composition of Functional Urban Areas (FUAs)**



Source: OECD, US Census Bureau, Statistics Canada, Statistics Austria, WIFO illustration.

While the individual case studies to the project use national data at a more disaggregated level, for the comparative data analysis we primarily use data from the OECD database "Regions and Cities"[3]. The use of OECD data offers several advantages for analyzing the various metropolitan regions in North America and Vienna. Firstly, it provides a consistent definition of the spatial boundaries of cities/metro areas. Secondly, it offers a standardized set of variables for these areas. While national data sources such as the US Census Bureau and Statistics Canada offer a wider range of indicators and more detailed sectoral and regional information, they often suffer from inconsistencies in spatial boundaries and content definitions between countries. In contrast, OECD data provides a minimum level of harmonization in both content and spatial boundaries but offers a more limited set of indicators for each metro region. Using both national data (in the case studies) and international data (in this synthesis report) therefore contributes to providing robust and reliable results.

From a sectoral perspective, we primarily focus on data on "export-based industries". This in our definition includes primarily the production of goods and thus the manufacturing sector, but also includes several further industries in tradable services[4]. These do not produce physical goods but are also tradable over larger distances. To contextualize the information on the individual metropolitan regions in the current chapter, we, however, also focus on several further indicators related to the overall economic, demographic, social, and environmental situation.

From a regional perspective, in this report we primarily focus on data on the OECD's "Functional Urban Areas" (FUA) displayed in Figure 2.2[5]. These FUAs are urban regions consisting of a core city (displayed in black in Figure 2.2) and the parts of its surrounding area (in gray in Figure 2.2) that are strongly connected to the respective core city through commuting, forming a common labor market[6]. We refer to this area as the commuting zone throughout this study.

The definition of the FUA therefore aims to provide a functional/economic delineation of core cities and their commuting zone, maximizing (i) international comparability and (ii) avoiding distortions due to purely administrative boundaries that no longer align with economic realities. We use this spatial division to compare metros from two perspectives: the larger functional urban area and the respective urban core. The former reflects the economic extent of the city and does not depend on the historical administrative boundaries. From a theoretical viewpoint, this is the preferred comparison region. The latter, on the contrary, is more aligned with the administrative boundaries and thus may be more relevant for policymaking, as it defines the

[3] This data was occasionally augmented by additional data sources, which will be discussed in the respective chapters of the study.

[4] These include services such as information and communication services (NACE code J), financial and insurance activities (K), and other services (RSTU).

[5] These are also equivalent to "Metropolitan Areas" as in OECD/EU terms, this can be used as a synonym for all FUAs with a population above 250.000 inhabitants.

[6] As Figure 2.2 shows, Seattle is the only FUA without a commuting zone. This is likely due to limited commuting flows between the core city and its surroundings. The OECD explicitly notes: "A Functional Urban Area consists of the city and its respective commuting zone. It can happen that, due to a low intensity of commuting flows, there is no commuting zone. In this case, there is a perfect correspondence between the FUA and the city." (See page 7 from: Dijkstra et al., 2019).

territory where urban policies can be implemented solely by the administration of the core city. This is especially true for Vienna, where the core city coincides with the administrative boundaries[7].

The focus on OECD data, however, implies that the metro-regions (as well as their "core" and "commuting zone") are defined differently in some respects from the definitions used by the authors of the case studies. These were asked to base their definitions on their specific information needs. This also means that some data used in this synthesis report may differ slightly from the numbers reported in the case studies. This may, however, be considered a lesser concern given that our focus in the current report is on robust stylized facts.

Already at first glance, the Functional Urban Areas suggest great heterogeneity in metro characteristics, as they differ vastly in both spatial extent and composition of their administrative units. For example, on the one hand, the Seattle metropolitan region consists only of three "core" counties (King, Pierce, and Snohomish) and no commuting zone. Similarly, the Pittsburgh metropolitan region is formed by only one core county, Allegheny, along with one county, Washington County, in the commuting zone. On the other hand, the Vienna metropolitan region comprises 323 municipalities, including the 23 districts of Vienna as the "core," while the Montreal metropolitan region consists of 177 census subdivisions, with 32 designated as the "core." This also implies that (as discussed in chapter 5.3.3) the challenges of coordinating regional policies and urban governance are likely to vary greatly among regions.

2.2 Basic metro characteristics

The economic history and geography of the case study metropolitan regions vary widely, as the individual case studies show[8]. All of these regions were originally inhabited by Native Americans, who had lived on this land for many centuries, before they were taken over by white settlers. However, the timing of this takeover and the emergence of urban structures differed greatly among the regions. For example, Boston and Montreal are among the oldest cities in the US and Canada, already settled by some of the first white settlers arriving to North America in the early to mid-17th century. By contrast, Pittsburgh and San Francisco were settled only in the second half of the 18th century, and Atlanta and Seattle as late as the mid-19th century. Compared to Vienna, whose urban history stretches back at least to ancient roman times, and where many downtown structures were built in medieval times, these cities are rather young[9]. This has implications for urban planning, in particular in downtown areas, as for instance, existing regulations pertaining to the protection of monuments in Vienna put substantial restrictions on the construction of new buildings in the downtown area.

[7] See e.g., OECD (2012): Redefining "Urban": A New Way to Measure Metropolitan Areas, OECD Publishing, Paris, or OECD (2022): The OECD Metropolitan Database – Database metadata and release notes.

[8] They provide a highly stylized and partial summary of the economic history of the case study metropolitan regions. We refer the reader to the individual case studies for more detailed accounts as well as references.

[9] This is even more so since North American metropolitan regions grew with the increasing use of cars. For instance, 80% of Montreal's population growth occurred after 1921, while Vienna had a population of 2 million already in the early 1900s that declined to around 1.5 million in the subsequent decades until the late 1980s.

Geography is another factor that distinguishes the case study metropolitan areas. Atlanta, like Vienna, is the only inland metropolis among them. It owes much of its original urbanization to becoming the terminal station of a railway line in the 19th century and has since always been considered a major inland transport hub in the US. Boston, Montreal, San Francisco, and Seattle are seaport metros, which has resulted in a much larger role of the fish-processing and ship-building industries. By contrast, the origin of Boston as an outpost of the British Empire implied that it was originally mainly a transport hub for the shipment of raw materials and agricultural produce to the UK. Finally, Pittsburgh is an important inland port, whose development into a steel city was also strongly driven by its access to cheap inland transport routes for bulky products. These different natural and historical conditions may have given the case study metropolitan regions different comparative advantages and technological and industrial trajectories since their urbanization. Many historians argue that this is a key to explaining their structural and cultural differences until today. For example, the case studies on Seattle and San Francisco point out that there is a debate in the US about whether the West Coast metros have a different business culture and innovative milieu than the East Coast metros due to their different climate, landscape, and pre-existing culture[10].

Following the evidence provided by the case studies, the North American metro regions covered provide a large variety of industrial development patterns in the late 20th and early 21st century that (in the shortest form possible[11] could be characterized as follows:

- Atlanta has traditionally been a major internal transport hub that, apart from manufacturing for local demand, also hosts significant federal agencies and a relevant military industry. It never had (and still does not have) a pronounced stronghold in export-based industries. However, its function as a transport hub has attracted many corporate headquarters to the region. Today, the region is home to 31 Fortune 500 companies, according to the local chamber of commerce. Additionally, there were several manufacturing investments (e.g., Kia and Hyundai) that are likely to provide jobs also for low-skilled labor in the region.
- Boston, by contrast, is a metropolitan region still undergoing deindustrialization in employment and which, unlike all other North American metropolitan regions in the project, did not experience a rebound of manufacturing employment after the economic and financial crisis. The metropolitan region's main industries are education, information technology, and life sciences, which are loosely linked to its extensive research base, including two of the world's leading institutions (MIT and Harvard). These industries are also the major employers in the metropolitan region. Nonetheless, the region's export base has increasingly shifted to services (and may even include the educational sector, as fee-paying students come to the metro region to study at its universities), so these are the main drivers of urban development today.

[10] In this respect the authors of the respective case studies refer to the work of Aydalot & Keeble (1988).

[11] This summary (by necessity) contains a very partial and pointed characterization of the individual metropolitan regions. We refer readers to the case studies for a substantially more differentiated analysis.

- Montreal also has undergone substantial structural change in recent decades. Since the 1970s, it has shifted from clothing and textiles industries, which were traditional pillars in manufacturing, to service industries that are highly internationalized. Today, Montreal is home to some of the world's largest engineering consulting firms, a major hub for the software publishing and computer gaming industries, and a leading center for artificial intelligence. In addition, the more traditional aerospace cluster also provides many jobs. However, like Boston, the economy has restructured to such a degree that tradable services may today arguably account for a larger part of the urban export base than manufacturing.
- Pittsburgh was known as *the* steel city in the US and a classic example of a monostructure industrial metropolitan region until the 1970s - 1980s. This specialization and the steel crisis of the late 1970s devastated its industrial structure, with employment in steel production falling from around 90,000 to around 44,000 employees in just four years (from 1980 to 1984). After the almost complete collapse of this traditional stronghold, Pittsburgh managed a remarkable resurgence, with restructuring being closely related to the development of health care services and artificial intelligence units, both of which were closely linked to local universities.
- The San Francisco Metropolitan area is a huge and populous region, whose core city traditionally had a rather diverse industrial structure, but nonetheless had its strongholds in shipping and technology-based industries (in particular electrotechnics). Since the 1960s, most of these industries gradually disappeared from the city, and it increasingly became and still is a residential city, with the remnants of the old industrial structure being several garment producers (e.g., the headquarters of Levi Strauss), and food industries. However, while the region's traditional industrial base eroded, a major development impetus came from the computer and electronic product manufacturing industry, which is the metropolitan region's main industry today. This industry emerged in Silicon Valley because of its existing strengths in electrical engineering and radio manufacture, and then started to spill over to the core city of the metro in the early 2000s. Today, the San Francisco metropolitan region is a global hub of computer-related industries.
- Seattle, as the other West Coast metropolitan region in our sample, historically shares many of the features of San Francisco, such as a diverse industrial base and an important seaport. Unlike San Francisco, however, Seattle boasts many major companies in a diverse set of industries, such as transportation equipment design and manufacturing (Boeing and Paccar), retail and logistics (Microsoft, Amazon) as well as Web Services (AWS and Expedia). These major companies have also been important contributors to Seattle's education system (in particular in MINT subjects) as well as to a vibrant startup scene, which is another key driver of the metropolitan region's current economic development.

In summary, the case study metropolitan regions, while hardly comparable to Vienna as discussed in more detail below, are interesting in the context of our project as they provide rather varied – and in some cases remarkable – examples of deindustrialization and a subsequent resurgence.

2.2.1 Demography

The indicators on demographic, economic, social, and environmental development, based on OECD data, also show a high degree of heterogeneity among the case study metropolitan regions. For instance, in terms of population, most of the North American metropolitan regions covered are substantially larger than Vienna, both when considering the Functional Urban Area and its core city. Only Pittsburgh, as the smallest among the case study metros, had just over 1.4 million inhabitants in the metropolitan area in 2019 and is thus less populous than Vienna. By contrast, San Francisco, as the largest metropolitan area, had approximately 6.7 million inhabitants. This makes it nearly five times larger than Pittsburgh and more than twice the size of Vienna. Atlanta, Boston, Montreal, and Seattle, by contrast, had populations of around 4.0 to 5.7 million in their metro areas.

These differences in size, along with differences in their geographic extent, degrees of suburbanization, and housing forms, also lead to startling differences in population density and therefore the degree of competition between residential and commercial land uses such as export-oriented production. For example, the core city of metropolitan Vienna has a population density of 4,595 inhabitants per square kilometer, which is more than double that of Montreal, the second highest. By contrast, all US case study metros have population densities below 1,000 inhabitants per square kilometer, even in their metro cores.

Table 2.1: **Demographic indicators for case study metropolitan regions and Vienna in 2019**

	Population		Population Change (2002-2019, in %)		Population Density (Inhabitants per km²)		Share Foreign Born (in % of total population), 2016	
	Core	FUA	Core	FUA	Core	FUA	Core	FUA
Atlanta	3,054,754	5,673,412	+29	+35	848	385	17	14
Boston	3,914,067	4,435,908	+10	+10	809	666	20	19
Montreal	3,468,196	4,599,452	+15	+19	2,138	379	27	22
Pittsburgh	1,215,716	1,422,582	–4	–3	630	342	6	5
San Francisco	6,387,342	6,709,230	+14	+14	739	491	33	32
Seattle	3,977,785	3,977,785	+28	+28	255	255	18	18
Vienna	1,897,491	2,983,513	+21	+18	4,595	310	35	27

Source: OECD City Statistics, WIFO calculations.

This, however, is not least due to differences in the structure of the metropolitan regions covered. Metropolitan Vienna (like Montreal) has a rather monocentric settlement structure, which is not the case with the US case study metros (see, e.g., Arribas-Bel & Sanz-Gracia, 2014). Therefore, Vienna has a small (but obviously dense) urban core (see also Figure 2.2) as compared to the US metros[12]. However, when considering the overall metropolitan area, the ranking of population densities changes significantly. Here, Boston (666 residents per square kilometer) is the densest and Seattle (255 residents per square kilometer) is the least dense FUA. The Vienna metropolitan region ranks only above Seattle in this respect. This characterizes Vienna as a metropolitan region with a very dense core but a comparatively sparsely populated commuting zone.

Differences in population growth are equally startling. The Vienna metropolitan region, with a cumulated population growth of 18% over the period 2000 to 2019, was the sixth fastest-growing metropolitan region in the European Union (see Mayerhofer et al., 2021). However, Atlanta (+35%) and Seattle (+28%) exceed this growth by far, while Pittsburgh's population declined over the last two decades.

Besides these differences in total population, the case studies also indicate that the structure and diversity of population vary widely among the case study regions. In some cases, this (combined with discrimination and exclusion of some groups) has caused serious social problems in the metros and hampered economic development. For example, the case study on Atlanta emphasizes the negative impact that the legacy of the Jim Crow-laws[13] has on the educational structure of people of color. This affects the availability of skilled human resources in the region, as Atlanta has the largest community of people of color in the US. By contrast, the case study on Montreal emphasizes the positive impact that ethnic diversity and its unique role as a French-speaking city have had on urban economic development. A general impression from this evidence is that ethnic diversity is seen as a locational advantage in contexts that avoid exclusion and discrimination of minorities. Furthermore, the case of Atlanta is particularly striking, as it also shows the long-lasting adverse effects of discriminating regulations on regional development.

According to OECD data, also Vienna has become a highly internationalized city in terms of its population structure in recent decades, even compared to the North American metropolitan regions. This is especially true for Vienna's urban core, where the share of foreign born was 35% in 2016, higher than in any of the US case study regions. Among them, San Francisco (33%) had the highest share of foreign born and Pittsburgh the lowest in their metro cores. Vienna's diversity also extends to the FUA, where only San Francisco's share of foreign born (32%) was higher than that of Vienna (27%) in 2016. Since then, the share of foreign born has increased significantly in Vienna, not least because many of the refugees who came to Austria in the 2015/16 refugee crises moved to Vienna after receiving a permanent residence title in Austria (see Dellinger & Huber, 2021). Therefore, in 2022, almost 50% of the population in Vienna's core city had a migration background (i.e., were either 1st or 2nd generation immigrants) according

[12] Vienna has by far the smallest area in the core city within the sample. In 2022, the urban core of Vienna accounted for barely 5% of the land area of the metropolitan region. This contrasts to, for example, Boston, whose core city accounts for almost three quarters of the area of the entire metropolitan region.

[13] The "Jim Crow-laws" were a collection of state and local statutes legalizing racial segregation in the southern states of the US from just after the Civil War until 1968.

to data from the Austrian labor force survey, with the Viennese labor market showing strong signs of occupational segregation by ethnicity (see also Ebner-Zarl et al., 2023).

2.2.2 Land Use Patterns

Unsurprisingly, land use patterns in the case study metros closely follow the specifics of their settlement structures, mirroring the population density and the geographic size of the individual regions. Consequently, the (very compact) core of the Vienna metro provides the smallest per capita area both for commercial and residential uses (25 m² and 65 m² per capita, respectively). In comparison, Atlanta, for example, has eight times more area available for commercial uses in its core region (191 m² per capita). Indeed, comparing the core to commuting zone commercial areas per capita across the case study regions reveals that Vienna, with a ratio of 1:8, has by far the most "uneven" intra-metropolitan distribution of commercial land. Looking at the residential area per capita across space paints a nearly identical picture. Vienna's core again comes out as very compact, while Seattle (408 m² per capita), Pittsburgh (396 m²), Atlanta (370 m²), or Boston (330 m²) have more than 5 times more land available for residential use per inhabitant[14]. Issues of spatial planning and land provision are therefore likely to be significantly more important in Vienna than in most North American case study metropolitan regions.

Table 2.2: **Distribution of land and land use in metro areas, 2022**

	Total Area				Commercial Area		Residential Area	
	Core		Commuting Zone		Core	Commuting Zone	Core	Commuting Zone
	km²	in %	km²	in %	(m² p. capita, 2021)		(m² p. capita, 2021)	
Atlanta	3,601	24	11,139	76	191	256	370	598
Boston	4,839	73	1,825	27	117	219	330	588
Montreal	1,623	13	10,517	87	69	265	129	646
Pittsburgh	1,930	46	2,232	54	170	383	396	777
San Francisco	8,645	63	5,024	37	139	551	199	541
Seattle	15,575	100	–	0	165	–	408	–
Vienna	413	4	9,206	96	25	205	65	437

Source: OECD City Statistics. "–": no commuting zone.

2.2.3 GDP per Capita and Labor Productivity

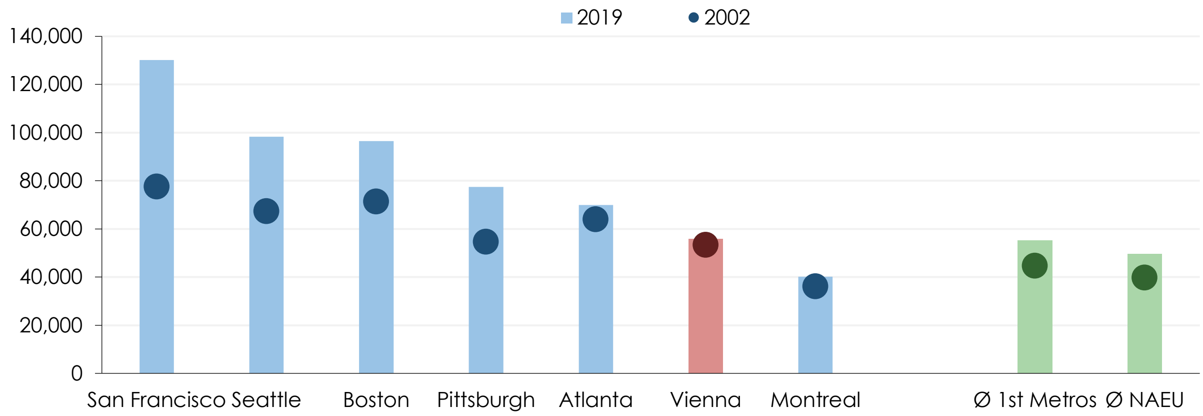
The available evidence also points to significant differences in economic development levels between the metro regions. This is shown in Figure 2.3 which compares GDP per capita in the Vienna metropolitan region with the six case study metros, the average of the (50) EU27 1st-tier

[14] Recall that North American metropolitans grew with car use, which set them on a very different path in terms of land use than, e.g., Vienna.

metro regions[15], and the broader North American-European area in 2002 and 2019[16]. The case study metropolitan regions are highly developed regional economies throughout. Consequently, Vienna's GDP per capita (at USD 55,774) is slightly higher than the EU27 1st-tier metro regions in 2019 in purchasing-power standards, but it only exceeds Montreal's among the case study regions. In contrast, the US case study metros far outperform Vienna in this key indicator of economic development. In particular, San Francisco's GDP per capita is more than twice that of Vienna in 2019, while Seattle and Boston surpass Vienna by about three quarters.

Figure 2.3 also shows that the US case study metros' big lead has to a large extent only emerged in the past two decades. Indeed, the four most strongly growing US case study metros increased their GDP per capita by between +35% (Boston) and +68% (San Francisco) in real terms during this period, while in the benchmarks of the (50) EU 1st-tier metro regions and the broader North American-European area it also grew by about a quarter each. Vienna, however, lagged even the slowest growing North American case study metros (Montreal +11%; Atlanta +10%), with a meager cumulative real GDP per capita growth of only +5% from 2002 to 2019.

Figure 2.3: **Economic development levels in the case study metropolitan regions**
GDP per Capita at the FUA level, constant prices, constant PPP, base year 2015; in USD



Source: OECD City Statistics, WIFO calculations.

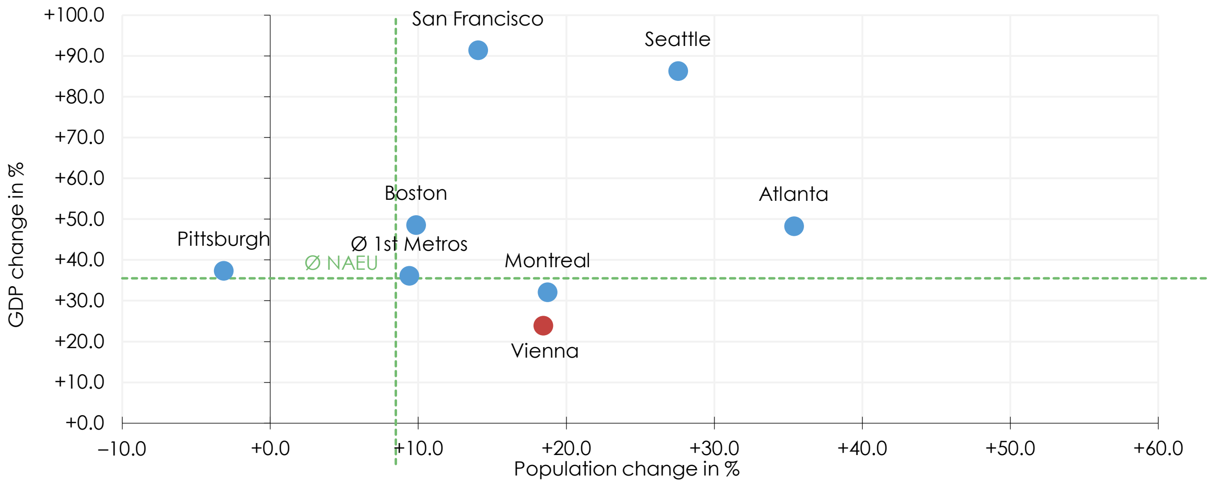
This rather unfavorable development of Vienna's GDP per capita has resulted from a combination of high population growth and weak economic dynamics. As shown above, however, also some US case study metros (notably Atlanta and Seattle) experienced population growth that exceeded that of Vienna by far, without facing a similarly sluggish development of GDP per capita. This suggests that Vienna had more difficulties of integrating its rapidly growing

[15] In our analyses we will repeatedly compare Vienna also to the average of "comparable" metropolitan regions in Europe, to highlight Vienna's position in the European urban system and to indicate differences between US and European Metros in general. The comparison group of the (50) "1st-tier metro regions" used in this context includes the capital cities of the EU27 as well as all other metropolitan regions in the EU27 with more than 2.5 million inhabitants in the agglomeration area.

[16] We use data from 2019 to avoid picking up spurious effects of the COVID pandemic in subsequent years.

population into the labor force and making it fully "productive" than the US metros. This may partly reflect the different structure of the population migrating to the respective metros. This in Vienna was to a considerable extent driven by exogenous "push factors" and included a significant share of less skilled immigrants[17]. It may, however, also reflect the higher inertia of European regional labor markets, which generally adjust more slowly to supply and demand shocks than the US regional labor markets (see, e.g., Arpaia et al., 2014, Beyer & Smets, 2015)[18].

Figure 2.4: **Development of GDP and population in the case study metropolitan regions**
FUA-level, 2002-2019 in %



Source: OECD City Statistics, WIFO calculations.

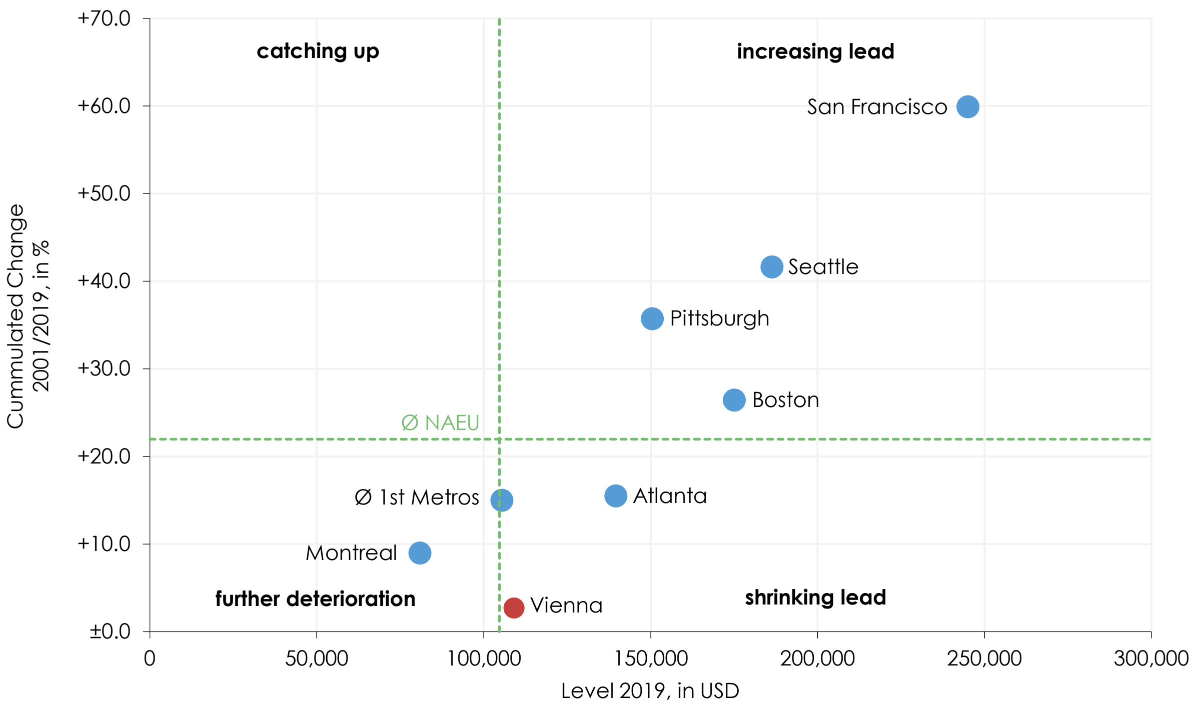
Similarly, average labor productivity as well as productivity growth vary widely among the case study metros (see Figure 2.5). As with GDP per capita, Vienna lags most of the case study metros in terms of GDP per worker (all except Montreal) in 2019 and has also experienced substantially lower productivity growth in 2001/19 than all the case study metros (including Montreal). San Francisco, Seattle, Pittsburgh, and Boston, with cumulative efficiency gains of between +60% and 26% expanded their lead significantly since 2001, while Atlanta (+15%), and Montreal (+9%), despite losses in their productivity position compared to the NAEU benchmark, still recorded higher productivity growth than Vienna (+3%). The underlying causes for this (relative) efficiency loss of the Viennese economy can be mainly attributed to the direction of structural change in the metropolitan region: While research and innovation capacities remained intact and even grew faster in Vienna than in the average EU 1st-tier metro-region, employment

[17] These include immigration gains after the fall of the "Iron Curtain" and during the Yugoslav wars in the early 1990s, as well as significant population influx triggered by the end of transitional provisions in labor market access for citizens of the new EU member states (2007, 2011), the peak of refugee's immigration in 2015, and asylum migration from Ukraine recently.

[18] More recent evidence, however, suggests that Vienna may have transited to a to a more employment-intensive mode of growth since 2009 as, in the face of continued immigration, employment growth more than doubled from 2009 to 2018 (see Mayerhofer et al., 2021).

growth, which was largely centered on high-skill- and medium-high-skill industries until the mid-2000s, shifted noticeably to skill-extensive (and thus low-productive) sectors after the Great Recession, partly in response to the influx of less skilled workers from abroad. This boosted regional job creation but also dampened productivity growth (see Mayerhofer et al., 2021).

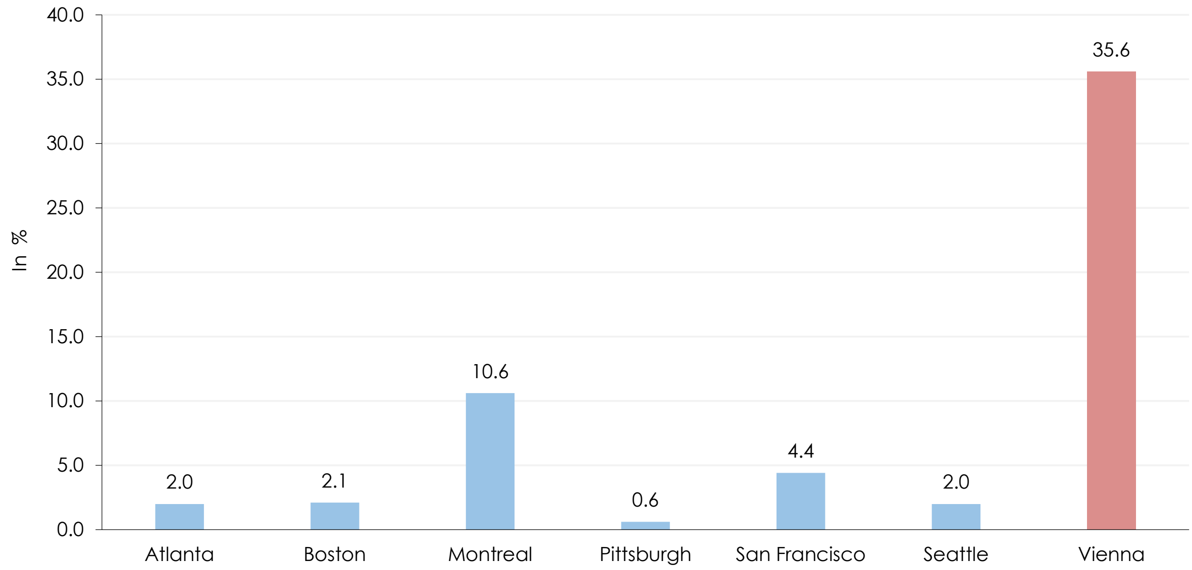
Figure 2.5: **Labor productivity in the case study metropolitan regions**
GDP per worker at the FUA level, constant prices, constant PPP, base year 2015, in USD



Source: OECD City Statistics, WIFO calculations.

Despite this rather weak economic performance in the medium term, Vienna has remained a dominant component of the Austrian economy – a big fish in a small lake, generating more than one-third of Austria's GDP. This is a further policy-relevant factor that distinguishes Vienna from the North American metros in the project: The US metro region with the highest share of national GDP (San Francisco) contributes only 4.4%, and its Canadian counterpart (Montreal) about 10.6% to their respective national economic output. However, over time, Vienna has lost significance also in a national comparison, reflecting substantial convergence processes in Austria. Since the turn of the millennium, there has been higher per capita growth in GDP as well as labor productivity in industrial and rural regions as compared to the national metro regions (Peneder et al., 2023). In the Anglo-American context, in contrast, metropolitan regions, despite considerable variations among them, have, in general, remained stronger drivers of growth.

Figure 2.6: **Share of metropolitan region's GDP in the country's GDP (2019)**



Source: OECD City Statistics, WIFO calculations.

2.2.4 Labor Markets

The labor market situation, at least in terms of overall employment and unemployment rates, seems to be one of the few areas where the metro regions covered have slightly more similar developments in recent years. The employment rates across metros are more similar than other indicators, although there are still significant differences. They ranged from 59.3% in Montreal to 65.7% in Boston among the case study metros in 2019[19]. However, the labor market dynamics differed significantly. Pittsburgh had the strongest increase in employment rates since 2002, while Atlanta had a decline of 4.9 percentage points. The unemployment rate was noticeably higher in the Montreal metro (5.1%) than in the US metros, where it ranged from 4.3% in Pittsburgh to 2.6% in San Francisco. Notably, all case study metros witnessed a substantial decrease in unemployment rates compared to 2002. The most significant decline occurred in San Francisco, where the unemployment rate dropped by 4.3 percentage points to the lowest rate in the sample at 2.6% in 2019[20].

The comparisons to Vienna must be interpreted with caution, as the data for the Vienna metropolitan region in Table 2.3 are estimated from national Labor Force Survey sources that do not allow for an exact delineation of the Viennese metropolitan area. However, the general picture emerging from this data is highly consistent with previous analyses of Vienna's economic performance. Vienna has lower employment rates among the population aged 15+

[19] Once more we choose 2019 as a reference point for the comparison to avoid confounded data on account of the differential impact of the COVID-19-crises on the Austrian and US labor market.

[20] However, part of this decline may be due to unemployed people leaving the city on account of housing prices.

and higher unemployment rates. Moreover, unlike most North American metropolitan regions, the employment rate has grown more slowly, and the unemployment rate has increased over the last two decades. The low employment rates of the population aged 15+ in Vienna are mainly due to differences in the pension systems and an accordingly low employment rate of the elderly in Austria[21]. Therefore, employment rates of the 15- to 64-year-olds are around 70% in Vienna and thus more comparable to North American standards. The high and rising unemployment rates and the slow employment growth, however, once more highlight the challenges Vienna faces in integrating its growing migrant labor force.

Table 2.3: **Labor market indicators in case study metropolitan regions and Vienna**

	Employment rate (population aged 15+)		Unemployment rate	
	2019, in %	Change 2002-2019, in percentage points	2019, in %	Change 2002-2019, in percentage points
Atlanta	62.6	–4.9	3.4	–1.9
Boston	65.7	+2.1	2.7	–2.5
Montreal	59.3	0.0	5.1	–3.6
Pittsburgh	61.0	+2.6	4.3	–1.1
San Francisco	63.8	+1.9	2.6	–4.3
Seattle	64.2	+1.7	3.3	–3.0
Vienna	56.7	+0.7	6.8	+1.4

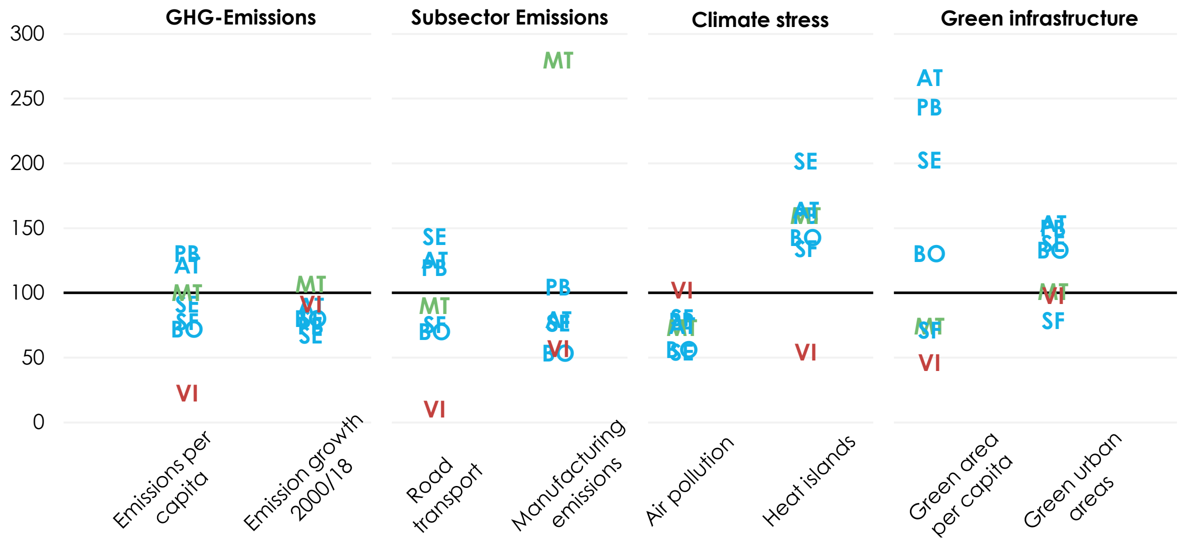
Source: OECD City Statistics, WIFO calculations. – Vienna: Data taken from Austrian Labor Force Survey, with metropolitan region imputed from data on Vienna and Lower Austria.

The case studies and the relevant literature highlight several more subtle differences between European and North American metros in general and the case study metros and Vienna in particular. A large, mainly US-American literature (see, e.g., Cutler et al., 2008), emphasizes the high ethnic and racial residential segregation of US metropolitan regions and discusses its negative effects on poverty rates and other social indicators. According to the so-called Spatial Mismatch Hypothesis (see, e.g., Dong and Kwan, 2020 or Glaeser & Hausman, 2020), (mostly poorer) members of ethnic minorities in US metropolitan regions live in areas that are far from workplaces and have poor access to other urban infrastructure (i.e., public transport, schools, and educational institutions), which reduces their job finding rates. In Vienna, by contrast, ethnic and racial residential segregation is much less pronounced and generally considered as a minor problem, as spatial planners in the traditionally labor-governed city have aimed to combat segregation by dispersing social housing projects throughout the city since the 1920s[22].

[21] As all Austrians are covered by a compulsory pension system that sets in at the age of 65 for men and 60 for women, employment rates of the population aged 60+ are extremely low compared to international standards. In addition, early retirement is a common phenomenon among some parts of the Austrian workforce.

[22] Almost 40% of all (close to one million) housing units in Vienna are subsidized housing: Almost 25% of the housing units are publicly owned social housing, another 15% are owned by nonprofit cooperatives.

Figure 2.7: **Emissions in Vienna and the case study metropolitan regions**
Indicators at the TL2- or FUA-level; Index OECD = 100



Source: OECD City Statistics, WIFO-calculations. – Air pollution (2020): mean population exposure to PM2.5 air pollution; Heat islands (2020): summer daytime difference in land surface temperature (in °C) between the built-up area and its surroundings; Green area per capita (2021): m² per capita; Green area (2021): share of green areas in FUA's urban core.

2.2.5 Environmental situation

Finally, also environmental indicators show significant differences both among the case study metros and between these metros and Vienna (see Figure 2.7). Although all metros have a high quality of life according to available rankings, as this was a criterion for selecting the case study metros, Vienna outperforms the North American metropolitan regions in terms of (low) greenhouse gas (GHG) emissions as well as in terms of (few) heat islands. This is mainly due to its comparatively low manufacturing emissions and its highly developed public transport system. In contrast, Vienna lags the case study metros in terms of air pollution (i.e., fine particles in the air) as well as green area per capita. This is mainly due to these indicators referring to the metropolitan core, which is much denser in Vienna than in the North American metros. The population of Vienna's core, with 12.0 µg/m³, was exposed to the highest level of particulate matter with a diameter of less than 2.5 micrometers ("fine dust") among the comparator regions in 2019. This exceeds the threshold defined as acceptable by the World Health Organization (WHO) of 10 µg/m³ (reduced to 5 µg/m³ since 2021). This suggests that Vienna's core city faces greater challenges in reducing particulate matter pollution than the North American metros, due to its dense urban structure[23].

As for security in the metropolis, homicides per 100,000 inhabitants, which is an indicator often used in international comparisons, are substantially lower in Vienna than in the US metropolitan

[23] Particulate matter is a very local type of air pollution. In urban areas densely built up with tall buildings, it cannot be easily carried away or diluted by the wind, which is why it accumulates on the spot.

regions[24]. This may be related to higher income inequality and generally higher social challenges in the latter, but also to differences in gun laws and other legal aspects.

[24] The OECD does not provide data on this indicator for Vienna. However, the police crime statistics of the Federal Ministry of the Interior reported a total of only ten homicides in Vienna in 2021, which is a negligible number by comparison.

3. "Re-industrialization" after deindustrialization? Comparing the case study metropolitan regions and Vienna

Despite the heterogeneity among the metro regions emphasized in the last chapter, one commonality among the case study metropolitan regions is a pronounced deindustrialization in terms of employment, which started in the late 1960s and early 1970s in most cases. This led to major structural shifts throughout the case study metropolitan regions. Indeed, one of the most salient stylized facts emphasized in all the case studies is the substantial decline of traditional manufacturing industries in the last decades. For example, Pittsburgh experienced the demise of steel manufacturing, which led to a rapid downturn and a subsequent almost complete restructuring of the economy. Similarly, according to Glaeser (2005), Boston shared many of the structural characteristics of the US "rust belt" cities until the 1980s but has since managed to "re-invent" itself. In addition, the case studies of Montreal, San Francisco, and Seattle also provide accounts of large-scale industrial restructuring.

Thereby, all the metropolitan regions covered in the case studies have been successful in developing new activities that replaced the declining manufacturing sector to some degree. The case studies suggest that the export-base of the metropolitan regions has shifted substantially toward services, with some emerging and fast-growing sectors sometimes including services that were not considered tradable until recently (e.g., education in Boston or health services in Pittsburgh). However, most of the case studies (except for Boston) also state that since the financial and economic crisis of 2009 there have been signs of a stabilization of manufacturing employment in many of the case study metropolitan regions.

Understanding the mechanisms of deindustrialization and the potential for subsequent re-industrialization in urban spaces is essential for our study. This is because manufacturing remains the sector with the largest share of internationally traded products[25]. As such, it is a vital part of the export base of metropolitan regions and indirectly supports service trade through the increasing importance of services as intermediaries in manufacturing. This is particularly important for metropolitan regions with their usually strong service orientation. Moreover, a large theoretical and empirical literature[26] suggests that having a fair share of manufacturing in an economy's output is associated with several desirable attributes, such as higher productivity (growth), well-paid jobs, and greater R&D intensity.

[25] Manufacturing still accounts for the largest part of international trade. While services currently account for more than half of the GDP of developed countries, a worldwide trade volume of US-$ 18 trillion in goods still compares to only US-$ 6 trillion in services according to traditional measurement. Even if the estimated supply of services through commercial presence (i.e., trade by foreign affiliates, through GATS mode 3) is added, services trade does therefore not match goods trade at present (WTO, 2022).

[26] See Mariotti et al. (2021) for an overview and additional evidence.

3.1 Drivers of deindustrialization: Results from theory and case studies

According to the relevant theoretical and empirical literature[27], deindustrialization has been caused by both internal (domestic) and external (global) factors. Among the global factors, the major contributors are:

- The offshoring of production stages and the lengthening of value chains in increasingly fragmented production networks (e.g., Baldwin & Venables, 2010; Baldwin, 2011). This was incidentally even more pronounced in the US than in Europe, and led to a relocation of activities and knowledge towards regions with lower production costs (both nationally and internationally);
- the emergence of alternative export bases apart from manufacturing, such as knowledge-intensive and financial services in urban regions and tourism in rural regions, reducing manufacturing shares (e.g., Palma, 2008).

Among the domestic factors, the literature points to

- decreasing relative prices due to higher average productivity growth in manufacturing compared to services (e.g., Baumol, 1967; Saeger, 1997);
- changes in consumption patterns towards services with rising incomes (e.g., Falvey & Gemmel, 1996; Peneder & Streicher, 2018);
- an increasing interdependence between and hybrid forms of manufacturing and services, that boosts demand for knowledge-intensive business services (KIBS) with rising complexity (e.g., Ciriaci & Palma, 2016; Di Berardino & Onesti, 2020); and
- purely statistical effects from outsourcing of large firm's former in-house services, shifting employment and output from manufacturing to services (e.g., Tregenna, 2010).

These causes for deindustrialization may have been more relevant in large conurbations than elsewhere[28], and should thus explain the more unfavorable development of manufacturing in metropolitan regions in general.

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[27] See Rowthorn & Ramaswami (1997), Mayerhofer (2007, 2013), Tregenna (2013), Peneder & Streicher (2018), or Mariotti et al. (2021) for detailed literature reviews on this topic.

[28] First, large metropolitan regions are typically characterized by higher land and labor costs as well as unfavorable conditions for the transport of bulky physical goods. Therefore, decentralization and offshoring of productive processes from urban to suburban or peripheral locations (both nationally and internationally) are more intense (e.g., Baldwin, 2011), leading to a shrinking manufacturing share in employment and possibly output. At the same time, advantages in human capital (Glaeser & Saitz, 2004; Moretti, 2013), information density, and knowledge-spillovers (Henderson, 2005) give rise to a specialization of large metropolitan regions s in knowledge-intensive (and in part tradable) services (Fujita & Thisse, 2002), also dampening its manufacturing share. In addition, decentralization, and offshoring of metropolitan manufacturing (parts) leads to complex activities with higher productivity growth remaining in urban environs (Mistry & Byron, 2011), leading in turn to productivity-driven declines in manufacturing employment shares, but also to more hybrid forms of production with a higher share of services in the urban industrial fabric. More than that, also for cost reasons, the outsourcing of highly productive servo-industrial activities of larger companies (e.g., Headquarter-, R&D- or ICT-functions) to independent service firms seems particularly common in metro regions, making the above-mentioned "statistical"-effect of outsourced holdings and subsidiaries particularly relevant for urban areas. Finally, income levels in metropolitan regions are typically higher (OECD, 2022), implying a higher relative local demand for services rather than manufacturing goods.

In addition, the case study findings from interviews conducted in Atlanta, Boston, San Francisco, and Seattle point to additional impediments in manufacturing development mainly in core cities. These are rooted in the increasing competition for land between residential and economic uses, and the competition between service providers and goods producers within the latter. In addition, a number of policy relevant fields such as zoning laws, spatial and traffic planning, and the general support provided by policymakers are mentioned as challenges to the development of manufacturing in the case study metropolitan regions.

The interviews with business representatives indicate that with a growing urban population, developing land for residential uses is substantially more attractive than developing industrial land for both political and economic reasons (due to high housing prices)[29]. Furthermore, in some cases, it was also argued that the demand for services in metropolitan regions increases the competition for the remaining land for business uses. The service sector has a competitive edge also from a planning perspective, as office space is more compatible with "mixed" residential and economic uses, can be more easily provided in multi-story structures, and typically requires less infrastructure and causes less environmental problems[30].

The complaints regarding zoning and urban planning range from a lack of dedication for commercial land use in zoning regulations to a lack of foresight regarding the infrastructure needs of manufacturing firms to an increasing intolerance of nearby residents towards the specific disamenities (such as noise) caused by manufacturing enterprises and an increased NIMBYism[31] in some cases.

Regarding economic policy, some interviewees from firms (notably in the case of Seattle) also criticize a lack of support by regional or local policy actors, either for enterprises in general or for manufacturing in particular. In some cases, it is argued that this is because existing support structures (financial or organizational) are often geared to the needs of the service sector. However, a lack of sufficient skilled labor and high costs in most metropolitan regions are more frequently mentioned as impediments.

These complaints from business actors refer to the US case study metropolitan regions and may thus – taken on their own – not apply to European metropolitan regions (and Vienna). Nonetheless, they are highly consistent with similar interview-based evidence for Vienna and a range of other European metropolitan regions. For instance, in a recent ESPON project (Mariotti et al., 2021) WIFO and three other partners led by Politecnico di Milano conducted similar interviews in seven European metropolitan regions, including Vienna[32]. The issues and problems highlighted by business agents and spatial planners in these metropolitan regions were very similar

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[29] Politically, meeting residential needs is highly popular and therefore likely to increase political support for incumbent politicians, while economically price differentials between land for residential and commercial use have been high and rising in many metropolitan regions in recent years.

[30] See the case studies on Boston, Atlanta, and San Francisco for argumentations in this line and/or complaints concerning a lacking land use.

[31] NIMBYism is an acronym for "not in my back yard" and refers to the behavior of someone who opposes something being built or done near where they live, even though they generally support the idea of it being built or done somewhere else.

[32] The other metropolitan regions were Berlin, Riga, Oslo, Turin, Stuttgart, and Warszawa.

to those reported in the North American case studies[33]. The only exception is that European interviewees also identified a lack of coordination in spatial planning between core city administrations and their counterparts in the surrounding areas as an additional issue, particularly in Vienna. Moreover, issues of lacking financial support were perhaps more strongly emphasized in most European metropolitan regions. Finally, both in the case studies in the current project and previous interviews conducted in Vienna, issues related to an excessive orientation of the existing support systems towards service providers, often discussed in policy debates on subsidies, were rarely mentioned by the interview partners.

From a policy perspective, this suggests that the pressures on manufacturing in most metropolitan regions could be somewhat reduced by improved spatial planning procedures. This would likely involve an increased coordination of economic development and spatial planning strategies, a more explicit consideration of the requirements of export-based production in spatial planning, and an increased involvement of local actors in attempts to mobilize land for production uses. However, it is highly unlikely that the reported problems can be completely solved, as they are essentially inevitable concomitants of high-density locations.

The same applies to the general (global and domestic) factors that drive deindustrialization. Indeed, it is hard to find striking arguments why these factors should change fundamentally soon, especially when it comes to the main drivers mentioned, i.e., the specific cost disadvantages of highly developed (metro) regions (particularly in land, labor, and transport costs), the productivity differences between industry and the service sector[34], or the consumer bias to services in high-income areas. This clearly contradicts expectations about a fundamental "reindustrialization" of metropolitan regions. On the other hand, there is indeed recent evidence indicating a certain consolidation of manufacturing in metro regions in Europe (Mariotti et al., 2021), possibly driven by changing consumer preferences and digital technologies that enable new, specifically "urban" production activities.

3.2 Manufacturing evolutions in Vienna and the case study regions: Unitary employment losses, heterogeneous productivity trends

Against this background, the following empirical analysis examines the development of manufacturing in our case study metropolitan regions and Vienna and compares them from different perspectives. How intense has deindustrialization been in the case study metropolitan regions, and in what way did manufacturing evolutions differ? What is the role of manufacturing in these metropolitan regions after this structural change? Is there any genuine "deindustrialization" at all, or is the loss of employment in the sector primarily a result of higher productivity gains

[33] This is, however, no surprise, given that most of the mentioned issues are closely related to the problems faced by almost any company located in a densely populated, high-cost location.

[34] While the productivity paths in the service sectors are by no means uniform, no general catching-up in efficiency levels can be identified for the entire tertiary sector in Europe (e.g., Maroto-Sanchez & Cuadrado-Roura, 2009). Rather, knowledge-intensive services in particular – with limited own productivity levels – increase productivity in other sectors (for empirical evidence, see Firgo & Mayerhofer, 2017), and the high growth of such services could thus increase the productivity advantage of industry.

(i.e., an "upgrading" of manufacturing)? And: are there signs of a "phasing out" of deindustrialization or even of "re-industrialization"?

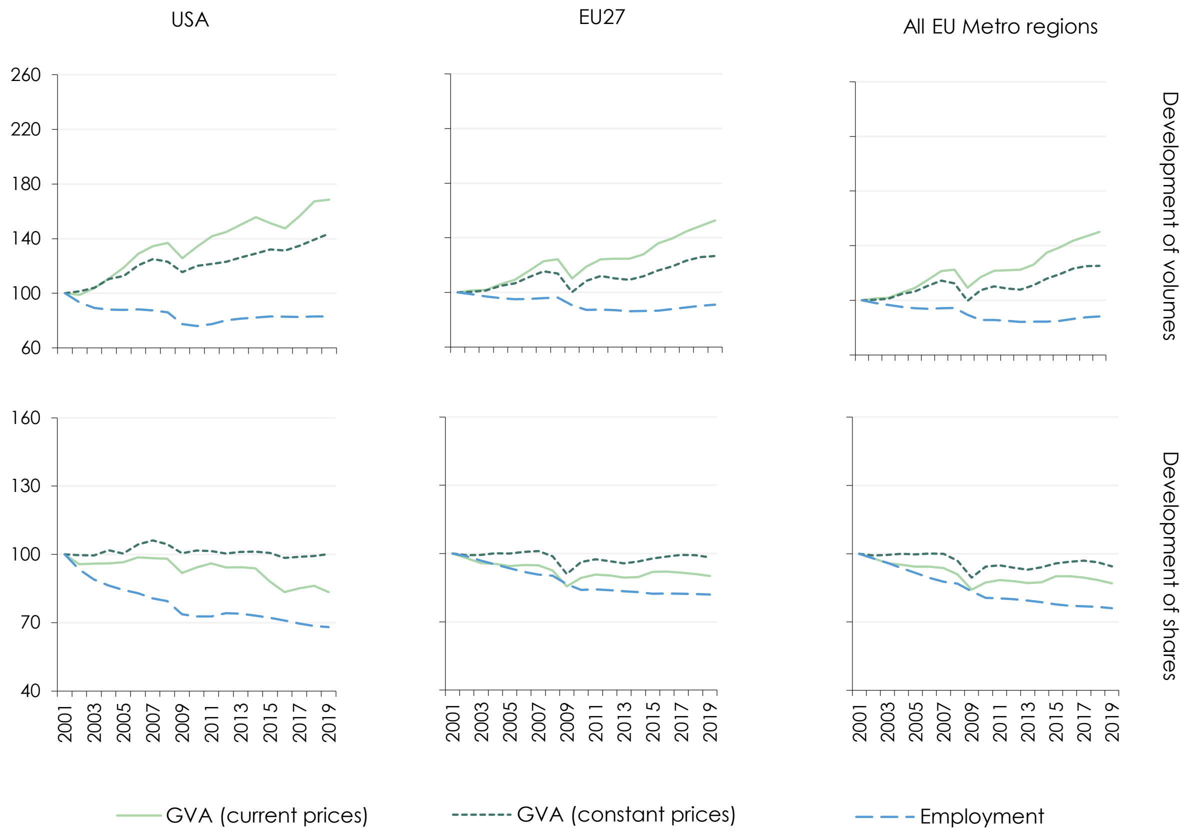
3.2.1 Data construction and stylized facts

To address these issues, we used sectoral data on manufacturing GDP, GVA, and employment from the EU Commission's ARDECO database for the European NUTS-3-regions, from the Bureau of Economic Analysis (BEA) for the U.S. counties, and from the Institut de la statistique du Québec (ISQ) for the metropolitan regions of Québec. We aggregated these data to the metropolitan level using the OECD's delineation of metropolitan regions (FUA) to construct comparable data with sectoral information at the (1-digit) NACE/NAICS level for the (50) EU27 1st-tier metro regions (including Vienna) and the U.S. metropolitan regions of Boston, Pittsburgh, San Francisco, and Seattle. For metropolitan Montreal, we could only calculate some required indicators due to a lack of data on output at constant prices. In addition, we could not compile sectoral data at the FUA level for Atlanta, as this metro region consists of many small counties for which sectoral information is often not available for data protection reasons[35]. Therefore, Atlanta is not included in the following comparisons.

Figure 3.1 provides an overview of the main trends of employment and GVA at constant and current prices in manufacturing (NACE sectors B-E) in the US, the EU27 and the EU metro regions Figure 3.1 since the turn of the millennium, with the year 2001 normalized to 100. These data are broadly consistent with the stylized facts found in much of the literature and in the case studies annexed to this report: For both the U.S. and the EU27 the share of employment in manufacturing decreased noticeably as did the GVA share at current prices over the whole period, despite rising GVA levels (both at constant and current prices). By contrast, gross value-added shares in current prices were much less affected by this downward trend or even stagnated. Employment in manufacturing decreased in terms of both volumes (upper panel) and shares (lower panel) since 2001, with greater job losses in the US. By contrast, gross value added (GVA) increased significantly in volume in nominal and real terms, with European manufacturing performing weaker than the US's. Manufacturing output gains were slightly higher in nominal than in real terms, while GVA shares declined in the former and largely stagnated in the latter. This pronounced deindustrialization in employment but not in output points to higher productivity gains in manufacturing and lower price increases for industrial goods than for services.

[35] Sectoral BEA data for the other U.S. metropolitan areas also had a few gaps for data protection reasons. These, however, applied only to small subsectors and individual years and were bridged by interpolation.

Figure 3.1: **Development of manufacturing in metropolitan regions in comparison (1)**
FUA level, different performance indicators, Index 2001 = 100

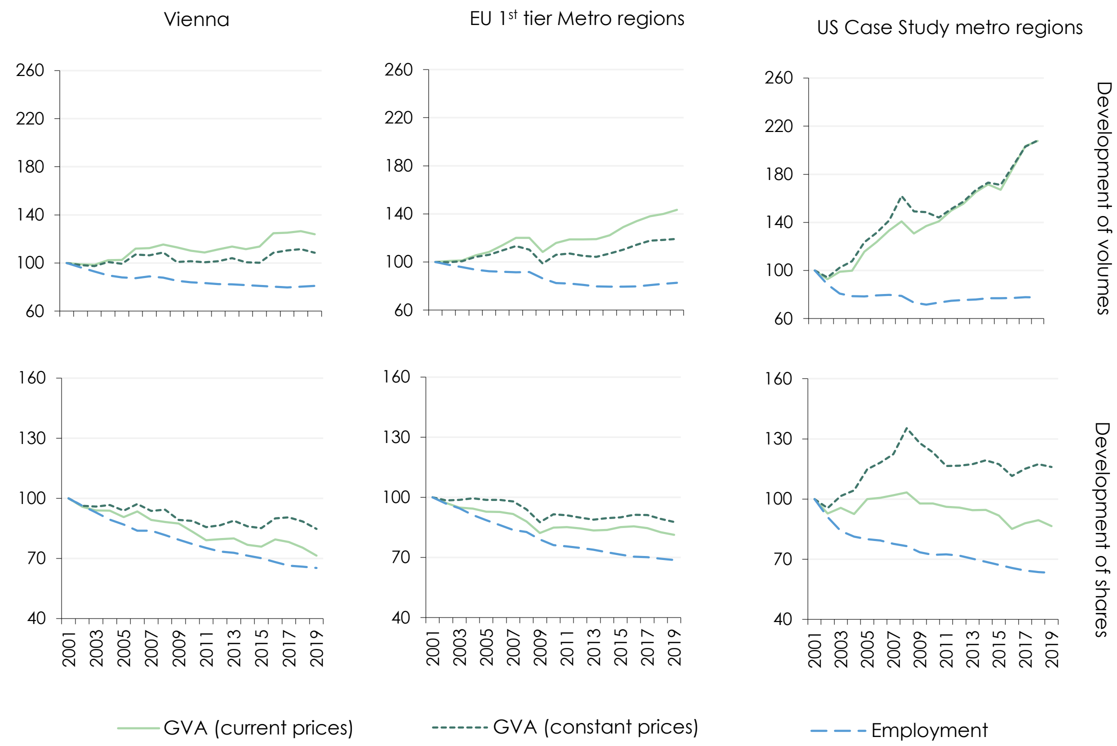


Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); ARDECO (JRS/EC); WIFO calculations.

These basic patterns of industrial development in the EU27 metropolitan regions (241) were similar to those of the European economy, as shown in Figure 3.1 (right panel). However, manufacturing developed somewhat weaker in the EU27 metro regions than in the EU27 total, regardless of the indicator used. This is even more the case for the 1st-tier metro regions (50) of the EU21, as Figure 3.2 (middle panel) illustrates. This is likely due to the locational disadvantages of some manufacturing industries (e.g., those sensitive to land and wage costs) in (large) urban areas, the resulting competition for land, and the greater exposure of metro regions to the drivers of deindustrialization discussed above.

However, the metro regions were able to adapt to these setbacks to different degrees, as evidenced by the heterogeneity of manufacturing developments in the period observed. This becomes clear from comparing manufacturing development in the EU 1st-tier metro regions and especially Vienna (left panel of Figure 3.2) with that of the U.S. case study metropolitan regions (right panel). Vienna's manufacturing trend followed a similar pattern to that of the EU 1st-tier metro regions, but still lagged slightly behind this group on all indicators. In contrast, according to the BEA data, manufacturing developments in the U.S. case study regions as a group were much more favorable, especially on the output side. Manufacturing employment also declined slightly in these regions over the period 2001–2019, similar to Europe (and Vienna), so that the share of employees in goods production continued to decline. However, manufacturing value-added in the U.S. case study regions grew on (weighted) average more than twice as fast as in the 1st-tier metro regions of the EU27. In addition, industrial prices remained remarkably stable in the U.S. case study metropolitan regions, resulting in an even greater lead in the dynamics of GVA in real terms. As Figure A. 1 in the Annex shows, this superior manufacturing output trend compared to metropolitan Europe (and even more so to Vienna) applies to all U.S. case study regions, but not to Montreal (as of 2007). However, significant differences are also evident within U.S. metropolitan regions, with San Francisco and Boston being the main drivers in terms of output dynamics[36].

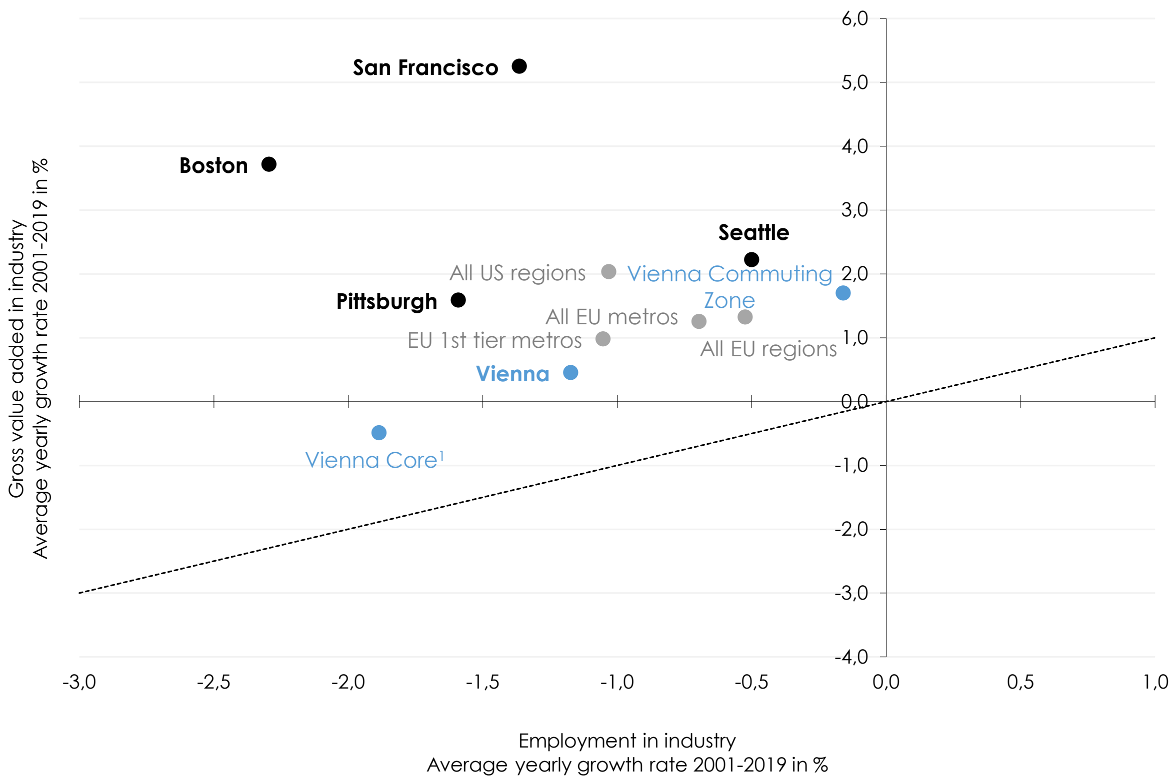
Figure 3.2: **Development of manufacturing in metropolitan regions in comparison (2)**
FUA level, different performance indicators, Index 2001 = 100



Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); ARDECO (JRS/EC); WIFO calculations.

[36] These two metropolitan regions are also the only ones in our sample where the development of manufacturing output in real terms was comparable to (San Francisco) or even exceeded that in current prices (Boston), indicating rising prices for the goods produced. It is not possible to analyze the reasons for this specific development here in detail. However, it is likely to be related to the considerable restructuring of the industrial fabric towards technology- and knowledge-intensive subsectors, especially in these urban regions.

Figure 3.3: **Employment and GVA growth in manufacturing in Vienna and the case study regions**
FUA level; GVA of constant prices; 2001-2019



Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); ARDECO (JRS/EC); WIFO calculations. – [1] Vienna Core: AT130.

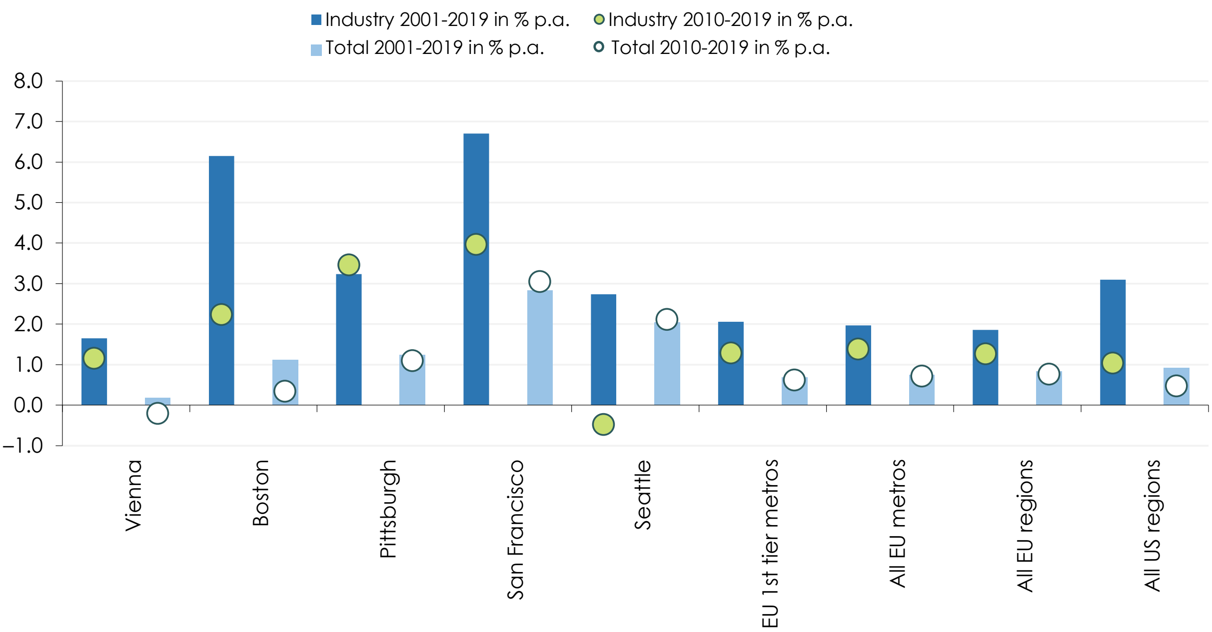
3.2.2 Manufacturing in Vienna: Weak momentum in productivity and output

Figure 3.3 shows the outstanding position of Boston and San Francisco in terms of (real) industrial output growth. It compares the annual growth rates of manufacturing output (on the horizontal axis) and employment (on the vertical axis) in the metropolitan regions. Manufacturing in these two metro regions grew about twice as fast as in all U.S. regions over the 2001–2019 period, with an annual real value-added growth of more than 5% (San Francisco) and about 4% (Boston), respectively. Pittsburgh and Seattle had similar growth rates to the U.S. average, although Seattle performed poorly in recent years. In contrast, European metro regions lagged these U.S. developments noticeably. This applies especially to Vienna, where real manufacturing output growth, at +0.5% per year, was only half as dynamic as the EU 1st-tier metro regions. As Figure 3.3 also shows, this was mainly due to a weak growth in Vienna's city core, where manufacturing value added shrunk by 0.5% per year in real terms between 2001 and 2019. Thus, the slight upward trend in (real) manufacturing output in metropolitan Vienna total was solely attributable to its commuting zone, where land prices are lower and competition for land generally weaker – an intra-metropolitan divergence in industrial performance, that was even more pronounced for employment (Core –1.9% p.a.; Commuting Zone –0.2% p.a.).

However, Vienna's (relative) manufacturing development (in line with the European trends) was much more favorable in terms of employment than in terms of output compared to the U.S. case study metropolitan regions. Vienna's manufacturing employment (–1.2% p.a.) reduced only slightly more than in the average 1st-tier metro region. However, it remained well ahead of San Francisco, Pittsburgh, and Boston, despite their disproportionately steeper industrial output paths.

Figure 3.4: **Productivity growth in Vienna and the case study metropolitan regions: Industry and economy total**

FUA level, GVA per employed person (constant prices), Average yearly growth rate



Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); Institut de la statistique du Québec; ARDECO (JRS/EC); WIFO calculations. – Montreal: no data on real GVA.

Vienna's labor market development improved as a result of this, but also implied considerable growth disadvantages for Vienna (and the European metro regions) due to lower productivity growth. The comparably favorable job development in Vienna has thus come at the expense of in efficiency and competitiveness losses in the period under review. Figure 3.4 shows that manufacturing achieved significantly higher productivity growth than the economy in all comparator regions during the period under review. It also shows the considerable lead in productivity growth that all U.S. regions had over the EU27 regions, but especially that the U.S. case study metro regions had over the EU metro regions. This advantage in efficiency gains has been declining over the past decade (except for Pittsburgh) in a now generally more productivity-extensive environment. Indeed, on average, U.S. regions are achieving lower efficiency gains in manufacturing than those in the EU27 in the later period. However, at the metropolitan level, higher productivity gains in the U.S. case study metropolitan regions remain prevalent also in 2010-2019, with Seattle being the only exception. This is even more true in comparison with manufacturing in Vienna, which lagged even the EU 1st-tier metro regions in productivity growth over the full period (+1.6% p.a. vs. +2.1% p.a.) and has only recently been able to catch up with the now weaker efficiency trend in these regions (2010–2019 +1.2% p.a. vs. +1.3% p.a.).

3.3 A decomposition of manufacturing employment losses: Genuine deindustrialization or productivity effect?

In summary, a downward trend in manufacturing was only common in employment and was accompanied by diverse, but positive productivity developments in all metro regions covered in our analysis. This raises the question whether the decline in manufacturing employment was actually due to a loss of importance of the sector (and hence genuine deindustrialization) or resulted from productivity gains and thus an "upgrading" of manufacturing in terms of competitiveness in the metropolitan regions under review. To answer this question and to quantify the various impacts on manufacturing employment in the respective regions, Figure 3.5 presents the results of a decomposition analysis of manufacturing employment change. It distinguishes four effects[37]:

1. a **labor productivity effect**, which measures the change in manufacturing employment that is due to changes in manufacturing productivity growth (and thus "manufacturing upgrading") in percentage points;
2. a **genuine deindustrialization effect**, which measures the change in manufacturing employment (in percentage points) associated with changes in the output (GVA) share and thus a strong or weak performance of the manufacturing sector in the metro region considered;
3. a **metro share effect**, which controls for the contribution of shifts in the metro region's share in national value added to the change in manufacturing employment in percentage points, indicating the impacts of a growth (dis-)advantage of the metro economy compared to the respective country;
4. an **economic growth effect**, which results from the value-added growth of the national economy in which the metro region under review is embedded, measured in percentage points.

The results of this decomposition (shown in Table 3.1) reveal some important regularities, but also regional differences in the determinants of manufacturing employment change in the period from 2001 to 2019.

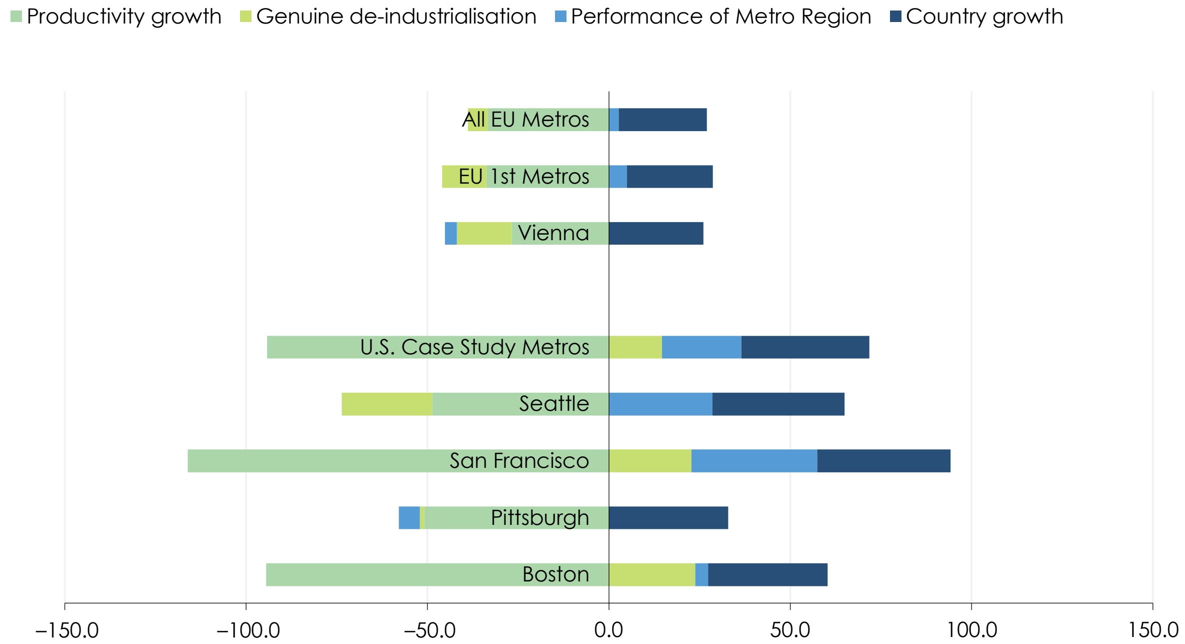
The most important finding is that (labor-saving) efficiency gains were the main cause of manufacturing employment losses in all regions: The contribution of the "productivity growth effect"

[37] See the Annex for a more detailed presentation of the methodology of the decomposition approach used.

to employment change in manufacturing (green) is negative and large in all metropolitan regions, particularly in the U.S. case study metro regions, where it is by far the largest effect. This indicates that an upgrading of metropolitan regions' manufacturing sector in terms of productivity played a decisive role in the development of their manufacturing jobs. This labor-saving effect was partly offset by the "country growth effect" (dark blue), which contributed positively to employment growth in manufacturing in all regions in our sample[38].

Figure 3.5: **Components of employment change in Vienna and the case study metropolitan regions**

4-way-decomposition; 2001-2019; cumulative change in %, contributions of the different components in percentage points



Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); Institut de la statistique du Québec; ARDECO (JRS/EC); WIFO calculations.

[38] This is not surprising as the economies of the U.S., Canada, the EU27 and Austria have all grown on average over the observation period. The magnitude of this effect is, however, quite considerable in all cases, which highlights the importance of the national economic environment for urban manufacturing development.

Table 3.1: **Components of employment change in Vienna and the case study metropolitan regions**

4-way-decomposition; 2001-2019; cumulative change in %, contributions of the different components in percentage points

	Employment Change (%)	Contribution to Employment Change of… (percentage points)			
		Productivity growth	Genuine deindustrialization	Performance of Metro Region	Country growth
		Time period 2001-2019			
Boston	–34.2	–94.5	23.8	3.5	33.0
Pittsburgh	–25.1	–50.9	–1.2	–5.8	32.9
San Francisco	–21.9	–116.1	22.8	34.7	36.7
Seattle	–8.6	–48.7	–25.0	28.5	36.5
Vienna	–19.1	–26.8	–15.1	–3.3	26.0
U.S. Case Study Metros	–22.4	–94.2	14.6	21.9	35.3
EU 1st Metros	–17.3	–33.8	–12.2	4.9	23.7
All EU Metros	–11.8	–33.3	–5.5	2.7	24.3

Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); Institut de la statistique du Québec; ARDECO (JRS/EC); WIFO calculations.

In contrast, neither the "genuine deindustrialization effect" (ochre), which reflects a general loss of importance of the manufacturing sector in terms of output, nor the "metro share effect", which reflects the performance of the metro economy total (light blue), follow a common trend. In San Francisco and Boston and based on that the average of the U.S. case study metropolitan regions, a favorable development of manufacturing output contributes to employment, while in all other metro regions manufacturing employment losses also result from a "genuine" deindustrialization in the medium term. Similarly, a dynamic metro region's economy clearly supports manufacturing employment change in most metropolitan regions (especially in Seattle and San Francisco), while it curbs it in Pittsburgh and Vienna.

The effects determining manufacturing employment change in the metro regions covered are quite heterogeneous, with the EU metropolitan regions and Vienna lagging the U.S. case study regions. Indeed, losses of manufacturing employment in the latter were on a (weighted) average solely due to high productivity gains and thus an industrial "upgrading" in 2001–2019 (–94.2 PP), while the development of the sector's output share tended to support manufacturing employment (+14.6 PP), as did a higher contribution from national growth and (especially) of the U.S. metros' performance compared to the European 1st-tier metro regions. At the level of individual metropolitan regions, this specific industrial development pattern of U.S. case study metropolitan regions was driven primarily by San Francisco and Boston, both combining an outstanding manufacturing productivity trend with rising output shares of the sector. This should not come as a surprise, given the strong technology orientation of the production sector in these cities described in the case studies.

By comparison, industrial productivity growth in Pittsburgh and Seattle was significantly lower (although higher than in the European metropolitan regions) and, at least in the latter, was associated with relevant deindustrialization phenomena. However, these were offset by a favorable development of the total economy in the case of Seattle, while in Pittsburgh, a weak metropolitan development reinforced them.

Vienna fits into this picture, with rather moderate industrial employment losses in the period 2001–2019 (–19.1%). Productivity gains were only responsible for this to a comparatively minor extent (–26.8 PP), while the contributions of a weak metro economy total (–3.3 PP) and not least of a shrinking industrial output share (–15.1 PP) were comparatively significant. Thus, efficiency improvements have also been the most important factor influencing manufacturing employment losses in Vienna. However, in contrast to the North American case study metropolitan regions, these were also accompanied by output losses (i.e., genuine de-industrialization) and a poor growth performance of the metropolitan economy also contributed substantially to the decline in manufacturing employment.

This implies that while the North American metropolitan regions have shown satisfactory growth in total gross value-added (and therefore productivity) in their economies, for Vienna, deindustrialization has also been associated with substantially slower growth in total gross value-added in manufacturing, embedded in an also slowly growing economy over the period 2001 to 2010. From a policy perspective, this suggests that the main challenge in Vienna in comparison to the case study metropolitan regions has been to increase productivity in both manufacturing and other activities. This may also point to a weakness of the metro, relative to the case study metropolitan regions, to develop high value-added new activities and to generate value-added growth in existing activities both in manufacturing and in other sectors outside of manufacturing.

3.3.1 "Re-industrialization" in the last decade?

Finally, the question remains whether our empirical evidence on manufacturing development in Vienna and the case study regions supports hopes for an end to the midterm de-industrialization trend or even a "re-industrialization" of their economic base. The time path of manufacturing employment, already shown in Figures 3.1, 3.2 and A.1 above, suggests a cautiously optimistic view here at first glance. At the country level, manufacturing employment was still declining for much of the 2000s in terms of volumes and (even more so) shares, but consolidated in the 2010s, with employment now rising again moderately and its share largely stabilizing. The EU 1st -tier metro regions, the case study regions and Vienna in principle showed a similar consolidation, albeit at a slower pace. And indeed, some arguments have been made as to why this could be a longer-term trend. In particular, it has been argued that:

1. large factories that could do so have already moved away from core cities to the urban commuting zone, the national periphery or abroad in the decade-long process of deindustrialization. Most industries factories that have remained are presumably more productive

and therefore less sensitive to labor costs[39], and they are the ones benefitting from the specifics of an urban environment (Ferm & Jones, 2017).

2. changing consumer preferences and disruptive effects of modern ICT and digital technologies are likely to have strong effects on the location (also) of manufacturing economic activities. This may give rise to new, specifically "urban" manufacturing activities, whereby new urban crafts-oriented production as well as a digitally enhanced "smart" production may be essential parts of this trend[40]. We will come back to this argument in chapter 4.
3. despite past deindustrialization, metropolitan regions are still important for manufacturing as more than half of the workforce in European manufacturing generating almost two-thirds of the EU's total industry output is still employed in metro regions (Mariotti et al., 2021). This, according to some authors (Berger, 2015), suggests there should still be a sufficiently large critical mass in manufacturing, at least in the European metro regions, to allow for a turn-around in industrial evolutions in the face of the changing technological preconditions.

To analyze this possible trend of a consolidation of manufacturing development also in metropolitan regions in more detail, we repeated the above decomposition analysis for the sub-period 2010 to 2019. Table 3.2 shows the results of this exercise and compares them with those already shown for the full observation period[41].

As can be seen from the first column of the table, in contrast to the whole period, manufacturing employment increased in Pittsburgh, San Francisco and Seattle, and declined at a much more modest pace in Vienna and Boston from 2010 to 2019. This does indeed suggest that the deindustrialization trend in manufacturing has at least gradually come to an end in the last decade[42].

The recent improvement in manufacturing employment dynamics in urban areas does not necessarily imply a general revival of urban production. This is evident from the comparison of the contribution of the different factors underlying the deindustrialization process in both periods: As shown in columns 2 to 5 of the table, the main reason for the better manufacturing

[39] According to empirical evidence, urban manufacturing firms tend to be smaller (Helper et al., 2012), more knowledge-intensive (Van Winden, 2011), and in early stages of production. In addition, they are more likely to work in networks (Berger, 2013) and, due to the functional specialization of cities (Duranton & Puga, 2005), are more of a "hybrid", "servo-industrial" type. Nonetheless exceptions for exist- One exception for instance is the automotive industry where the production of electric car parts and Lithium batteries are all highly land extensive and are unlikely to have a locational advantage in cities

[40] For examples of both types of new industrial activities see, e.g., Läpple (2018), Butzin & Meyer (2020) or Fedeli et al. (2021a).

[41] Thereby the table shows annualized growth rates to present comparable results for these periods of different lengths.

[42] Nevertheless, it remains to be emphasized that while manufacturing employment paths have improved noticeably in all our comparator regions over the latest decade, this does not apply with the same uniformity on the output side. While the improvement in industrial employment growth in all EU regional types (including Vienna) was also associated with an improvement in (here previously weak) output growth in manufacturing, this was not consistently the case in the U.S. regions. Rather, the marked improvement in the industrial employment trend in the U.S. case study regions in the 2010s was accompanied by a comparable upward trend in output growth only in Pittsburgh, while Boston, Seattle and thus the case study regions on average) experienced declines in industrial output dynamics during this period, indicating a slowdown in productivity growth.

employment trend in all regions in 2010-2019 compared to the full period was the lower productivity growth in all regions. This decline in the effects of labor-saving streamlining was particularly large in the U.S. case study metro regions (except for Pittsburgh), but it also explains most of the more favorable employment trends in all European regional groups (including Vienna). By contrast, a phasing out of the "genuine deindustrialization effect" had only a minor role in the better employment trend in manufacturing in the European metro regions and Vienna since 2010, but not in the U.S. case study regions, where the contribution of the output-side development of the sector, again except for Pittsburgh, became negative in the last decade.

Table 3.2: **4-way-decomposition; change in % p.a., contribution of the different components in percentage points p.a.**

	Employment Change (%)	Contribution to Employment Change of… (in percentage points per year)			
		Productivity growth	Genuine de-industrialization	Performance of Metro Region	Country growth
		Time period 2001-2019 p.a.			
Boston	–2.3	–6.3	1.6	0.2	2.2
Pittsburgh	–1.6	–3.2	–0.1	–0.4	2.1
San Francisco	–1.4	–7.2	1.4	2.2	2.3
Seattle	–0.5	–2.8	–1.4	1.7	2.1
Vienna	–1.2	–1.6	–0.9	–0.2	1.6
U.S. Case Study Metros	–1.4	–5.9	0.9	1.4	2.2
EU 1st Metros	–1.1	–2.1	–0.7	0.3	1.4
All EU Metros	–0.7	–2.0	–0.3	0.2	1.4
		Time period 2010-2019 p.a.			
Boston	–0.4	–2.2	–0.6	0.2	2.2
Pittsburgh	0.7	–3.5	2.1	–0.1	2.2
San Francisco	1.5	–4.0	–0.4	3.7	2.2
Seattle	1.1	0.5	–4.1	2.5	2.2
Vienna	–0.4	–1.1	–0.5	–0.3	1.5
U.S. Case Study Metros	0.9	–2.9	–0.7	2.3	2.2
EU 1st Metros	0.0	–1.3	–0.5	0.3	1.5
All EU Metros	0.3	–1.4	0.0	0.2	1.5

Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); Institut de la statistique du Québec; ARDECO (JRS/EC); WIFO calculations.

Finally, it is worth noting that the performance of the metro region total retained its positive impact on manufacturing employment change in almost all comparison regions and further increased in most US case study regions. However, this was not true for Vienna, where the effect of the regional performance was negative and has decreased further recently. This (at least compared to the leading metropolitan regions in this study) points to continuing challenges with generating growth in activities outside manufacturing and developing new export-based activities in both production and services in Vienna.

4. Which (export-based) activities are growing in metropolitan regions?

Manufacturing is a diverse sector that encompasses a wide range of activities in terms of products, the geographic extent of markets, the size of enterprises, and the technologies used. For example, it includes both large multinational enterprises (e.g., in the engineering or electronics sectors) with thousands of workers and local producers (such as local bakeries or repair shops) with single-person operations. It also covers activities at very different stages of the production process, from high-tech research facilities that output prototypes and patents, to headquarters that specialize on management activities with little or no production, to traditional production enterprises. Despite the general trend towards deindustrialization, metropolitan regions may therefore still have locational advantages in certain segments of manufacturing, either in specific sectors or functions.

Furthermore, although manufacturing is the sector with the largest share of exports, it is by no means the only sector that contributes to the export base of a region. Services also produce tradable outputs such as computer programs, patents etc., even if they are not physical products. Services can also produce tradable outputs, such as computer programs, patents, etc., even if they are not physical products. This is especially true for services related to information and communication, financial and insurance activities (i.e., NACE divisions J and K), as well as engineering and consulting services (see OECD, 2017). Therefore, this chapter examines new opportunities for export-oriented production in urban contexts from a more disaggregated sectoral perspective.

4.1 Theoretical predictions

Two main developments have been identified as potential sources of new opportunities for metropolitan regions in previous literature: The first is the convergence of technological trajectories for the manufacturing and services sector, which leads to the blurring of boundaries between them. Emerging "hybrid" production and business models that integrate industrial and service components are becoming more prevalent in metropolitan regions. Their output is not pure goods, but solutions that combine hardware and software elements. The second is the reduction of transport costs for information due to modern ICT and digital technologies, and in some cases, the increased mobility of certain consumers of services (e.g., students or patients) which expands the market radius for (especially knowledge-intensive) services. This essentially makes services that were previously considered non-tradables, tradable, a fact that may strengthen the export base of metropolitan regions despite deindustrialization.

Modern ICT and digital technologies may also have a disruptive impact on the location of export-based economic activities in manufacturing. This may give rise to new, specifically "urban" manufacturing activities, which can be roughly classified into two types[43]:

- **New urban crafts-oriented production**: This type of "new urban manufacturing" involves customized, small-scale production of hand-crafted consumer products. They appeal to a (mostly affluent) urban population that values high-quality, sustainable, regionally

[43] See, Läpple (2018), Butzin & Meyer (2020) or Fedeli et al. (2021a) for examples of both types of new industrial activities.

produced and (partly) design-oriented products. Cities offer locational advantages for these activities, such as better market access, cultural access, and brand origin. In addition, recent studies reveal advantages of a closer integration and a temporary proximity to final consumers, e.g., through their temporary involvement to enable more individualized products. The "urban maker movement" (Hill et al., 2020) is also related to this type of production. It is based on professionally accompanied and organized "do-it-yourself" in "maker spaces" or "FabLabs", enabled by new industrial tools (e.g., 3D printer, laser cutter). These approaches enable low-emission processing and the manufacture of small batches, which in turn allow small-scale and urban-friendly production at small, decentralized production sites. They also provide relevant job opportunities in the producing sector, which is important given Vienna's weak industrial employment trend shown above. They are also hardly susceptible to out-migration[44], and of little concern from an environmental standpoint. However, this type of urban manufacturing is probably of only minor importance as a driver of the export base, as its products are mainly aimed at (parts of) the regional population. Nonetheless, the case studies suggest that even such locally oriented production may become tradable in certain contexts (see below for details).

- **"Smart" production**: In contrast, recent developments in ICT and the rise of digital technologies may have great potential for cities' export bases, as they may change the spatial advantages of "digitally enhanced" production. In a (very) stylized macro perspective, Baldwin & Evenett (2015), for example, expect that ICT and robotics in combination with big data and artificial intelligence will further facilitate the "unbundling" of parts of the production process. This may foster a "reshoring" and a return of production to large cities. According to these authors, the technologies mentioned will advance an automated and robotized industrial production but will also allow a spatial separation of labor and labor services. This enables (also foreign based) online service work ("telemigration"; Baldwin & Forslid, 2020). Together, this may reduce the impact of wage differentials between regions, as production becomes increasingly jobless and, for instance, a robot in Austria may well be controlled or maintained by a teleworker in India. This vanishing importance of wage differentials may lead to a relocation of (parts of) manufacturing to consumer locations (i.e., metropolitan regions) in high-wage countries. This is especially true as digital technologies allow small batch production and a stronger "customization" of products, which requires more interaction between producers and customers. In sum, a declining significance of labor costs in (automated) production may increase the importance of proximity to demand as a locational factor, and this may facilitate the (re-)location of production to metropolitan regions[45], although it will not result in much employment growth.

As far as the latter perspective is concerned, a broad set of disruptive enabling technologies is indeed currently taking shape which, integrated into extant production, may contribute to a renewal of localized industries (Bailey & DePropris, 2019; Corradini et al., 2021) towards a

[44] Value creation in a strong interaction with clients evolves in a problem-based "circular" loop process. Therefore, this kind of production cannot exploit scale economies through a geographical division of labor (Bathelt & Glückler, 2018).

[45] One drawback of these productions is that they are highly productive and would therefore hardly be a source for future employment growth.

"digitally enhanced manufacturing" (Busch et al., 2021). The extent to which these "Manufacturing 4.0 technologies" (I4Ts) will trigger a "Fourth Industrial Revolution", as some authors (e.g., Kagermann et al., 2013; Schwab, 2017) claim, must be left open here, especially since their definition varies in the literature[46]. However, the rise of these I4Ts is likely to spur a series of significant changes that suggest the emergence of a "new technological paradigm" (OECD, 2017).

Unlike previous technological waves that increased the automation of repetitive physical work, I4Ts are about the large-scale automation of entire groups of tasks, including repetitive intellectual or non-routine tasks. This is likely to impact on employment through rising production efficiency from the redesign of manufacturing processes within and across firms and the resulting change in the capital-labor ratio (Corradini et al., 2021). On the other hand, new I4Ts may give rise to new business models, sectors, markets, and consumption spaces through various applications (De Propris & Bailey, 2021). At the same time, new I4Ts and their impact on efficiency could foster the decarbonization of the economy, enabling a better coexistence between manufacturing and urban living (Acatech, 2015). At the same time, I4Ts are likely to reconfigure and geographically recompose industrial value chains, with some opportunities also for urban areas. Besides the aforementioned shift in importance from labor cost differentials to market access in a more automated production, a decisive factor here is likely to be the fact that I4Ts allow smaller lot sizes and production sites. In addition, they are likely to drive "territorial servitization" (DePropris & Storey, 2019)[47] and a greater strategic colocation of innovation and production activities (Bailey et al., 2018), leading to even more blurred boundaries between manufacturing and services.

4.2 Reasons for manufacturing companies to locate in urban cores: The case study evidence

The interviews with business actors conducted in the framework of our case studies reflect these theoretical considerations, but also provide some additional evidence on why enterprises, despite high prices and a general shortage of land, are still located in metropolitan areas. Even though this evidence, due to the limited number of interviews conducted, is only anecdotal, we can briefly summarize the following arguments for locating export-based production in the core metropolitan regions:

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[46] C-physical systems, the Internet of Things, internet services and smart factories (DePropris, 2016) are at the core of these technologies. However, recent contributions (e.g., Strange & Zucchella, 2017; Balland & Boschma, 2021) also mention further innovations. These include additive manufacturing, augmented reality, autonomous robots and/or vehicles, cloud computing, cybersecurity, systems integration, quantum computers and, finally, big data analytics, and artificial intelligence.

[47] The term refers to a symbiotic recoupling between manufacturing and services, that I4Ts may foster. Indeed, many new business models enabled by I4Ts require production activities to integrate manufacturing functions with advanced digitally enabled services to allow co-innovation solutions between firms and customers (Bellandi et al., 2019). In addition, they allow consumers to overcome the need to own products by allowing them to hire or lease them. In consequence, the relationship between producer and customer no longer ends with the sale but is extended by a use-oriented service. Thus, manufacturing firms need to access competences that would naturally reside outside of their production process (e.g., co-design, IT integration, leasing, payment solutions, maintenance, upgrading), that knowledge-intensive service firms provide. These services are typically more prevalent in metropolitan regions (Delgado-Márquez & García-Velasco, 2013; Mayerhofer & Firgo, 2016).

1. **Co-location with innovators:** This reason applies to cases where production needs to be located close to R&D facilities because the development of new production requires personal and informal interaction between researchers and producers. This is more likely in high-tech and research-intensive industries (such as biotechnology in Boston and electronics design in San Francisco), where this is also documented in our case studies. They also take different forms: In the Boston biotech case, R&D and production are done by different firms: R&D in startups and production in larger firms, and the need for interaction arises from the process of turning research results into marketable products. In the San Francisco electronics design and manufacturing case, by contrast, the cooperation is between a small firm producing components for larger manufacturers and the coordination need arises from tailoring the components to the client's need. Similar effects have also been documented for the division of labor within large manufacturing multinationals in the literature. One example is the automobile industry. In this case, producers retain small production units near their headquarters because prototype development requires the interaction between product designers, engineers, and researchers within the same company (see e.g., Fedeli et al. 2021a, on Stuttgart).
2. **Access to highly skilled and specialized labor:** In this case, the locational advantage is in the highly educated workforce that is available in metropolitan regions. In particular, local universities often provide a resource pool for highly specialized and skilled labor. While this reason has been directly documented only in one case study (on the biotech industry in Boston) and slightly less directly for Seattle, where the large multinationals in the region have played a very active role in developing the local universities, the literature has many more examples of these mechanisms and examples can be found in almost all metropolitan regions. For example, one case in point in Vienna is Boehringer-Ingelheim, who frequently mentions its close cooperation with the University of Natural Resources and Live Sciences in Vienna as a main reason for locating in Vienna.
3. **Proximity to product and input markets.** This argument – according to the case studies – can take various forms and is documented in all the case study metropolitan areas. One form occurs in the production of highly customized (luxury) consumer goods (e.g., jewelry). In this case, the production process requires customization that is based on the personal interaction between consumer and producer. Another form found in the food industry is when products are of limited storability, or when freshness or a regional origin are important quality aspects. Finally, a third form occurs when there is a high demand for a specific input that justifies the high costs incurred in the metropolitan region. A particularly interesting case in this respect found in the Boston case study is the production of molecular genes. Here, the need to have access to a sufficient supply of living T-cells creates an incentive to locate near a large pool of potential donors.

Interestingly, the Boston case study also documents that while many of these activities are based on local demand and thus have a minor impact on the export base of the metro at first sight, they can sometimes result in exportable products. This is obviously the case when proximity to the input market is the main driver of the location decision. It also applies to cases where proximity to output markets is important, if the innovations made in such productions can be codified and marketed[48] or if the local demand for a product allows economies of scale that support the international competitiveness of a production.

4. **Supply security and risk minimization:** This has arguably become more important due to the COVID-19 pandemic and the subsequent disruptions in supply chains, illustrating the costs and risks to offshoring. In consequence, in several cases (documented in the Atlanta case study) either production chains have been reorganized such that more of the production chain is closer to the consumer (and thus in metropolitan regions) or such that the entire production chain is relocated closer to the customer.

   As documented in the Atlanta, Boston, and Seattle case studies, however, similar risk-related arguments apply to markets with rapid demand fluctuations. In these cases, producers choose to locate close to the market to have sufficient flexibility to react on demand fluctuations and to minimize the risk of being unable to satisfy this demand due to long transport routes. This mechanism may also increase demand for warehouse capacities in or near large cities, as increasing stocks is another strategy to cope with the risks associated with just-in-time delivery systems and long, uncertain supply chains.
5. **Regulation and access to state funding and support:** While access to state funding and support is rarely cited as a primary reason for locating in a metropolitan region, regulatory reasons have been mentioned occasionally in the case studies. These are often related to requirements for domestic or local sourcing of certain products and have traditionally played a large role in markets that provide services and products for the government sector (with the military being the prime example).
6. **Legacy manufacturing:** This means that certain enterprises are located in metropolitan regions for historic reasons and have little reason to move unless they grow. Therefore, they "hang on" to their location. The single instance where this has been documented is several apparel producers near Seattle. Even in this case, however, it was observed that these producers also have a high tendency to move elsewhere in case they grow and cannot find suitable locations within the metro. This suggests that such production is not particularly conducive to growth.
7. **Preferences and convictions of individual entrepreneurs:** This, judging from the evidence in the case studies, is a rare phenomenon as it was documented in only one instance. In this case, a business representative argued that reducing a firm's carbon footprint could also be an argument for local production.

In sum, the case studies of Atlanta, Boston, Seattle, and San Francisco conclude that the most viable form of manufacturing in high-cost urban areas tends to be low-volume, small-scale, and with modest employment benefits. In addition, it is argued that medium-volume facilities producing a high mix of varieties and manufacturing related to innovation and the production of non-tradables (especially specialty foods) could be further sources of manufacturing in the cores of metro regions. The central point raised by these case studies, however, is that since

[48] The intuitively most appealing day-to-day example would be recipes in the food industry, but patents, blueprints and trademarks are other very relevant examples for such processes.

urban environments typically offer locational advantages for small-scale production, and since successful small producers are likely to leave the metro as they grow, successful urban development depends on the continued development of new activities and thus on a process of continuous structural change.

From a policy perspective, this highlights that for export-based production to be sustainable eventually, a continuous flow of new products, entrepreneurs, and businesses is needed because once successful and standardized, also the current new producers are likely to move from the metro. Consequently, long-term success in urban development is ultimately associated with the ability to re-invent a location by developing a "pipeline" of new ideas and subsequent activities.

4.3 Initiatives to support (export-based) production in the case study metropolitan regions

The case studies also illustrate various policy initiatives and projects that are undertaken in the case study metropolitan region, in addition to these general motivations for locating in urban cores. These can be briefly categorized into three types: (a) initiatives that aim to support startups and innovations, (b) initiatives that aim to motivate existing producers to remain in urban agglomerations and to attract investments from existing companies, and (c) spatial planning initiatives that focus on the (re-)vitalization of certain parts of the metropolitan regions using mixed use concepts[49].

The first type of initiatives targets different segments of the startup market: For instance, LabCentral is a non-profit shared lab with multiple locations in and around Cambridge. It serves early-stage high-tech companies that spin out from university research, with different spaces offering slightly different features. As a result, it can accommodate companies that have moved beyond initial startup but are not yet ready for commercialization, as well as companies in the pre-clinical trial stage of development.

Commonwealth Kitchen (also located in the Boston metro), by contrast, is a shared small-batch food producer, co-packing facility and small business incubator located in an old meat processing plant in Dorchester's low-income, historically Black neighborhood.

The second type of initiatives includes SFMade in San Francisco, like SeattleMade, which is a collaboration of 12 companies and a part of the nationally organized Urban Manufacturing Alliance. It aims to help manufacturers in the city of San Francisco to start, stay, and grow in the city. It also aims to contribute to the inclusion of traditionally excluded groups, and the idea is that manufacturers are stable, pay decent wages, and have opportunities for advancement. In contrast, Georgia Power in Atlanta, as the state power provider for Georgia, has been a

[49] More extensive descriptions as well as some of the opinions and challenges reported by these examples are provided in the case studies. Due the limited number of interviews that could be conducted within the case studies they cannot claim representativity. Nonetheless we believe that they provide telling examples of the highly differentiated ways in which producers are supported in the case study metropolitan regions.

major actor in attracting investment from other regions by assisting prospective investors in evaluating Georgia as a location and assisting in searching for adequate production sites.

The third type of initiatives involves Pier 70, which is a mixed-use development that includes restaurants, housing, and spaces intended for designers, makers, small manufacturers, and laboratories. The Eastern Neighborhoods Plan, by contrast, is the main policy initiative to support urban manufacturing in the city of San Francisco. It is a much larger and highly interesting initiative that has the goal to protect industrial uses, not only in manufacturing but also in distribution and repair services, in a zoning designation called "production, distribution, and repair" (PDR).In summary, these initiatives reflect the principle strategies to support production that are also pursued in urban policies in European cities (see, e.g., Fedeli et al. 2021b, for a long list of "inspirational cases" in the European context). However, they also provide a flavor of the highly differentiated approaches and the institutional variety in which such support has been provided in different cities.

4.4 What new activities are growing in metropolitan regions?

To examine the new activities that are developing in the case study metropolitan regions and to what degree they are general or place-specific, we collected data on the employment in NAICS (North American Industry Classification System) 3-digit industries in the U.S. case study metropolitan regions (with Montreal excluded due to data constraints)[50] for the period 2012 to 2019. The analysis of this employment data will provide a broad-based perspective on which industries are particularly localized in these metropolitan regions and which industries are growing faster. However, this analysis may miss out on newly developing and especially highly productive activities, as they tend to have low employment volumes due to both their novelty and high productivity. Therefore, we supplement this analysis with an analysis of venture capital financed startups below.

4.4.1 Evidence from sector specialization

We collected employment data at the U.S. County level using the U.S. Bureau of Labor Statistics' Quarterly Census of Employment and Wages (we used annual averages) and aggregated these county data to the level of OECD's Functional Urban Areas[51]. We excluded the agricultural sector (NAICS 2-digit "Agriculture, Forestry, Fishing and Hunting") from our analysis and focused only on those NAICS 3-digit industries that had more than 1,000 employees in both 2012 and 2019.

Figure 4.1 provides a first glance at this data by plotting the employment shares of NAICS 3-digit industries in the respective metropolitan region in 2019 on the vertical axes and the share of US wide employment in the same NAICS 3-digit industry on the horizontal line. As a result, all industries located above the 45-degree line (also shown in the Figure) have a higher

[50] For Vienna an even more granular analysis is provided in chapter 5.

[51] The case studies use the same data to show the localization and employment growth at the NAICS 3-digit level in on a finer scaled regional breakdown at the county level. In addition, the Annex lists the ten most localized NAICS 3-digit industries (see Table A. **1**).

employment share in the metropolitan region than in the US as a whole and are therefore localized in the considered metropolitan region. We have also color-coded the industries according to their higher-level 2-digit category.

This figure reveals that, not surprisingly, the case study metropolitan regions have an above-average employment share in service industries that are related to typical urban functions such as health care[52], education (in Boston), hospitality services[53], and trade[54], which are typically classified as non-tradable.

By contrast, manufacturing sectors are localized only in a few metropolitan regions, and this localization is usually due to region-specific factors. For example, the localization of transportation equipment manufacturing in Seattle is due to Boeing's presence in the region, while the localization of computer and electronic equipment manufacturing in San Francisco is due to the many computer component producers in the Silicon Valley area. Furthermore, in Seattle this also applies to the localization of non-store retailers (i.e., electronic shopping and mail-order houses, vending machine operators, direct selling companies), reflecting the presence of Amazon in the region.

One common denominator between the case study metropolitan areas is, however, the localization of knowledge-intensive business services as a typical tradable sector. Particularly, this applies to professional, scientific, and technical services, which are disproportionately localized in all the US case study metropolitan regions. This sector includes a wide range of services such as scientists, accountants, advertising and marketing specialists, lawyers, managers and other consultants, architects, engineers, computer system designers, all of whom are usually considered knowledge intensive.

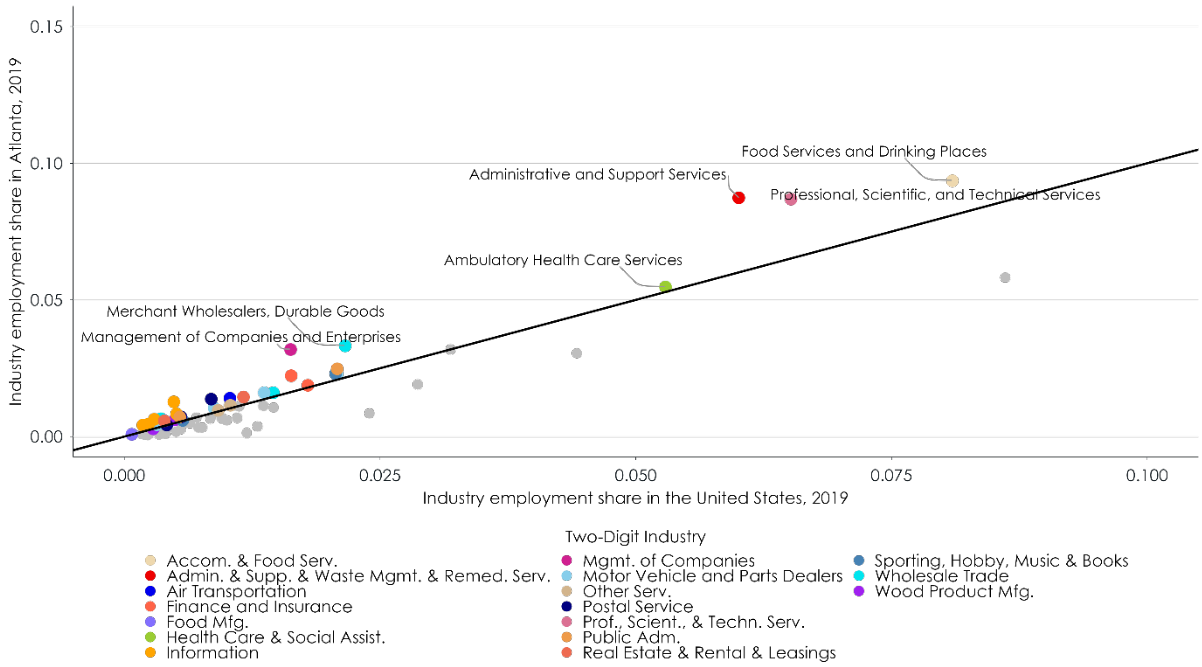
[52] This includes, for example, ambulatory health care services in Atlanta and Pittsburgh, and hospitals in Boston, and Pittsburgh.

[53] E.g., food services and drinking places (Atlanta, San Francisco).

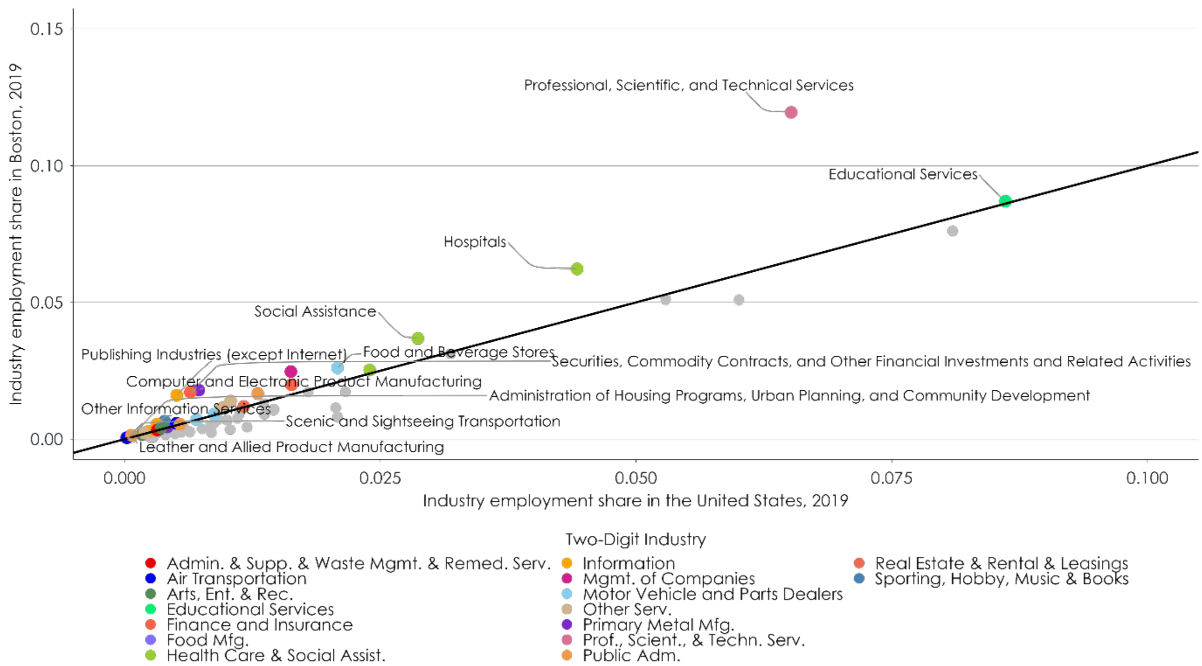
[54] E.g., specialty trade contractors in Seattle and San Francisco, merchant wholesalers in Atlanta.

Figure 4.1: **Localization of NAICS 3-digit industry employment in the US case study metropolitan regions**

Atlanta

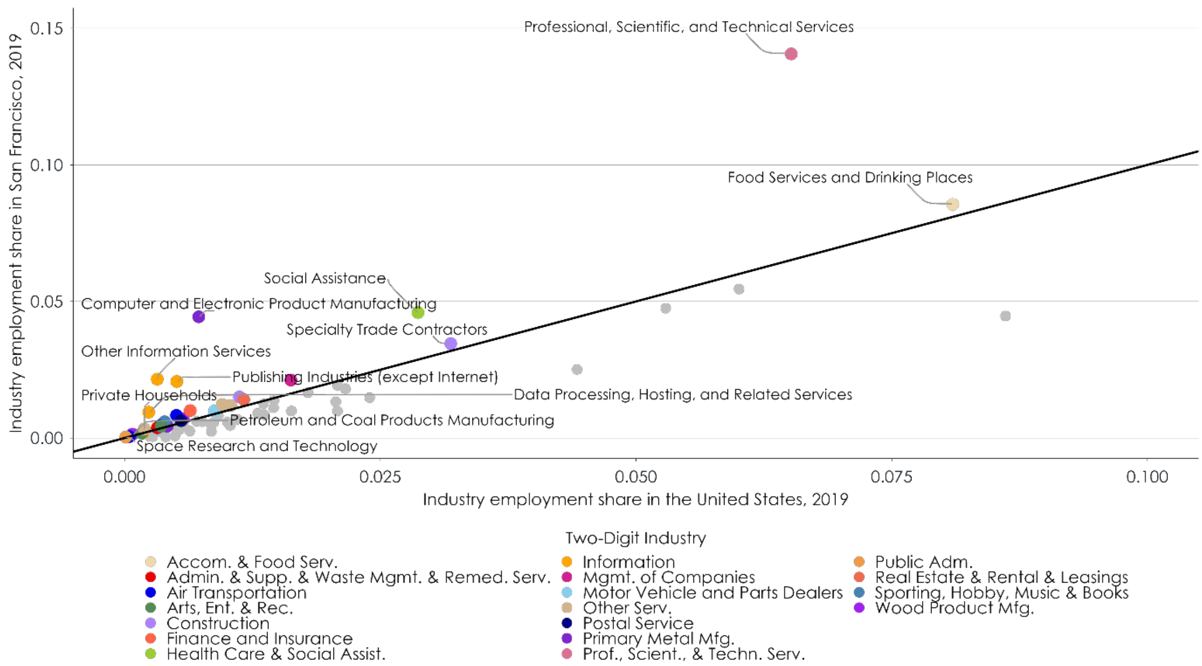


Boston

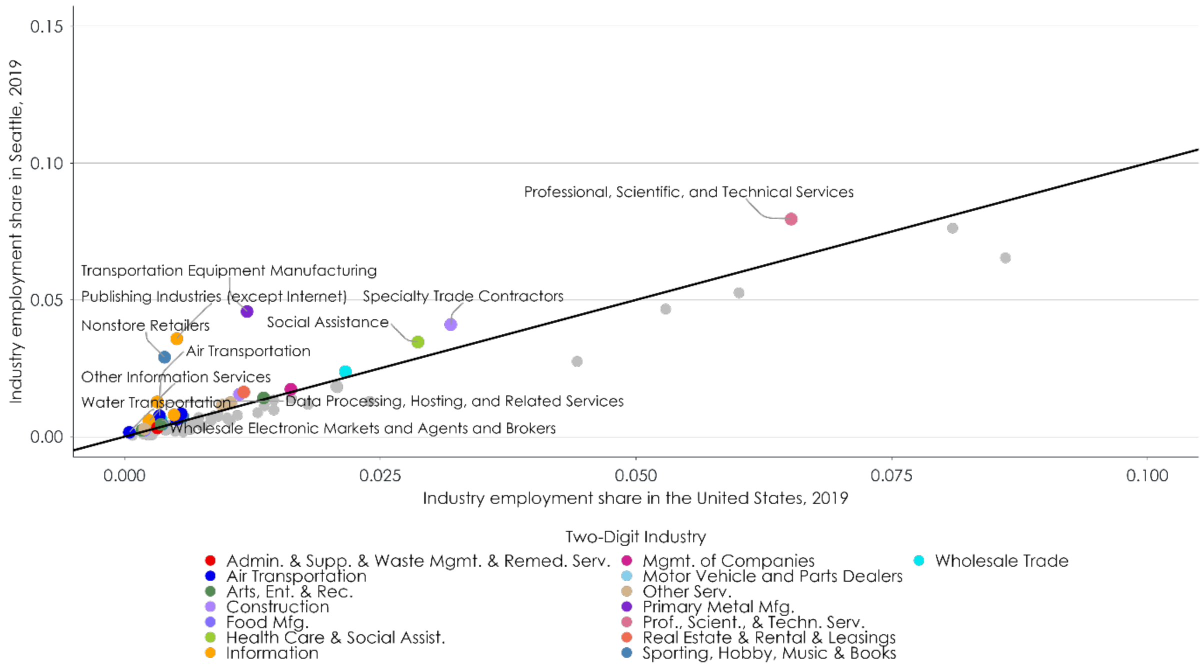


Pittsburgh

San Francisco



Seattle



Source: U.S. Bureau of Labor Statistics, WIFO calculations.

Additionally, some important specializations are specific to individual metropolitan regions. This is most evident in some 3-digit branches in the financial services sector, another tradable service sector, in Pittsburgh (such as credit intermediation and related services) as well as in the management of companies and enterprises[55]. This also applies to the localization of administrative support services in Atlanta, which, however, mostly consists of producers of non-tradable services such as office administrative services, facilities support services, employment services, business support services, travel arrangement and reservation services, investigation and security services, real estate services, and other support services.

Therefore, as also found for Vienna below, only few manufacturing industries are localized in the US case study metropolitan regions, with the exceptions usually related to the presence of large firms in the regions. Therefore, the regional specialization profiles of our case study metro's have almost entirely shifted to services, especially professional, scientific, and technical services (as part of the knowledge-intensive business services), which are disproportionately localized in all the case study metro regions and potentially provide an additional export base for the metros[56].

[55] These include offices of bank holding companies, offices of other holding companies, corporate, subsidiary, and regional managing offices.

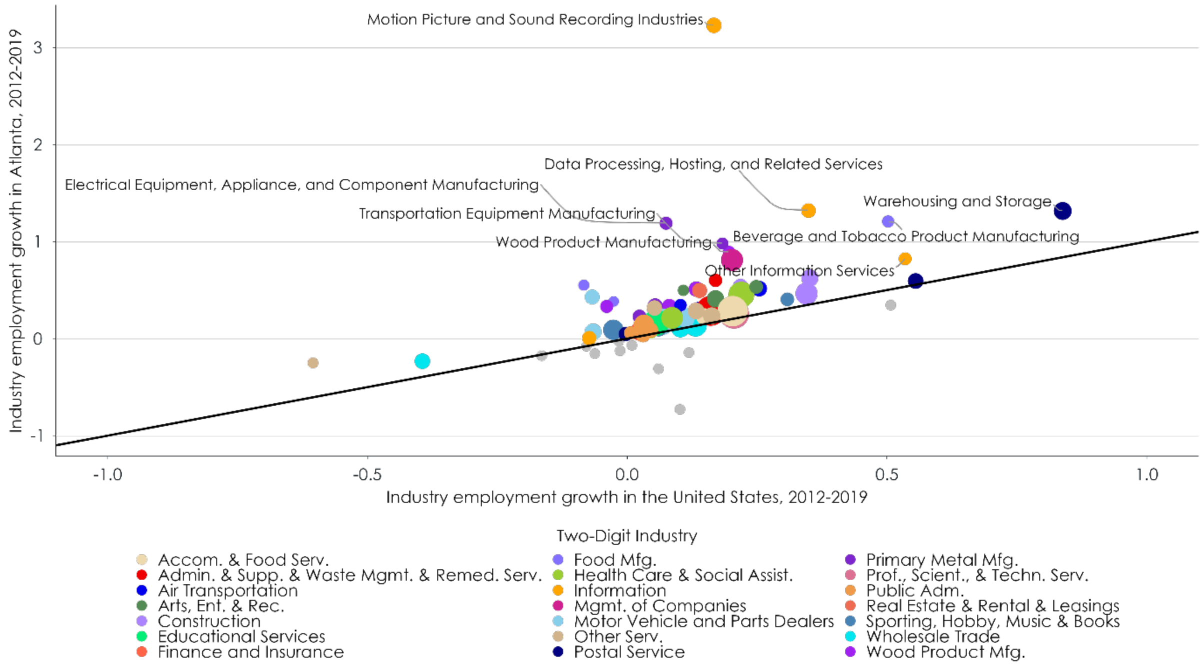
[56] In addition, the data reported in the individual case studies suggests that this characterization applies even more to the urban cores of the case study metropolitan regions.

4.4.2 Evidence from sector growth

Figure 4.2 analyzes sectoral employment growth patterns in the US case study metropolitan regions relative to the US, similarly as Figure 4.1 analyzes specialization. The size of the dots in Figure 4.2 is scaled to the number of employees in the industry in 2019. We also color-code and report only those industries that have a higher employment growth in the respective FUA than the industry's U.S. employment growth. From this analysis, three key areas of economic activities with above-average growth rates emerge[57].

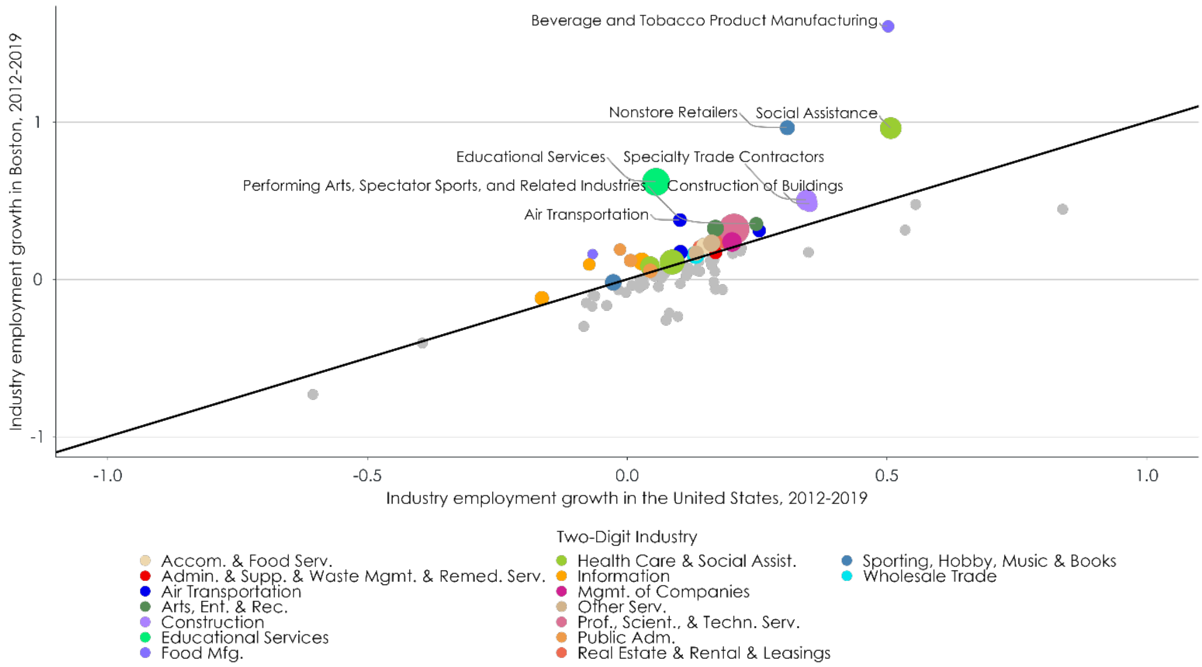
Figure 4.2: **Growth performance of NAICS 3-digit industry employment in the US case study metropolitan regions**

Atlanta

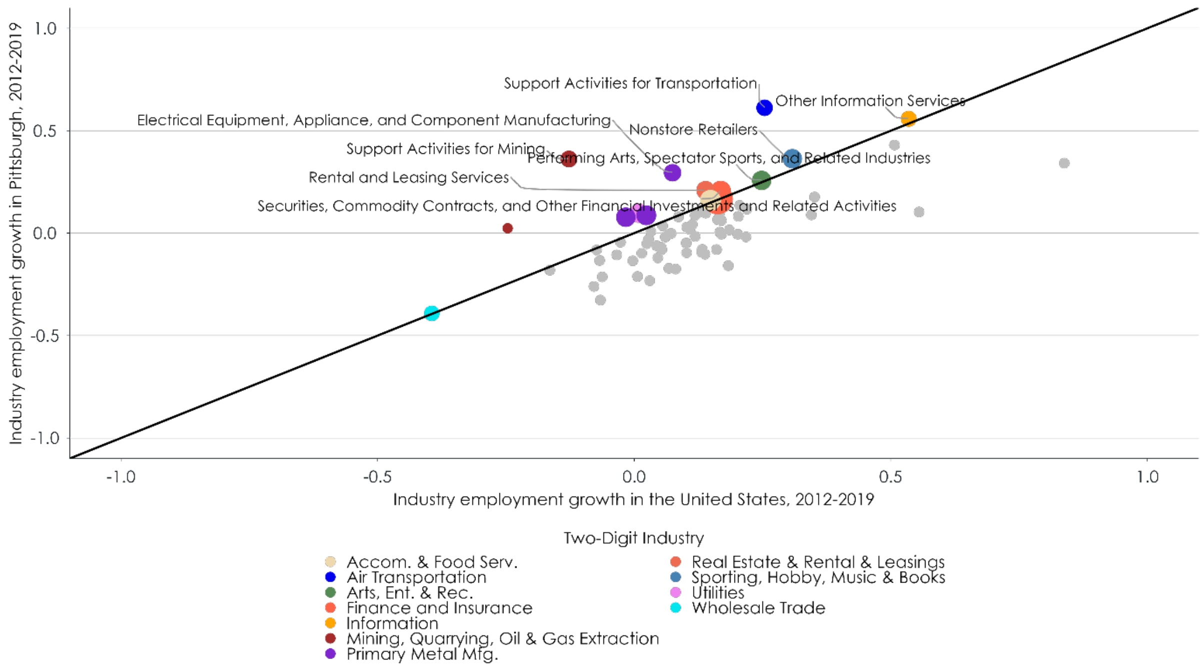


[57] A list of the ten fastest growing NAICS 3-digit industries in the period 2012 to 2019 is enclosed in the Annex (see Table A. **2**).

Boston

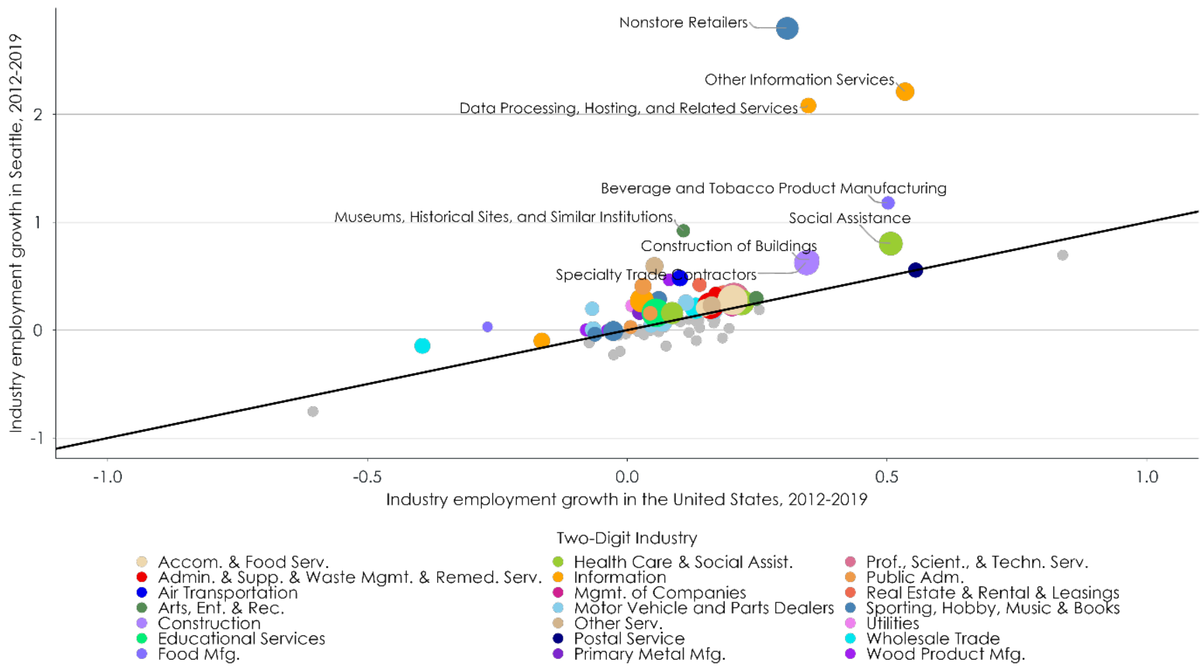


Pittsburgh



San Francisco

Seattle



Source: U.S. Bureau of Labor Statistics, WIFO calculations.

- The first area is a large group of industries (such as education, health, transportation, construction, utilities but also entertainment) in which employment growth is primarily related to growing local demand and thus to demographic growth. Examples of this are found in all case study metro regions, and the list of such industries is rather long everywhere[58]. Therefore, these activities also provide most of the employment growth in the case study regions. However, they are unlikely to contribute substantially to the export base of a metro as they are mostly non-tradable.
- The second area is a group of services that may be called internet-based, affiliated with the information and communication sector that is internationally highly tradable. These sectors have also contributed substantially to total employment growth in almost all case study metro regions. Here, the examples include computing infrastructure providers, data processing, web hosting, and related services in Atlanta, Pittsburgh, San Francisco, and Seattle, non-store retailers and web search portals, libraries, archives and other information services in Pittsburgh, San Francisco, and Seattle.
- The third area is consumer goods industries that likely benefit from the proximity to the differentiated demand of consumers in metropolitan regions. The main example is the production of beverages (incl. tobacco), which has achieved above-average growth in almost all considered US metropolitan regions and was even the fastest growing industry in Boston over the period 2012 to 2019. Similar arguments also apply to apparel manufacturing in Boston and to specialty trade contractors[59] in Boston and Seattle.

Besides these industries, which stand out as growth drivers in all US case study metro regions, several additional industries achieved high growth in specific individual metropolitan regions. In Atlanta, this applies above all to the motion picture and sound recording industry, which, starting from rather low levels, has expanded its employment more than threefold after receiving substantial tax privileges and state support in Georgia[60] in the last decades. This also holds for warehousing and storage, where employment growth has probably benefited from

[58] They include the construction of buildings and waste management and remediation services in Atlanta, social assistance, educational services, construction of buildings, air transportation, performing arts, spectator sports, and related industries, amusement, gambling, and recreation industries in Boston, support activities for transportation, performing arts, spectator sports, and related industries, rental and leasing services in Pittsburgh, transportation, social assistance, transit and ground passenger transportation, couriers and messengers, utilities in San Francisco and museums, historical sites, and similar institutions, social assistance, construction of buildings, religious, grantmaking, civic, professional, and similar organizations in Seattle.

[59] The term includes, among others, the electrical, mechanical (heating and air conditioning), plumbing, roofing, insulation, plaster/drywall, painting, and landscaping contractors.

[60] Georgia provided several incentives to the film industry in the last decade. Thus, the state's first tax incentive was a point of purchase sales and use tax exemption introduced in 2002. In 2008 under the Georgia Entertainment Industry Investment Act a transferable income tax credit of 20% of all in-state costs for film and television investments of $500,000 or more and an additional 10% tax credit to approved projects that embed a Georgia Entertainment Promotional logo within the titles or credits of each production was granted. Accordingly, it is estimated that by 2015, Georgia spent over $504 million in issued tax credits.

Atlanta's function as a transport hub, and for the manufacture of electrical equipment, appliances, and components.

In Boston and Seattle, by contrast, industries that do not have a top 10 position in terms of employment growth stick out as region-specific sectors with above-average growth, most notably professional, scientific, and technical services in Boston and chemical manufacturing in Seattle. In Pittsburgh, on the other hand, due to the much stronger industrial orientation of the metro, similar observations apply to a slightly larger list of strongly growing industries such as support activities for mining and the manufacturing of electrical equipment, appliances, and components. Finally, in San Francisco this applies mainly to transportation equipment manufacturing, which is probably related to the fact that San Francisco and the state of California provide rather lenient regulations for testing self-driving vehicles, which has made them a particularly attractive location for such tests (for more details refer to the Annex).

4.4.3 Evidence from venture capital finance

The preceding analysis provided an overview of highly localized and rapidly growing industries in the case study metropolitan regions based on official statistics. However, such an analysis inevitably misses many of the newly emerging activities. On the one hand, many of these new are still small in terms of employment and thus "fly below the radar" of official employment statistics. On the other hand, industrial classifications used in official statistics, regardless of how finely granulated they are, are often considered to be ill-suited to identify new production opportunities in a setting where the differences between production and service provision are becoming increasingly blurred and existing industrial classifications have not yet been adapted to the specifics of such servo-industrial production.

To overcome this weakness, we supplement the above analysis with a more exploratory but hopefully still insightful analysis, based on data on venture capital financed firms taken from the Crunchbase database. Due to a lack of a unanimous definition of startups in the literature[61], we focus on companies that were founded after 2014. Crunchbase also provides information on the type of the last funding the company received. We selected firms where the most recent funding was an early funding round (i.e., either pre-seed, seed, Series A or Series B funding)[62], as this is most likely to identify smaller new activities that are not identified in more aggregated data. Furthermore, we limited the analysis to firms that are still active and where the

[61] While the term is generally used to describe newly established businesses on the search for funding, well established companies like UBER are also sometimes referred to as startups.

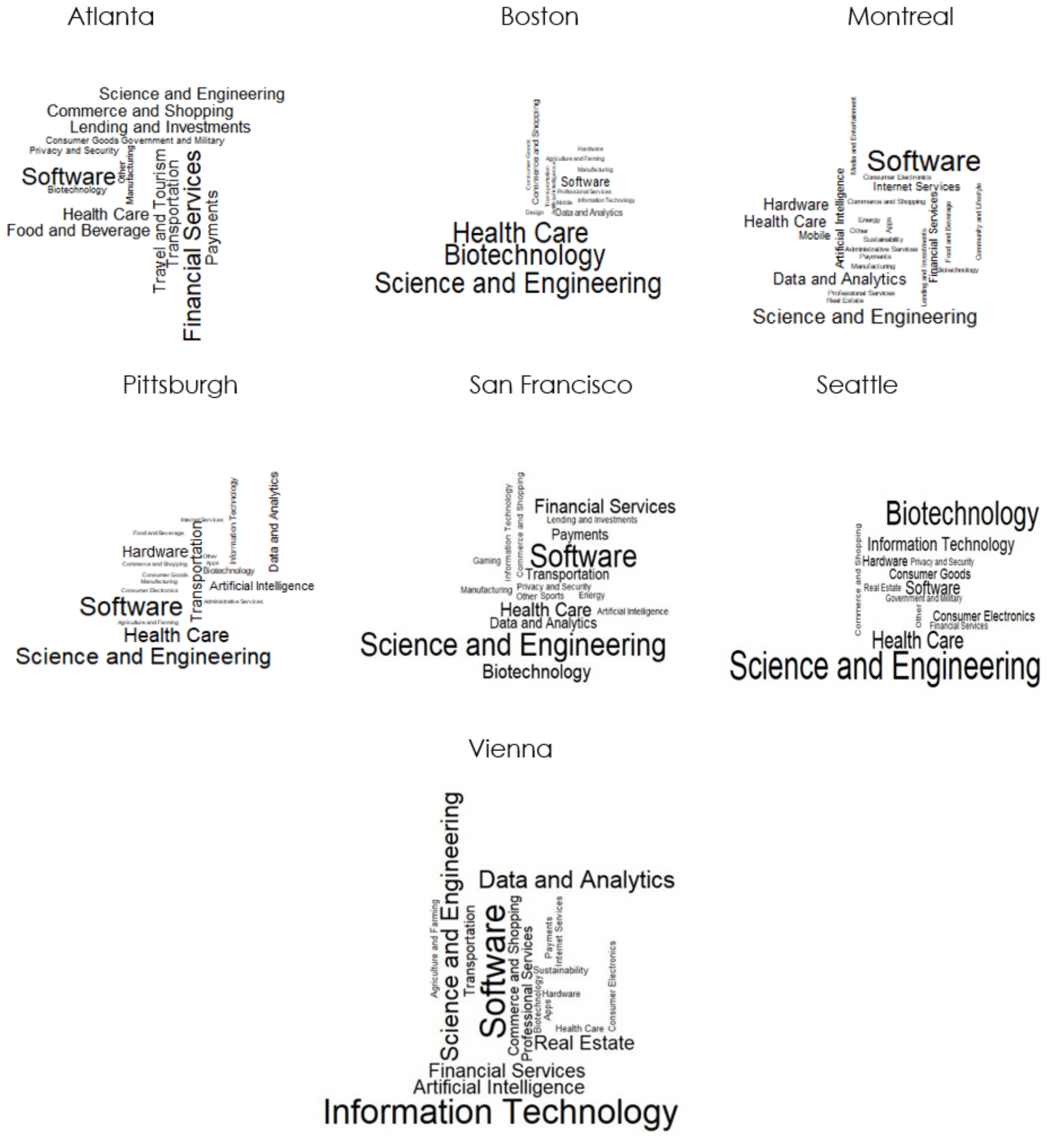
[62] According to the Crunchbase definition, pre-seed rounds represent the initial funding phase, often lack institutional backing, or involve relatively modest amounts, frequently below $150,000. After pre-seed rounds, companies proceed to seed rounds, which they secure in their early stages as they strive to gain traction. Seed rounds typically range in size from $10,000 to $2 million. Subsequent funding rounds for early-stage companies include Series A and Series B funding, which span from $1 million to $30 million on average. The subsequent funding stages, Series C and beyond, cater to more established, late-stage companies.

current funding status is either "early-stage venture", "seed", or "merger and acquisition" to exclude initial public offering (IPO) firms from the sample[63].

This data from the Crunchbase database is collected by a commercial enterprise for purposes that are not related to statistical analysis. Therefore, it cannot claim the same completeness or representativity as data collected by statistical offices. However, it provides information on the extent of startup activities that is largely consistent with the findings of other studies. For instance, this data suggests that venture capital financed startups are rather rare in Vienna and Pittsburgh, but much more common in Boston and San Francisco. In total, this database lists only 271 venture financed startups in Vienna and 296 in Pittsburgh, while in Boston and San Francisco these numbers are 1,044 and 5,538 respectively. For Seattle, Atlanta, and Montreal, the respective numbers are 825, 624 and 387. Similarly, in our selected startup sample, the largest funding in Vienna and Pittsburgh ranges between 100 and 150 million US-$ and the 10th largest between 10 and 20 million US-$, while in Atlanta, Montreal, and Seattle the largest funding ranges between 200 and 300 million US-$ and in San Francisco and Boston even the 10th largest funding exceeds that of the largest in Vienna and Pittsburgh.

[63] An alternative to this would be to consider unicorn startups. These are privately owned, highly successful startups, with a value of over $1 billion. However, as these companies are not valued on the stock market, the adequate valuation of such companies is not straightforward. Since the traditional evaluation approaches (market approach, cost approach, income approach) have been criticized in the literature (Montani et al., 2020) and we have no information on how the Crunchbase database values the companies, we focus on the initial stages of financing. This has the additional advantage that all metropolitan regions provide observations for these startups, which is not the case for unicorns (while for Boston, San Francisco and Seattle Crunchbase reports 13, 140 and 10 unicorns respectively, there are no unicorns in Atlanta, Montreal, Pittsburgh, and Vienna in the Crunchbase database).

Figure 4.3: **Word cloud representation of major startup activities in case study metros and Vienna**



Source: Crunchbase, WIFO calculations.

This data also allows for a first analysis of the structure of startups in the respective metropolitan region. Crunchbase assigns multiple industry groups to each firm based on a detailed business description[64]. The industry groups do not follow standard statistical codes but are selected from a list of 40+ industry groups pre-defined by Crunchbase Therefore, the process of assigning

[64] For a list see https://support.crunchbase.com/hc/en-us/articles/360043146954.

these descriptors is more subjective than using statistical industry codes, but it allows an insight into the activities of the startups[65].

Figure 4.3 visualizes the results of this analysis by displaying a word cloud of the industry groups of the 10 largest startups in terms of total funding in each metropolitan region[66]. In this word cloud, the font size reflects the frequency of a certain industry group in each metropolitan region. In other words, if a word is printed in the largest font size, it means that from the list of industry groups, Crunchbase used that word most frequently to describe the activities of the largest startups in the respective metropolitan region. This representation does not allow a comparison of the number of startups in a sector across regions, but it highlights the relative importance of a specific industry group within the region.

Some common themes emerge from this analysis. In almost all metropolitan regions, science and engineering, biotechnology, software, and health care are key fields in which startups are active. This reflects the main technologies that drive innovation globally and suggests that many of these startups have a strong service orientation in their output. However, while venture capital financed startups are generally associated with these technologies, the details of their relative importance vary considerably. This is probably best illustrated by comparing Boston, which is described as a hot spot of technological development in the case studies, and Atlanta, where technological innovation seems to be lower according to our case study evidence. This is also reflected in our startup data. In Boston, three fields (science and engineering, biotechnology, and health care) are equally important among the startups. In Atlanta, however, startups are often defined as being in the more traditional fields of financial services and software.

Similar observations apply to a comparison between the two West Coast metropolitan regions of Seattle and San Francisco. For both metropolitan regions, science and engineering are relatively prominent on the list of descriptors for startup activities. In San Francisco, this is associated with a high relevance of software, whereas in Seattle, this is associated with an additional specialization in biotechnology. The only two metropolitan regions where these descriptors are similarly important are Montreal and Pittsburgh. These two metropolitan regions are quite similar in terms of the importance of software and science and engineering, but also in health care and artificial intelligence. However, they differ in terms of the importance of, e.g., hardware and software. While startups developing computer hardware are more important in Pittsburgh, software development is more important in Montreal's startup sector.

For Vienna, results are less robust due to the low number of venture capital financed startups and a generally low level of venture capital. However, it stands out among the case study metropolitan regions for its strong emphasis on information technology in its local startup scene. The Crunchbase data reveals that this is primarily due to several firms in real estate, logistics

[65] The regional delimitation of the data is also not entirely clear, as it is provided by Crunchbase, who however, do not clarify the regional concept used.

[66] Table A. **3** in Annex to chapter 4 provides information on the name, last funding type, total funding, and a short description of the 10 largest startups in the case study regions and Vienna.

and financial services that are using information technologies in combination with artificial intelligence systems in various forms.

5. What can Vienna learn from the case study metropolitan regions?

The case studies and the preceding analysis reveal that the economic development of the metropolitan regions under consideration is influenced by some common trends, but also by substantial differences in their specific manifestations. For example, all metropolitan regions have experienced significant deindustrialization in employment in recent decades, but the pace and the underlying causes of this process vary considerably. Likewise, all regions have witnessed the emergence of new export-oriented activities, mainly based on services and innovation, and their ability to constantly innovate is crucial for their long-term economic success. Nonetheless, the extent to which these new activities have compensated for the loss of the former industrial export base, as well as their nature, differs across the metro regions covered. Finally, venture capital-financed startups in all metropolitan regions appear to rely on similar key technological domains, but they emphasize different technologies in each region

These findings imply that common overarching development trends manifest themselves in different ways in the case study metro regions (and in Vienna), depending on their size, level of economic development and institutional setting. Therefore, it is not possible to directly transfer the experiences and policies of the North American regions to Vienna. Learning from these successful regions requires identifying the driving forces behind the development of new industrial pathways based on our case study findings and the relevant literature, and then comparing them with the preconditions in Vienna. This may help to determine which, if any, new industrial paths might be promising for Vienna, and which economic policy actions seem necessary to create favorable conditions for them to emerge and prosper.

5.1 Some hints from theory: Driving forces for new industrial path developments

Over the past few decades, research has made significant progress in understanding how, where and under what conditions new regional industrial paths emerge and evolve[67]. In consequence, there is now widespread agreement that industrial trajectories are place-based and shaped by agglomeration economies, bringing path dependencies and "history" into play. However, the conditions and mechanisms that enable the creation of "new" industrial paths remain a topic of inquiry. Based on the existing literature (see Figure 5.1), some of the key factors that affect the development of new industrial paths are:

1. **Chance events** – Early contributions to the literature (e.g., David, 1985; Arthur, 1989; Krugman, 1991) emphasize the role of exogenous shocks or historical contingencies as triggers of new developments. These studies, often based on case studies of "successful" regions (such as the Silicon Valley), emphasize the individual locational decisions of early

[67] For surveys on this recent literature see, e.g., Tödtling & Trippl (2018); Hassink et al. (2019), Uyarra & Flannagan (2022) or Gong et al. (2022).

innovators and anchor firms)[68], as well as historical events that exogenously change the locational advantages of certain regions[69]. These events create regional "windows of locational opportunity" (Scott & Storper, 1987) for a short time, when the regional playing field is relatively flat in the early stages of an industry's emergence (Storper & Walker, 1989)[70]. However, once the new industry is established and growing, it evolves along with increasing returns and agglomeration economies. This allows the region to achieve a leading position in the emerging industry and lock-in once a critical mass is reached.

2. **Related diversification** – More recent contributions[71] challenge this emphasis on chance and the locational freedom of new industries, arguing that pre-existing regional structures influence their emergence positively or negatively (Martin & Sunley, 2006; Martin, 2010). In this view, a region's ability to engage in new economic activities depends on existing local "capabilities", i.e., place-specific competences, skills, and experiences that are inherited from previous rounds of regional economic development and associated with existing specializations. These capabilities constitute an enabling or constraining environment for the development of new paths, but also determine which new paths are viable. As new activities emerge primarily through a recombination of complementary and related capabilities at the firm level (Boschma & Frenken, 2011), a regional industry mix that consists of a large variety of different yet (technologically/cognitively) related activities ("related variety"; Frenken et al., 2007) will exhibit a higher potential to diversify in new activities and industries due to the numerous possible re-combinations. Hence, a given regional set of industries (and the capabilities linked to them) can foster regional diversification, as it provides opportunities for new combinations that give birth to new activities. However, it may also hinder diversification if the capabilities required for a new activity are not present. Therefore, regions are more likely to diversify into new activities that are related to existing local activities and specializations[72].

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[68] For example, narratives of the rise of Silicon Valley typically highlight the decision of William Shockley (the inventor of the semiconductor) to relocate from New Jersey to be near his aging mother in Menlo Park, but also the "accidental" agglomeration of other "key persons" in the region, from Terman, Hewlett, Packard and Jobs to Gates, Zuckerberg, Brin, Page, or Thiel. At the firm level, Fairchild or Hewlett-Packard are often mentioned, "first movers" benefiting from the emerging open-source networks in the region (Storper, 2013).

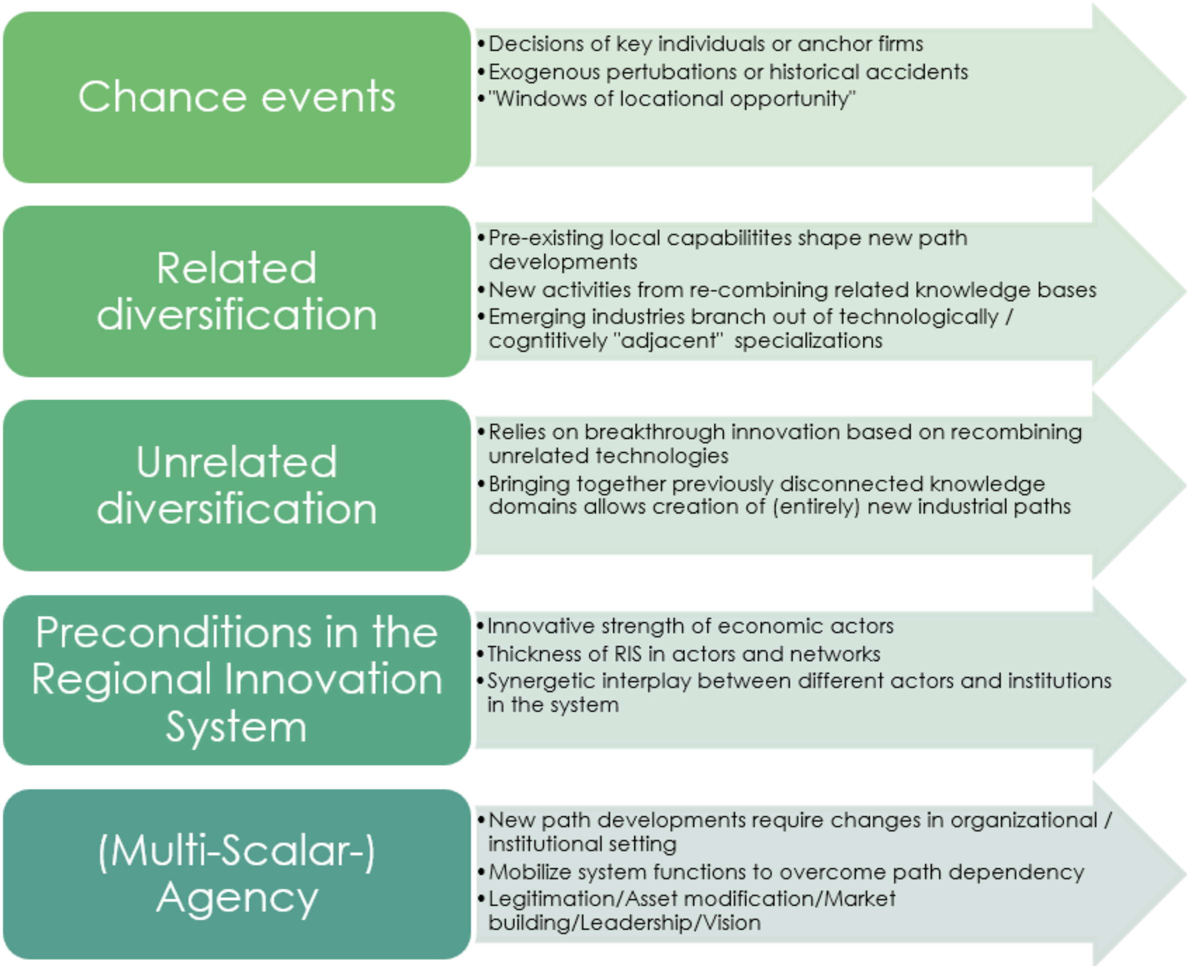
[69] Pertinent examples include the build-up of large-scale armament production in wartimes, the effects of integration processes (e.g., on border regions), the emergence of new transport networks (e.g., the U.S. railway system shifting locational fortunes from port cities to the interior of the continent) or technologies (e.g., the advent of air conditioning shifting these fortunes from northern to southern U.S. states).

[70] This arises from the "generic" properties of new industries and the fact that sector-specific institutions, which could attract the emerging industry to certain locations, do not yet exist.

[71] For recent summaries of this literature cf. Boschma (2017) or Whittle & Kogler (2019).

[72] These theories have been corroborated by substantial empirical research (e.g., Hidalgo et al., 2007; Hausmann & Klinger, 2007; Neffke et al., 2011; Kogler et al., 2013; Essletzbichler, 2015; Rigby, 2015; Boschma et al., 2015; Brachert, 2013; Balland et al., 2019; Balland & Boschma, 2021) that test the hypothesis that new activities typically branch out of existing ones, and that new industrial path developments follow a regional branching process (Frenken & Boschma, 2007), in which new activities draw on and combine local activities.

Figure 5.1: **Determinants of new industrial path developments**
Key influencing factors from the relevant literature



Source: WIFO illustration.

1. **Unrelated diversification** – Empirical studies show that diversification in new industries that are not related to the existing industrial fabric also occurs, though less frequently. This "unrelated diversification" is typically associated with breakthrough innovations and the creation of "radically" new industrial paths. New activities do not arise here by re-combining existing knowledge along well-defined paths, but by new combinations of previously unrelated capabilities and technologies (Castaldi et al., 2015)[73]. Such events may be triggered by scientific discovery, radical new technologies as well as organizational and social innovations (Isaksen et al., 2018), based on the exploitation of knowledge in local universities (Vallance, 2016), spin-offs from technology firms (Feldman, 2007), and the inflow

[73] Boschma (2017) brings the example of the self-driving car that emerges out of new combinations of technology fields in automotives, sensor-based safety systems, communication and high-resolution mapping that have not been combined before.

of knowledge, firms, and other resources from outside the region (Binz et al., 2016). In any case, they are more likely to lead to the emergence of entirely new industries and are therefore considered highly desirable. At the same time, they are also difficult to achieve because of the infrequent knowledge spillovers between actors with cognitively distant knowledge bases and their high requirements for basic research. Unrelated diversification is therefore rare, although highly developed metro regions have some advantages for it[74].

2. **Preconditions in the Regional Innovation System** – The Regional Innovation System (RIS) literature (Cooke et al., 2004; Tödtling & Trippl, 2011) has widened these "entrepreneurial approaches" by offering a more comprehensive, systemic view[75], given that innovation and new activities depend on the interplay between different kinds of actors, networks, and institutional fabrics in a RIS. These various elements jointly generate synergies and system effects that go beyond the contributions of individual actors or elements. In this view, the chances for new path development are thus shaped by the existing technological trajectories in a RIS, but also by the presence and quality of knowledge and support organizations, institutions, and network configurations. Organizationally thick and diversified RIS, that already host various innovative firms, well-functioning support organizations, networks, and institutional settings, will therefore offer a more favorable environment for the rise of new industrial paths than organizationally thin or specialized RIS. This should favor metropolitan regions in general[76], but may also generate heterogeneity in the ability to capture new industrial paths within this regional group, not least between our case study metro regions (and Vienna).
3. **Multi-scalar agency** – Finally, recent theories of multi-scalar agency (Martin, 2014; Hassink et al., 2019; Grillitsch & Sotarauta, 2020; Baumgartinger-Seiringer et al., 2021; Uyarra & Flanagan, 2022; Miörner, 2022) further widen the analysis by emphasizing the importance of deliberate strategies to mobilize resources for new path developments. In this view, path creation involves considerable "system building" as well as institutional entrepreneurship (Grillitsch & Sotarouta, 2020) to transform existing assets and institutions or create new ones to build an enabling environment in which new industries can emerge and prosper (Asheim et al., 2017). A RIS may be well suited for existing paths, but not for disruptive innovations and radically new industries. Therefore, deliberate action to modify existing assets, such as qualifications, infrastructure, and institutions, may be essential for enabling new

[74] For example, recent empirical studies at the country level show that at least a medium stage of economic development must be reached for locations to diversify into unrelated industries (Petralia et al., 2017) or products (Pinheiro et al., 2018). At the same time, due to their size, metro regions allow a broad range of specializations and technology fields in one location, which should increase the probability of a re-combination of hitherto unrelated activities (Whittle & Kogler, 2019). Finally, the position of metro regions as nodes in international labor and capital flows should further increase this probability, since a significant part of (unrelated) diversification processes is enacted by actors from outside the region (Trippl et al., 2018).

[75] For a more detailed account of the RIS concept and its contribution to understanding new path development, see Tödtling & Trippl (2018).

[76] Metro regions should offer rather favorable conditions for new paths, due to high levels of variety found in their diversified industry mix, typically thick RIS structures and strong absorption capacities for external knowledge and resources (Tödtling & Trippl, 2018).

path creation (Trippl et al., 2020).Since this also involves (de-)institutionalizing and (de-)constructing rationales (Gong et al., 2022), "place leadership" and strategic communication may be needed to shape the collective expectations and visions in the region and guide the search of the actors in the RIS (MacKinnon et al., 2019)[77]. Especially in metro regions, this transformative change must be multi-scalar, involving multiple agents including the state, academia, non-governmental organizations, and various other stakeholders operating at multiple spatial levels (Trippl et al., 2020; Doloreux & Turkina, 2021).

5.2 Lessons from the case studies

The case studies for the North American metropolitan regions largely confirm the importance of the drivers for new industrial path developments, but also yield additional policy-relevant insights.

One important additional finding is that the driving forces mentioned in theory are ideal types that often coexist in practice. In fact, new path developments in our case study regions have historically resulted from an interaction of chance, related diversification, and multi-scalar agency and are often related to the "cultural traits" of a metro. These elements are often so closely intertwined that it is hard to isolate a single decisive factor. For instance, the emergence of the software publishing and computer gaming industry in Montreal involved (1) an entrepreneurial minded filmmaker as an element of chance, (2) the pre-existing engineering tradition in the metro as a basis for related diversification, and (3) a (French) creative culture that valued arts and arts development (as a factor related to multi-scalar agency) as key elements for the rise of this industry. In addition, the success of engineering consultancy in Montreal depended on the combined role of (1) the strong engineering tradition in the metro (as an element of related diversification) and (2) Canada's vast infrastructure needs and the consequently rapidly growing home market for engineering services (as an element of chance). Similarly, the San Francisco case study (as well as the related literature on the development of Silicon Valley) shows that computing in Silicon Valley was not a disruptive technological development, but rather stemmed from (1) the Bay-Area's long-standing tradition in electrical engineering (as a factor of related variety) and (2) the attraction of a major innovator in the field (incidentally from Boston) as an element of chance.

Since chance events are hard to influence by policy, we suggest that development strategies that build on (and broaden) existing technological strengths and thus rely on a "related variety approach" should be supported and complemented by broader based research and innovation policies that aim to increase the excellence of regional universities and to foster collaborations between these universities and the local companies, as well as by policies that encourage entrepreneurship and the inflow of external knowledge in the promising fields. For Vienna,

[77] In addition, scholars (e.g., Uyarra et al., 2020) emphasize the importance of market building in supporting (radically) new industrial paths, as relevant markets for them often do not yet fully exist. Hence, in early stages of an industry's emergence policy-supported niche markets may reduce uncertainty. Bringing together new producers and potential users, be that by disseminating inspirational cases, creating platforms for collaborative experimentation, or (not least) by targeted public procurement, may thus help to bring out latent, fragmented user needs and build receptive markets.

this would imply increased support and co-operation of the city for and with the local universities. This could include an intensified cooperation with and coordination of the activities of the business incubators existing at all the 22 public and 17 private universities as well as the 21 universities of applied sciences, funding mission-oriented cooperative research programs (between the existing tertiary education institutions) in the key technology fields deemed important for the future development of the metro (see below for a discussion) and organizing and supporting more strongly international exchange programs for both junior and senior researchers.

A second key finding of the case studies is that consistent with the literature, unrelated diversification is rare but may be an important game-changer. It is striking that in the case studies the only cases which could be considered as a diversification beyond existing technological paths are related to Boston, where a strong research base has helped the metro to become an early adopter of new key technologies, and Pittsburgh, where AI and health services emerged without relation to the traditional specialization in steel. In both cases, the development of these "new industrial paths" relied on more general traits related to the knowledge base of the region. For Boston, both the case study and the literature (see Glaeser, 2005) highlight the importance of a large supply of highly skilled labor, which may be linked to the city's function as a gateway city (or port of entry) for many immigrants. Furthermore, both case studies emphasize the central role of universities (in particular Carnegie Mellon University in Pittsburgh and MIT as well as Harvard University in Boston) and, in Pittsburgh, the presence of an innovative university president (as an element of chance) as key drivers of the industry success.

This suggests that the development of new technological paths, although rare and often unpredictable, yields high returns when it occurs and often depends on a combination of strong basic research institutions and tight actor networks in regional innovation systems. Therefore, a strategy that focuses on strengthening of basic research institutions and their connections to the local economy is more likely to succeed than policies that focus on "picking a winner" based on the experiences of other cities.

A third striking result from the case studies is the strong emphasis on specific actors in shaping and influencing the development of new specializations in a region. This applies in particular to the interaction of universities, large multinational companies and individual "entrepreneurs". Almost all the case studies stress the importance of entrepreneurial minded individuals and collaboration between tertiary education institutions and firms in developing new activities. This is particularly the case in those instances where we find a move into entirely new technological fields (i.e., Boston and Pittsburgh), but also applies to all other case studies that show evidence of development along existing paths. Furthermore, the case studies of Seattle and to a lesser extent of Atlanta show the strong influence of existing large multinational corporations (e.g., Boeing in Seattle). They shape the direction of research activities and entrepreneurial action by their impact on the venture capital market and their role in funding higher education institutions.

In our view, this suggests paying attention to establishing strong links between existing enterprises and startups and the research institutions in the region in development strategies, especially if the aim is to drive unrelated diversification. In principle, such strategies require a broad, systemic view on industrial development, with a strong emphasis on fostering the diversity and "thickness" of the regional innovation system.

As a fourth key result, some case studies also mention other influencing factors on industrial path development. This applies in particular to the role of geography and spatial spillovers, which can either facilitate or hinder the development of specific industries. For instance, some case studies mention spillovers from nearby locations as important supporting factors for the development of emerging industries. The most obvious case is the development of the computer industry in San Francisco's metropolitan core, which was mainly a spatial spillover from Silicon Valley, according to the case study. It also applies to the Montreal case study that highlights the relocation of an important engineering and IT consulting firm (CGI) from a nearby location to Montreal.

From a perspective of potential lessons for Vienna, this means that strategies focusing on the development of new export-based production should also consider resources available outside the (core) city region. Therefore, all such development strategies should cover (at least) the wider metropolitan region, which allows them to draw on a broader resource base.

Finally, the case studies also report important results about the reasons for failed development strategies. The case study of Montreal is particularly valuable because it reveals crucial pitfalls of top-down imposed development strategies. Briefly, the reasons for the failure of such initiatives were mainly rooted in (a) the fact that other locations had already built enough critical mass and a considerable competitive edge in a particular industry, preventing further development in the city. This was the case, for instance, in attempts to foster financial services in Montreal, where Toronto's lead was so large that it prevented the development of a second financial center in Canada. Additionally, (b) a lack of support from and of visibility for existing companies was mentioned in this case study as a cause of policy failure. In the Montreal case, this was shown by the example of attempts by the city to develop multimedia and e-commerce activities. In both cases, the city's initiatives lacked support from local enterprises, were spatially detached from targeted companies and were seen as unwanted competition by some incumbent firms.

This implies that policy initiatives for developing new industrial paths and activities in Vienna should consider the city's relative position compared to other (possibly competing) metropolitan regions in the same activity – especially for industries that benefit from economies of scale or high information density, which are typical for most technology- and knowledge-intensive activities. Moreover, the case study evidence shows that initiatives supporting new developments will only succeed if they can rely on the commitment of the relevant actors in the innovation system, as this is essential for enabling the multi-scalar agency that is required for radically new path developments to flourish.

5.3 Lessons for Vienna: Preconditions for new industrial path developments and some policy conclusions

The case studies and the relevant literature provide valuable insights into the emergence and evolution of new industrial paths in metropolitan regions. To draw lessons for Vienna, we will use these findings to identify the preconditions for new industrial path developments in export-oriented production in Vienna and to derive some policy implications. We will focus on the driving forces that can be influenced by regional economic policy, excluding chance events[78] or historical accidents as irrelevant factors. Therefore, we will analyze:

- Vienna's potential for related diversification strategies, including an empirical identification of the potential industries in manufacturing and knowledge-intensive services (chapter 5.3.1);
- The opportunities for new path developments from unrelated diversification, with a special focus on the available preconditions in Vienna's innovation system (chapter 5.3.2);
- The institutional prerequisites for multi-scalar agency to foster new industrial path developments in metropolitan Vienna (chapter 5.3.3).

5.3.1 Related diversification: Areas of opportunity in manufacturing and knowledge-intensive services in metropolitan Vienna

As the case studies and the relevant literature show, new path developments often follow related diversification mechanisms: new activities and emerging industries typically "branch out" of existing industrial strengths that are cognitively linked to them. Therefore, we ask to what degree industries using similar knowledge bases (and therefore cognitively/technologically "related") are localized in metropolitan Vienna, providing opportunities for further development of the city's export base via related diversification. We use employment data on the industries at the NACE 4-digit level (comprising 601 industry classes) for Vienna metropolitan region and Austria (as the benchmark)[79]. Since the case study metro regions in chapter 4 and the relevant literature suggest that these opportunities are particularly high in knowledge-intensive business services and information and communication services, we also analyze these tradable service sectors besides manufacturing (NACE C + D).

The empirical SWOT-analysis[80] adopts recent findings of the literature on related diversification, which state that viable regional strengths only emerge when strong industries (with relevant employment density as a foundation of agglomeration externalities) meet a regional environment rich of complementary, technologically and cognitively "related" industries. Therefore, the development potential of any industry class depends on both its degree of specialization (measured by its location quotient) and its degree of embeddedness in the region's industrial fabric (measured by the weighted location quotient of the industry classes related to it). This

[78] This is not to say that historic events do not have an important impact on current development perspectives. This particularly applies to Vienna, where the dissolution of the Austro-Monarchy is at the roots of the lack of large multinational enterprises in the city, and the Holocaust detrimentally affects the quality of research institutions to this day (see e.g., Polèse 2020).

[79] Our empirical analysis must rely on national comparisons, as harmonized data for the 4-digit level of the classification of economic activities are not available across countries, let alone at the inter-continental level.

[80] The approach was first proposed by Otto et al. (2014) and has been used by WIFO in several recent research projects (e.g., Mayerhofer & Huber, 2019; Mariotti et al., 2021; Firgo et al., 2021; Mayerhofer et al., 2022). For a methodological description see the technical supplement in the Annex.

allows us to distinguish four different categories of industry classes according to their development potential[81]:

- If an industry class is considerably localized and well embedded in "related" industries in the region, it should benefit from economies of scale and localized knowledge spillovers. It can be considered a regional "strength" and may be the source of related diversification.
- Conversely, an industry class with a low degree of specialization and embeddedness will hardly find favorable development prospects in the region, ceteris paribus. As a regional "weakness", such industries may be important for some reason (e.g., to exploit natural resources or to satisfy local demand) but will hardly play any role in policies fostering new industrial path developments.
- However, this will certainly be the case for industry classes that are still weakly localized in the region but can build on a favorable regional environment of "related" industries (high embeddedness). Such industry classes offer "opportunities" to develop new strengths via related diversification and will therefore be the focus of initiatives to help new industrial paths emerge and prosper.
- Finally, industry classes that are considerably localized but do not find a sufficient network of related industries (i.e., are weakly embedded) in the region tend to be a "threat" that could be reduced by strengthening the complementary industries necessary for it through structural policy initiatives.

We use an approach proposed by Neffke & Henning (2008) to empirically identify the (technologically or cognitively) "relatedness" of industry classes. This is based on inter-sectoral labor flows[82], and assigns each industry class in metropolitan Vienna to one of the above categories according to its degrees of specialization and embeddedness in 2022. Figure 5.2 maps the SWOT profiles of these classes in a 4-field diagram for manufacturing, and Figure 5.3 does the same for knowledge-intensive business services and information and communication services. The quadrants of the 4-field figures show the combinations of both parameters that allow a clear statement about the SWOT profile (Strengths, Weaknesses, Opportunities, Threats) of an industry class. For readability, only industry classes with at least 100 employees in the region are shown in the figures[83]. For these classes, the number of employees (circle size) and the relative innovation intensity[84] (circle color) are reported. Their NACE code is also shown for identification.

[81] To classify the industry classes into categories, we use indicator values of 1.1 and 0.9 as thresholds in line with the available literature. For industry classes with degrees of specialization or embeddedness between these values, no pronounced development expectations are assumed in the following SWOT analysis.

[82] See the technical supplement in the Annex for a description of this methodology.

[83] For a presentation of the results of our empirical SWOT-analysis for all (236) industry classes in metropolitan Vienna's manufacturing sector, regardless of their size, see Figure A. **5** and Figure A. **6** in the Annex.

[84] This innovation intensity is based on an empirically generated industry classification by Peneder (2010).

SWOT profile for manufacturing

Figure 5.2 maps the SWOT profiles of the 133 manufacturing industry classes with more than 100 employees in the Vienna metropolitan region[85], with the results further differentiated by its core region and the commuting zone in Figure A. 5 and Figure A. 4 in the Annex to chapter 5. The results show a rather diverse picture for the metropolitan region as a whole (Figure 5.2). Almost half (57) of the manufacturing sector classes with more than 100 employees have no clear SWOT-profile, mostly due to an inconspicuous degree of embeddedness. Among the manufacturing industry classes with a clear SWOT-position (76 with 55,545 employees), those with an above-average embeddedness and thus good prerequisites for new path development (strength, opportunity) are fewer in numbers (43%) but larger in employment (61%) than those with a low degree of embeddedness (threat, weakness). Only few manufacturing industry classes are poorly embedded and highly localized (i.e., threats) and industry classes with low embeddedness and low localization (i.e., weaknesses) are many but small, representing about 17.5% of the region's manufacturing employment.

Of the manufacturing industry classes with a high degree of embeddedness that are central to our research question, 20 with more than 100 employees can be considered as distinct strengths of the metro region. They account for almost a quarter of the region's manufacturing employment. The most prominent strength in the metro region from an employment perspective is the manufacture of pharmaceutical preparations (NACE code C 21.20), which in the innovation-intensive segment is complemented by the manufacture of railway locomotives and rolling stock (NACE code C 30.20) and some specialized, but small industries[86]. More important for employment than the latter, though, are some strengths in industries of medium or medium-low innovation intensity. These are mainly related to energy supply[87] and the provision of repair services[88]. Therefore, they are likely to be less relevant for the region's export base, except for some regional specialties related to the creative sector[89].

[85] In total, 217 out of the 236 NACE-4-digit industry classes in manufacturing are active in the Vienna metropolitan region, although 84 of these remain insignificant in size. The remaining 133 industries, which are shown in the figure, are responsible for 97.9% of manufacturing employment (98,550) in the region.

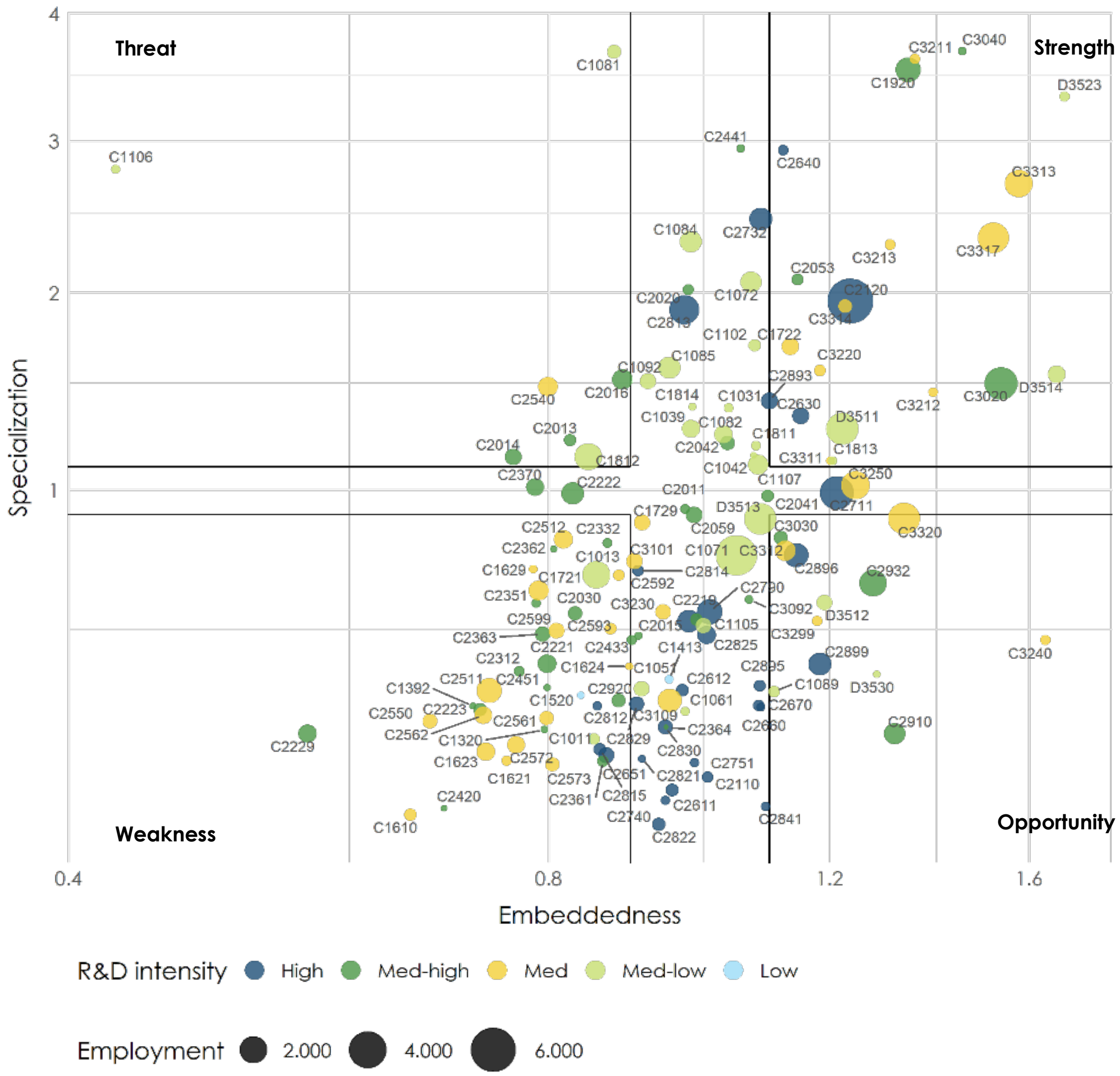
[86] E.g., manufacture of communication equipment – C 26.30; of refined petroleum products – C 19.20, consumer electronics – C 26.40, machinery for food production – C 28.93, military fighting vehicles – C 30.40

[87] E.g., production of electricity – C 35.11; trade of electricity – C 35.14; trade of gas through mains – C 35.23

[88] E.g., repair of other transport equipment – C 33.17; of electronic and optical equipment – C 33.13 and of electrical equipment – C 33.14

[89] E.g., manufacture of jewelry and imitation jewelry – C 32.12, C 32.13; of musical instruments – C 32.20; of coins – C 32.11)

Figure 5.2: **SWOT position of the manufacturing industry classes in Vienna metropolitan region**
Degree of specialization and embeddedness in the regional branch network; 4-digit industries; 2022



Source: Austrian Labor Market Service / Federal ministry of labor and economy; WIFO calculations. – Only industry classes with 100 or more employees in the regions are shown.

Finally, manufacturing industries that are well embedded but not yet specialized in metropolitan Vienna (and therefore opportunities for new path developments) include 24 industry classes, 12 of which have more than 100 employees. They currently employ around one eighth of the manufacturing workforce in the Vienna metropolitan region. In the innovation-oriented sector, these include some automotive industries (e.g., manufacture of motor vehicles and their parts – C 29.10 and C 29.32), mechanical engineering industries[90], but also emerging industries like the manufacture of new air and spacecraft items (C 30.30), of steam and air conditioning supply (NACE code C 35.30), games and toys (NACE code C 32.40) and other food products (NACE code C 10.89)[91]. In addition, this group also includes installation of industrial machinery (NACE code C 33.20), manufacture of medical and dental instruments (NACE code C 32.50) and electric motors and generators (NACE code C 27.20), which were in an intermediate stage between opportunity and strength.

This shows that a considerable part of the export-oriented manufacturing base in the Vienna metropolitan region operates in industries that are well embedded in the local industrial fabric and may be a good basis for related diversification-based industrial development strategies. Furthermore, unlike the US case study metropolitan regions, the strengths and opportunities within manufacturing apply to both high and medium innovation intensity.

However, a separate SWOT analysis for the core city and its commuting zone shows that both characteristics are mainly driven by the manufacturing base of the city's environs. Indeed, in the commuting zone (see Figure A. **4** in the Annex) industry classes that can be classified as weaknesses or threats are rather rare, while most of its industry classes (82% of those with a clear SWOT profile) are in the strength quadrant in terms of specialization and embeddedness, including less innovation-intensive industries in food production and other resource-intensive sectors.

The situation in the core of the Vienna metropolitan area (Figure A. **6** in the Annex) is quite different. Although about 60% of the metropolitan manufacturing workforce (59,892) still works in the city core, due to the monocentric structure of the metro region, the core's manufacturing ecosystem has thinned considerably due to deindustrialization and out-migration of enterprises in the last decades. As a result, most of the local manufacturing industry classes with a clear SWOT profile (67%) are weakly specialized and embedded in the core city and therefore qualify as a weakness once the commuting zone is excluded[92].

In contrast, the number of highly embedded and localized industries (i.e., strengths) is rather limited in the metropolitan core, although they are often quite innovation-intensive and large in terms of their number of employees. This is especially true for the manufacture of pharmaceutical preparations (C 21.20), railway locomotives and rolling stock (C 30.20), and of electric motors, generators, and transformers (C 27.11). Along with smaller innovation-intensive industries[93], these industries form the core of the city's industrial technology sector. Some other, less innovation-intensive industries with strength profile serve the local market, e.g., in repair and

[90] E.g., manufacture of plastics and rubber machinery – C 28.96; of other special-purpose machinery – C 28.99; of machinery for paper production – C 28.95.

[91] This is mainly composed of producers of sweets, vegetarian foods, coffee, and tea.

[92] This applies to around 31% of the manufacturing industry classes with more than 100 employees and to about 20% of all manufacturing industry classes, respectively.

[93] E.g., manufacture of consumer electronics – C 26.40, communication equipment – C 26.30, military fighting vehicles – C 30.40 or refined petroleum products – C 19.20.

maintenance or energy supply[94], or comprise craft-based industries close to Vienna's creative industry sector[95].

Finally, industries that are well embedded but weakly localized (and therefore opportunities for new path developments) are also scarce in the core city. They cover about 10% of the industries with a clear SWOT-profile in the metro's core and include mostly innovation-intensive industry classes. These include the manufacture of medical and dental instruments (C 32.50), electromedical equipment (C 26.60), the installation of industrial machinery (C 33.20), as well as some industries producing transportation equipment[96] or in mechanical engineering[97]. Among less innovation-intensive industries, only the production of games and toys (C 32.40) and of household and sanitary goods (C 17.22) belong to this group.

SWOT profile for knowledge-intensive services

Our SWOT analysis shows only limited potential for new industrial paths in manufacturing in the Vienna metropolitan area, especially in its core city. This suggests looking beyond manufacturing proper to strengthen the metropolitan export base and to focus on tradable services, which often benefit from the dense urban fabric. In this respect, the evidence in chapter 4 and the experiences of the case study metros suggest that knowledge-intensive business services (KIBS) and information and communication services (ICS) could offer promising opportunities for new (export-intensive) path developments through related diversification. This is confirmed by the results of an empirical SWOT analysis for the KIBS and ICS sectors in metropolitan Vienna, using the same methodology as for urban manufacturing.

According to the results (shown in Figure 5.3), **all** 4-digit industry classes of both information and communication services (blue) and knowledge-intensive business services (green) are localized in the metropolitan region. Moreover, most of these industry classes (82%) are also in a dense regional network of related industry classes, so they can be classified as strengths. Of these, a range of knowledge-intensive business services[98] as well as communication services[99] are particularly significant in terms of employment in the Vienna metropolitan region. In addition, most of the information services in metropolitan Vienna[100], although usually smaller in terms

[94] E.g., repair of electronic and optical equipment – C 33.13, repair of other transport equipment – C 33.17, production and trade of electricity – D 35.11, D 35.14

[95] E.g., manufacture of jewelry – C 32.13, C 32.12 and of musical instruments – C 32.20, striking of coins – C 32.11.

[96] This includes manufacture of motor vehicles – C 29.10, other parts for motor vehicles – C 20.32, or air and spacecraft – C 30.30

[97] This includes manufacture of special-purpose machinery – C 28.99, plastics machinery – C 28.96 or machinery for paper production – C 28.95

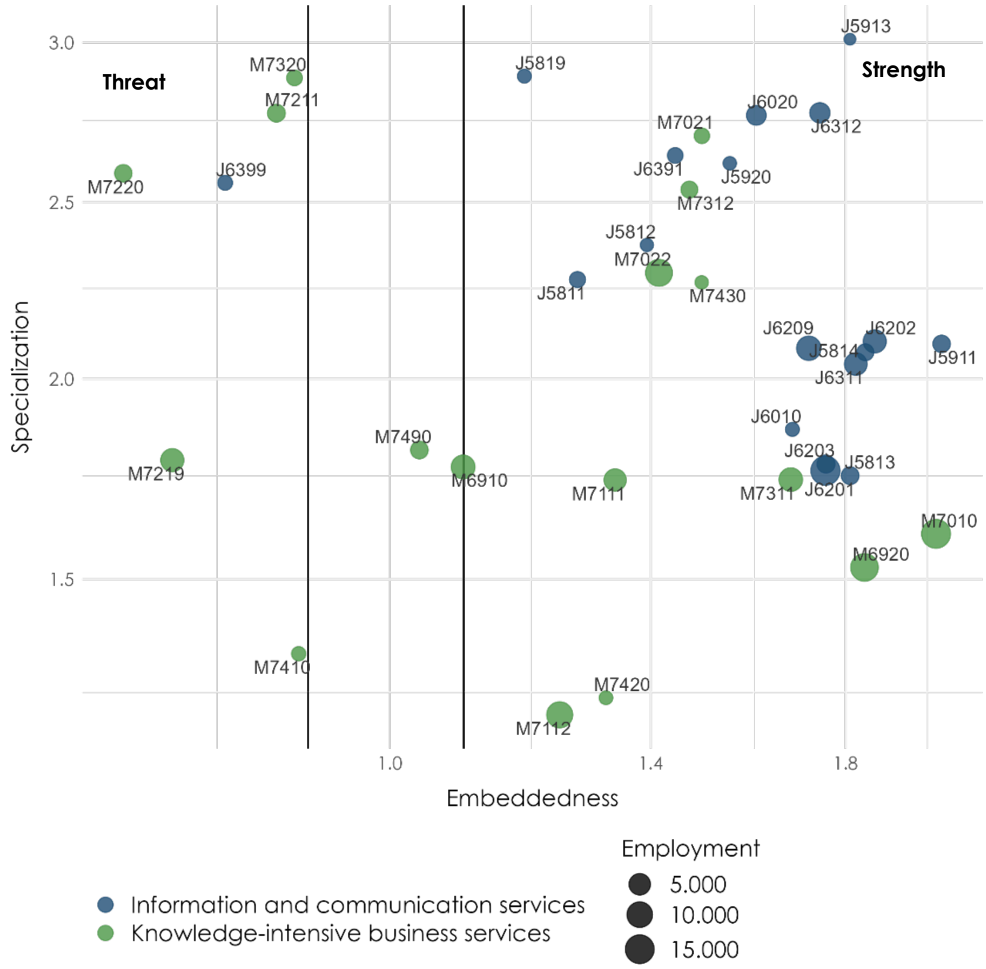
[98] E.g., business and management consultancy – M 70.22, activities of head offices – M 70.10, accounting, bookkeeping, tax consultancy – M 69.20, advertising – M 73.11, engineering activities and technical consulting – M 71.12 or architectural activities – M 71.11

[99] E.g., computer programming – J 62.01, web portals – J 63.12, computer consultancy – J 62.02, data processing – J 63.11, or other IT/computer services–- J 62.09

[100] E.g., motion picture/TV programming, production and distribution – J 59.13/J 60.20/J 59.11; sound recording – J 59.20; publishing activities – J 58.14/19/11/13

of employment, are highly specialized and embedded in the region, and thus enhance the Viennese strengths in tradable service industries.

Figure 5.3: **SWOT position of ICS- and KIBS industry classes in Vienna metropolitan region**
Degree of specialization and embeddedness in the regional branch network; 4-digit industry groups; 2022



Source: Austrian Labor Market Service / Federal ministry of labor and economy; WIFO calculations. – Only industry groups with 100 or more employees in the regions are shown.

From a regional policy perspective, it is especially relevant that the core region alone accounts for the broad strengths of the Vienna metropolitan region in knowledge-intensive (tradable) services. This is shown by separate SWOT analyses for its two subregions in Figure A. **6** (core city) and Figure A. **7** (commuting zone) in the Annex. Indeed, the degrees of specialization and embeddedness are (sometimes significantly) higher in the core city than in the entire metro region for **all** industry classes of the KIBS and ICS sectors.

By contrast, the commuting zone has no strengths in both knowledge-intensive service sectors. Here, the relevant industry classes are mostly classified as weaknesses and are relatively small in terms of employment. Moreover, the local industrial fabric, which is strongly oriented towards agriculture and manufacturing, offers few opportunities for new path developments in knowledge-intensive services, except for engineering activities and technical consulting (M 71.12) with its strong relatedness to manufacturing industries.

These results show that the SWOT profiles of the two subregions of the Vienna metropolitan region differ significantly due to different location conditions, but also configurations of the local industrial network and thus different "docking options" for related industries. Strengths in manufacturing in the commuting zone contrast with considerable advantages of the urban core in knowledge-intensive (business) services, while goods production finds a favorable industrial "ecosystem" only in a few, mostly innovation-intensive industries here.

Structural policy initiatives that aim to diversify existing industrial strengths and promote new path developments in export-oriented industries should consider this intra-metropolitan specialization. For the City of Vienna (as the major policy actor in the core metropolitan area) this means that initiatives to strengthen the urban export base should also emphasize the tradable services sector, especially knowledge-intensive business services and IC services. These industries have rapid product differentiation, so new opportunities constantly arise in market niches. Moreover, such services can be "door openers" for other internationalizing firms, creating possible self-reinforcing effects.

In the manufacturing sector, however, opportunities to develop new export-oriented activities in Vienna's core city are rather limited and mainly relate to innovation-intensive industries. A promising policy for urban manufacturing, especially in the metro's core, will therefore mainly focus on research, innovation, and qualification policy initiatives to cater for the needs of those industries remaining in the city. These initiatives will clearly have to go beyond manufacturing proper: As dispositive functions are increasingly integrated in manufacturers' value chains and production becomes increasingly "servo-industrial" and hybrid, the city's rich endowment in complementary knowledge-intensive services could be a significant advantage for maintaining a competitive manufacturing sector even in the core city. This argues for a thematic rather than sectoral approach in fostering new industrial path developments through related diversification, an approach that links manufacturing and service activities to enhance existing strengths and diversify them into new activities. However, such an approach will only realize its full potential if it is set up at the metropolitan level and can exploit the different strengths of the core city (in knowledge-intensive services) and its metropolitan hinterland (in manufacturing).

5.3.2 Unrelated diversification: Preconditions in the regional innovation system

Besides these topical development strategies, urban development strategies must also address the development of new technologies and thus unrelated diversification. Based on the case studies, regional development based on such radical innovations requires a strong link between basic research institutions (such as universities) and businesses, as well as a well-developed regional innovation system. Therefore, a successful implementation of such strategies requires a good understanding of the strengths and weaknesses of the regional innovation system in Vienna. Although a comprehensive comparative analysis of this regional innovation system is beyond the scope of this study, partly due to the limited data availability[101], some comparisons can be made regarding key input and output indicators of this system. These generally suggest that the case study metropolitan regions considered in this study are some of the leading research locations worldwide, with which Vienna can hardly compete, despite its rather favorable position in a European context[102].

In particular, the university system of many of the North American metropolitan regions is much better developed than Vienna's. This is evident when considering the Shanghai ranking of universities, as one of the most widely used world-wide university rankings (Table 5.1). This is most apparent in Boston, San Francisco, and Seattle. These metropolitan regions all host at least one of the top 20 universities in the ranking (Boston: Harvard University, MIT; San Francisco: University of California in Berkeley, Stanford University; Seattle: University of Washington) and in the case of Boston and San Francisco several more universities in the top 300. However, also the other case study metropolitan regions are the location of universities (such as McGill University in Montreal or the University of Pittsburgh) that are well established among the top 100 research institutions worldwide. The only exception is Atlanta, where the highest-ranked university (Emory) is not within the top 100, as is the highest-ranked Austrian University, the University of Vienna)[103].

Similarly, when assessing research output in areas that are likely to be key technologies for future economic development such as artificial intelligence, the basic research institutions in the case study metropolitan regions outperform Vienna by far. Here, a recent ranking of the publication output of universities in artificial intelligence by Brühl (2023) shows that all of the North American case study metropolitan regions except for Atlanta host one of the top 50 publishing universities in artificial intelligence, while this does not apply to Vienna (see Table 3.1). This clearly indicates that the preconditions in basic research that are the foundation for much of the (radically) new path developments are substantially less favorable in Vienna than in most of the North American case study metropolitan regions.

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[101] Regional comparisons in this chapter are based on indicators at the TL2 level, due to lacking data at regionally finer grids. This is comparable to a NUTS 2 level in the regionalization of Eurostat. This is problematic as the TL2 level for Vienna only encompasses the core city, whereas for the North American case study metropolitan regions it is substantially larger. Since innovative activities are mostly located in the metropolitan cores, this suggests that TL2 comparisons are biased in favor of Vienna. Our finding that Vienna lags the North American case study regions in most indicators may therefore even underestimate the RIS-based disadvantages of Vienna for unrelated diversification.

[102] According to the results of a recent study Vienna has the 6th highest R&D expenditure share in GDP among the European 1st-tier metropolitan regions, ranks among the top three 1st-tier European metropolitan regions in terms of both the absolute number of PhD students and the number of PhD students per 100.000 inhabitants in Vienna, is among the top 20 regions in terms of scientific publications and also ranks among the top ten 1st-tier European metropolitan regions in terms of internationally co-authored publications and participation in international collaborative projects funded through Horizon 2020 sources.

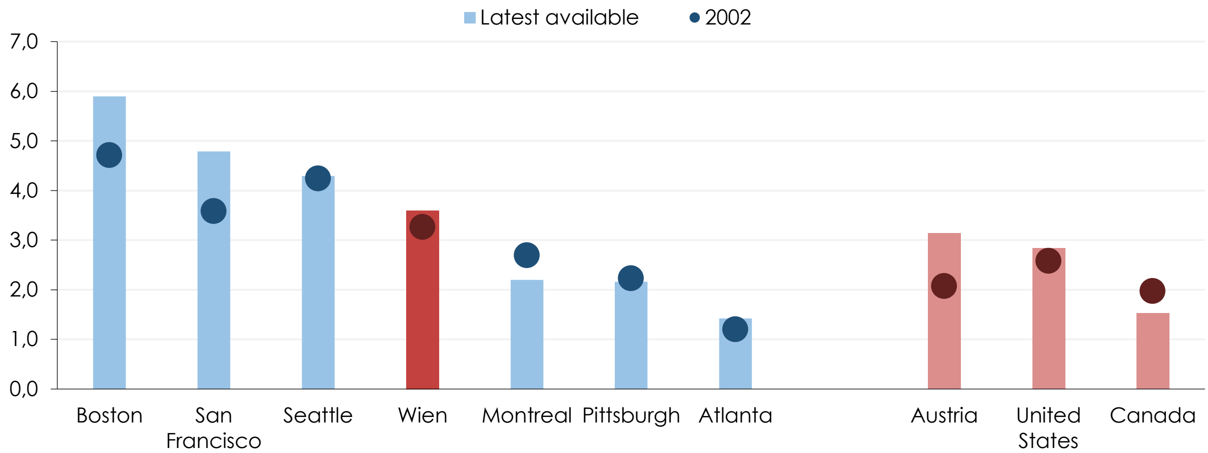
[103] The University of Vienna is ranked under the top 150 research institutions and the Medical University of Vienna as well as the Vienna University of Technology among the top 300 institutions, only.

Table 5.1: **Universities in Vienna and the case study metro regions (Ranking in the Top 300 of the Shanghai University Ranking and the Top 50 in publications in AI)**

Rank	University	Location	Rank	University	Location
Shanghai Ranking			Publication ranking in artificial intelligence		
1	Harvard University	Boston	1	Carnegie Mellon University	Pittsburgh
2	Stanford University	San Francisco	3	University of California, Berkeley	San Francisco
3	Massachusetts Institute of Technology	Boston	4	Stanford University	San Francisco
5	University of California, Berkeley	San Francisco	7	Massachusetts Institute of Technology	Boston
18	University of Washington, WA	Seattle	21	University of Washington, WA	Seattle
21	University of California, San Francisco	San Francisco	24	Harvard University	Boston
63	University of California, Sta Barbara	San Francisco	42	University of Montreal	Montreal
70	McGill University	Montreal	-	-	-
83	University of Pittsburgh	Pittsburg	-	-	-
101-150	Boston University	Boston	-	-	-
	Carnegie Mellon University	Pittsburgh	-	-	-
	University of Vienna	Vienna	-	-	-
	Emory University	Atlanta	-	-	-
151-200	Georgia Institute of Technology	Atlanta	-	-	-
	Tufts University	Boston	-	-	-
	University of California, Santa Cruz	San Francisco	-	-	-
	University of Montreal	Montreal	-	-	-

Source: Brühl (2023).

Figure 5.4: **R&D in Vienna and the case study metropolitan regions**
TL2 regions; R&D total expenditure in % of GDP, 2002 and latest available

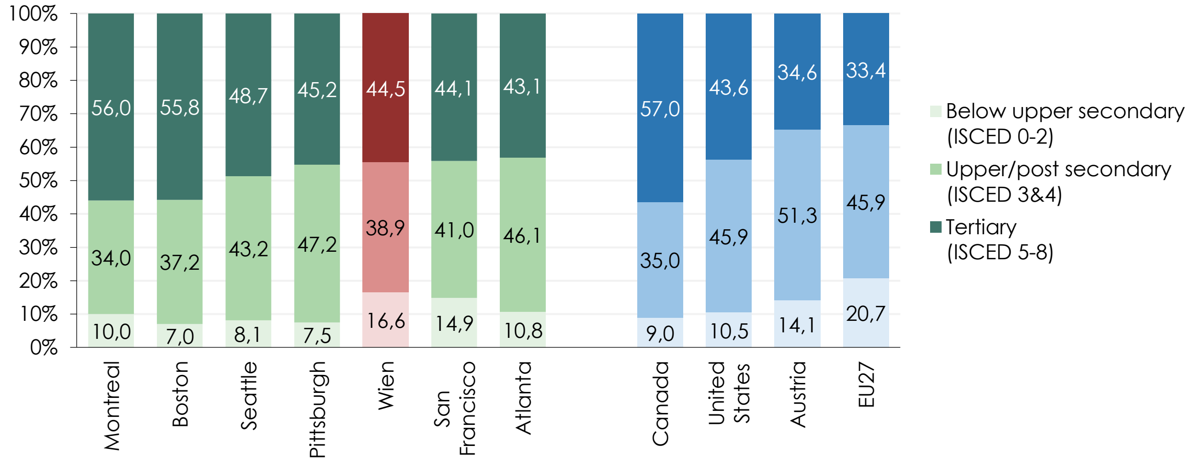


Source: OECD City Statistics. – Latest available data: 2018 (Austria, United States), 2017 (Canada, Vienna), 2014 (TL2 regions US and CA).

The regional innovation system shows similar patterns in most other measurable aspects. For example, Figure 5.4 compares the R&D expenditure as a percentage of GDP for the Vienna metropolitan region and the US case study metropolitan regions. Vienna ranks only in the middle ranges and falls far behind the leaders (Boston and San Francisco), even though the comparison favors Vienna because it uses the TL2 level, which covers only the core city for Vienna but a much larger area for the North American regions.

Moreover, Figure 5.5 shows the qualification structure of the resident population. In comparison to the North American cities Vienna has a higher share of residents, who have not completed upper secondary training. It ranks in the middle ranges of the North American case study cities in terms of the percentage of residents who have completed tertiary or upper secondary education, despite this indicator using the TL2 level again.

Figure 5.5: **Qualification structure in Vienna and the case study metropolitan regions**
TL2 level; Highest level of completed education (ISCED 2011); latest available year; share of 25-64-year-olds in %



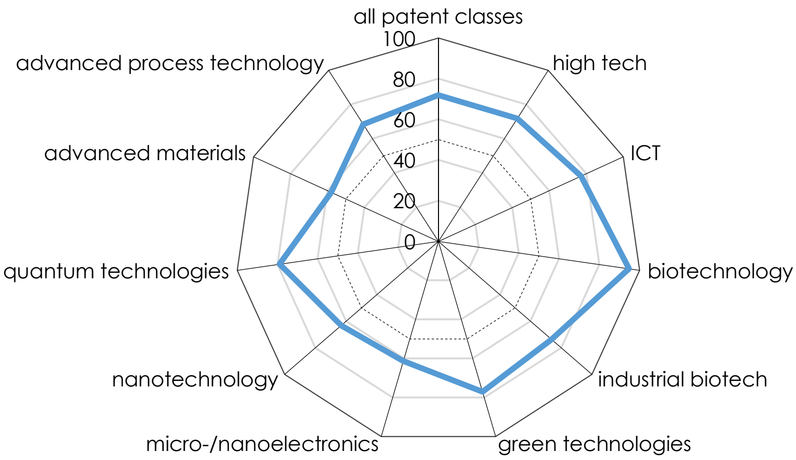
Source: OECD City Statistics. – Latest available data: 2021 (Austria, EU27), 2020 (Canada), 2019 (USA).

These results show that Vienna, although performing well with its regional innovation system in a European context, lags far behind the North American case study cities in terms of the quality of its basic research institutions and most other indicators related to the regional innovation system.

From a policy perspective this suggests that, unlike some of the North American metropolitan regions, Vienna would benefit more from a more focused strategy that targets excellence in specific research fields and key technologies, rather than a broad approach that aims for technological leadership in all research fields. The patenting activities in Vienna compared to the 1st-tier European metropolitan regions might indicate the type of specializations that could be pursued, rather than a comparison to the US case study metropolitan regions in this study. Figure 5.6 reports the percentage rank of the Vienna metro region within the 1st-tier European metropolitan regions in terms of patents in key enabling technologies with the European patent office[104].

Figure 5.6: **Patenting in Vienna as compared to the European 1st-tier metro regions: "Key Enabling Technologies (KETs)"**

International patent applications 2010-2017 (cumulated) by location of inventor, percentage rank among the 58 EU28 1st -tier metropolitan regions



Source: European Patent Organization (PATSTAT); WIFO calculations. – The percentile rank indicates for each technology field the share of all EU metropolitan regions with equal or less patents in the population of the 58 1st-tier metropolitan regions. For the delineation of the KET-technology fields cf. Eurostat (2009) http://ec.europa.eu/eurostat/cache/metadata/Annexes/pat_esms_an4.pdf as well as IDEA et al. (2012), For the delineation of biotechnology and ICT cf. OECD (2008) http://www.oecdorg/sti/oecdworkonpatentstatistics.htm, for green technologies OECD (2015) http://www.oecd.org/env/consuption-innovation/env-tech-search-strategies.pdf.

Figure 5.6 shows four potential areas of emphasis for Vienna based on its patenting activities. The first and most developed is biotechnology, where the Vienna metropolitan region ranks among the top 10% of the 1st-tier metropolitan regions in the EU. This is mainly due to the Vienna biotech cluster, which has emerged in the last three decades as a collaboration of several large research institutions in the life sciences. According to Wirth (2021), this cluster has had some impact on local economic development through spin-offs, patents, and cooperation with enterprises. The second and third are information and communications technologies and green technologies, of which information and communication technologies were also identified as strongholds of the Viennese economy in chapter 4 of this study. The fourth is quantum technologies, which is closely related to quantum computing, a field that has attracted

[104] This figure is organized in such a way, that the top regions in terms of the number of patent applications receive a score of 100 and the remaining regions receive a score that is equivalent to their rank in the number of patents within the 56 considered regions. Therefore, a score of 90% implies that Vienna ranks in the top 10% among the 56 1st-tier metropolitan regions considered.

significant interest from leading enterprises after one of its pioneers, who teaches in Vienna, won the Nobel Prize in 2022.

5.3.3 (Multi-scalar-) Agency

Vienna will need to make consistent efforts to further strengthen its regional innovation system and improve the conditions for the emergence of new path developments through both related and unrelated diversification. It will need continuous (horizontal) measures to enhance the quality of regional universities, to encourage the research and innovation orientation of regional companies, and to support startups.

However, an institutionally "thick" and diversified innovation system alone may not be enough to foster (radical) new path developments, because it is (necessarily) aligned with the existing companies and industrial paths at the location. Therefore, targeted (vertical) interventions will also be necessary to modify existing assets at the site (such as skills, infrastructures, support programs and agencies, regulations, etc.) in favor of emerging paths. Since such transformative changes in the existing system may require the cooperation and commitment of a wide range of relevant actors at the site (e.g., firms, research institutions, support agencies, etc.), they may face resistance from established incumbents. Therefore, effective leadership and strategic communication are crucial in legitimizing the new activities internally and externally and highlighting their benefits for the site and its existing actors.

The regional economic policy has limited ability to initiate such asset modification in favor of new developments, considering the large number of actors involved and the scale of financial resources available at the regional level[105]. Nevertheless, the regional public sector can be a key initiator by reducing the risk of new activities (e.g., through subsidies or guarantees), by acting as a moderator and coordinator in the transformation process, and by taking a role as a first mover (e.g., through mission-oriented research programs and targeted public procurement).

In fact, our case studies for the North American metropolitan regions show several examples where vertical public interventions have been successful in supporting new activities and industrial path developments. A notable example is Pittsburgh, where a substantial part of the turnaround after the steel crisis was based on a combination of strong political leadership by Mayor Tom Murphy and the activities of several (often nonprofit) organizations that have become major supporters of Pittsburgh's economic transformation, providing examples of the kind of institutional innovation necessary to overcome the institutional "lock-in" that characterizes mono-industrial regions in particular. One such actor is the Allegheny Conference of Community Development, which created the Southwestern Pennsylvania Growth Alliance to address fragmented policy actors in metropolitan regions and improve their competitiveness in securing state funding. Other examples include the Southwestern Pennsylvania Commission, which aims to coordinate public transport within the region, and various other policy networks and

[105] As an example, according to Statistics Austria, only 3.5% of the R&D conducted in the metropolitan core of Vienna was funded by the City of Vienna in 2019. Funds from regional economic policy were thus incomparably less significant than those from the federal government (20%), foreign countries (17%) and, of course, the corporate sector (55%).

foundations (e.g., Ben franklin Technology Partners, Heinz Endowments, PHG Innovation works) that have contributed to coordinating and funding individual development initiatives. Another example is Montreal, where numerous cluster initiatives (including some more and some less successful ones, as discussed in more detail in the case study) have aimed to support the development of new activities within the city.

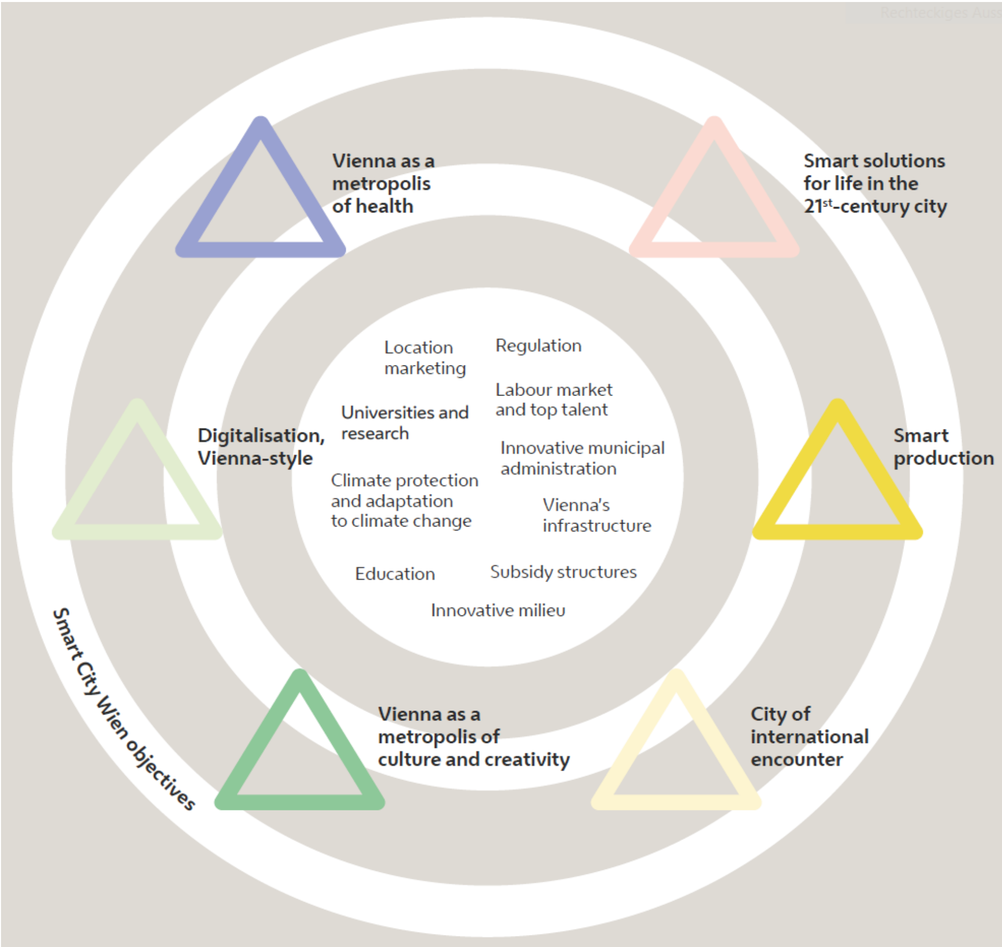
The City of Vienna is also pursuing vertical initiatives to further develop promising areas of strengths with potential international visibility, as in the case study examples. These initiatives are conceptually well designed, but they still have room for improvement in implementation. The strategy "VIENNA 2030 – Economy & Innovation" (Stadt Wien, 2019a) provides the guiding basis for action. Building on the objectives of the overarching "Smart City Wien Framework Strategy 2019-2050" (Stadt Wien, 2019), this strategy defines six "areas of leadership" that are assumed to have special strengths, competences, and capabilities in Vienna (see Figure 5.7).

The aim is to develop innovative solutions in these key areas by 2030 that can compete internationally. For each "area of leadership", a "topic managers" was appointed from a key firm or institution in the respective area. They are responsible for the systematic participation of the relevant stakeholders and the leverage of synergies between the firms and organizations in the field. The strategy is mainly implemented through "flagship projects" that are intended to drive development in the six areas and are (co-)financed by the City of Vienna. The Vienna Economic Council, a body consisting of high-ranking representatives of business interest groups, social partners, and relevant research institutions at the location, awards new flagship projects annually. The results and progress in the implementation of the strategy are presented and discussed in large-scale annual innovation conferences, which target a wider audience.

From a conceptual point of view, it is undoubtedly positive that the six "areas of leadership" pursued by the strategy are thematic rather than sectoral, aiming to link and bundle existing strengths across the boundaries of industries and economic sectors, and to gain an international profile in wider thematic priority fields. In fact, all areas defined in the strategy integrate industries from manufacturing and services, which reflects the increasing importance of servo-industrial, "hybrid" forms of production as well as Vienna's strength in knowledge-intensive services (see chapter 5.2). This and the attempted linking of the businesses and the relevant research institutions in the respective fields are likely to promote a wide range of diversification processes into new activities. In addition, an early empirical evaluation of the selected focus areas (Firgo et al., 2021) using a methodology like in chapter 5.2 showed that all "areas of leadership" defined can be regarded as viable and worth pursuing in terms of localization and embedding in the regional industry network of the core city of Vienna.

However, this analysis also showed that the defined "areas of leadership" are at very different stages of development, and that some of them have gaps in the networks of related industries. This will have to be considered in the further implementation of the strategy, for example, by differentiating the measures for each thematic area and by targeted initiatives to strengthen important but weak industries in its network. In particular, here the case study evidence on less successful initiatives provided by Montreal would suggest that securing the support of the local business community and avoiding overly ambitious aims that could be seen as mainly "marketing motivated" will be important elements to consider when developing the more nascent technologies.

Figure 5.7: **Targeted "areas of leadership" ("Wiener Spitzenfelder") as defined by the strategy "VIENNA 2030 – Economy & Innovation"**
Thematic focus areas and fields of strategic action to develop them



Source: Stadt Wien (2019a).

Moreover, the defined "areas of leaderships" are quite generic and broad in most cases, which reduces the likelihood that vertical initiatives in their favor will make a real difference, given the limited funds available. This suggests that these priority areas should be further refined where necessary, and that targeted measures should focus mainly on those niches in which the current constellation of actors promises new solutions and activities that can compete internationally.

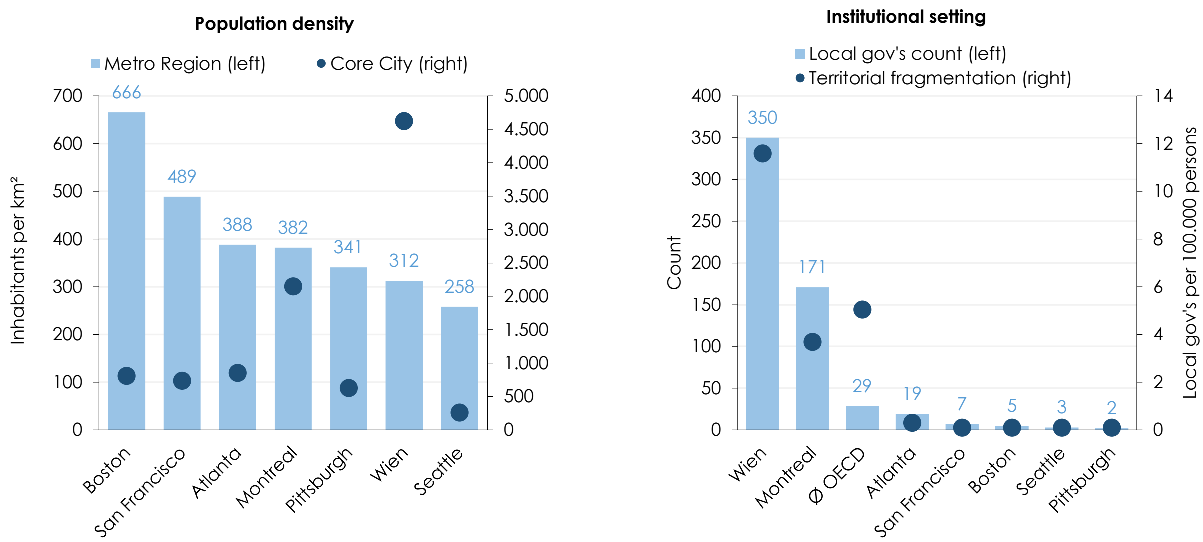
Finally, the implementation of the goals of the "areas of leaderships" through flagship projects, although efficient from an organizational point of view, does not ensure that the diverse entrepreneurial and institutional actors in the respective area develop a shared development vision and perspective for implementation. These would be crucial for a broad commitment to the defined thematic goals and thus the effectiveness of the approach. It will therefore be important to ensure that the flagship projects, in terms of design and selection, stimulate dialog between the actors involved, contribute to networking and cooperation between the firms and research institutions in the field, and open space for joint experimentation and the development of shared ideas that bring forth new activities.

The main shortcoming of this approach for developing promising new activities in selected "areas of leadership" through vertical initiatives is, however, that – as part of the "VIENNA 2030" strategy of the City of Vienna – it only applies to the core city of metropolitan Vienna. This significantly limits its potential impact: Structural policy initiatives must take a metropolitan perspective in an economically integrated functional urban region. This is especially true for metropolitan Vienna, whose sub-regions have different specializations with clear strengths in services in its core region and in manufacturing in the commuting zone, respectively (see chapter 5.2). In view of increasingly hybrid forms of production, this could open considerable advantages from intra-metropolitan division of labor if coordinated action is taken. Joint initiatives at the metropolitan level, which support diversification and thus favor new path developments, therefore promise high returns, but are difficult to implement in view of the fragmented governance structure in Vienna metro region. Again, here the case study evidence on Pittsburgh suggests that such cooperation is easier to achieve when it focuses on concrete shared goals (such as increasing central government funding) of the partners.

In fact, metropolitan Vienna may have a higher need for metro-based initiatives in several policy areas than the North American case study metro regions. However, these initiatives also face more barriers in metropolitan Vienna, due to its complex and fragmented institutional setting. Figure 5.8 illustrates this with a few indicators.

One such policy area is metropolitan land policy, as all case studies identify the lack of available land as a major reason for deindustrialization and the displacement of export-led production from the metro regions. The left panel of Figure 5.8 shows by a simple comparison of population densities in these regions that this problem is likely to be particularly pronounced in Vienna, due to a highly monocentric settlement structure. While the Vienna metro region as a whole is less densely populated than most North American case study regions, its metropolitan core is not. The population density in the core city of Vienna is more than double that of the second ranked case study region (Montreal), and 6 to 9 times that of the US metro's city cores.

Figure 5.8: **Territorial preconditions in Vienna and the case study metropolitan regions**
FUA-level



Source: OECD City Statistics; WIFO-calculations. – Population density (2020): inhabitants per km². Local gov's count (2022): local governments in FUA. Territorial fragmentation (2020): local governments per 100.000 inhabitants.

Problems arising from a lack of space and conflicts of use between commercial and residential development are therefore particularly pressing in Vienna's core city. The City of Vienna has developed a technical concept ("Productive City"; Stadt Wien, 2017) to secure suitable land for producing firms through urban planning guidelines. This concept identifies operational zones for industrial uses in deep spatial granulation and prohibits conversions (e.g., for residential purposes) based on an inventory of available land and forecasts of the expected space requirements in producing industries. This can help to reduce the pressure on business uses from a lack of space and competition for land in the growing city if it is implemented consistently in zoning and not weakened by exceptions in individual cases. However, this concept, like the "VIENNA 2030" strategy above, only applies to the core city of the Vienna metro and does not consider the disproportionally richer land resources of the metropolitan commuting zone. This means that potential benefits at the metropolitan level, such as a more diverse land supply and a better alignment with the needs of various users, are not exploited.

Similar examples of sound economic policy approaches, which, however, are limited by the boundaries of the administratively delimited city and thus do achieve the full impact that would be possible with intra-metropolitan cooperation and steering, can be found in several policy fields in Vienna. One reason for this is an extremely complex and fragmented governance structure in metropolitan Vienna with a multitude of governmental actors. As shown in the right panel of Figure 5.8 the OECD counts 350 local governments with formal powers in spatial planning and local economic development here, much more than in the case study metro regions, some of which are much larger. The number of local governments per 100,000 inhabitants in metropolitan Vienna is thus more than three times higher than in Montreal and exceeds that in most US metro regions by a factor of 100. This may explain why issues of metropolitan governance are mostly not a priority in the case studies. In Vienna, by contrast, it is a major problem, especially since the distribution of formal responsibilities among its (many) governmental actors requires consensus for joint activities for metropolitan development.

For example, the Austrian government has no formal authority in spatial planning and regional economic policy, which is a problem itself, since many of its policies (such as transport, infrastructure, qualification or research policy) have strong spatial effects. The federal states have the authority in supra-local spatial planning and regional economic development, and three of them share responsibility in metropolitan Vienna[106], each with its own planning regimes, economic concepts and actions as well as partly long-standing political differences. Finally, the almost 300 municipalities in the region are responsible for local spatial planning and the implementation of planning developments. They are also in charge of zoning and local development plans. The federal states (as the supra-local planning authority) can annul their decisions in individual cases, but they cannot force them to make specific dedications. Therefore, proactive spatial development initiatives require the (joint) consent of the municipalities involved. Intra-metropolitan cooperation is further complicated by the fact that most of these municipalities are rather small, what makes it hard to work together "at eye level"[107]. In addition, the financing of the Austrian municipalities is based mainly on their population size (as basis for allocations from federal taxes), and a community tax based on the local payroll, which creates incentives for locational competition rather than cooperation.

In view of this, attempts to strengthen intra-metropolitan cooperation and to develop effective strategies and actions at the metropolitan level have been highly controversial and conflictual in the metropolitan region of Vienna and the case studies (e.g., on Seattle) point to repeated conflicts over such issues. In view of the increasing empirical evidence demonstrating the productivity- and growth-harming effects of administrative and economic policy fragmentation in metro regions[108], persistently striving to enhance and deepen such cooperation remains a pressing issue, at least in Vienna. A recent WIFO study (Mayerhofer & Huber, 2019) has developed ideas on how and based on which incentives and instruments progress could be made here, despite the challenging institutional set-up in the region. Such progress would be necessary to raise cooperation and the coordination of economic policy interventions in and for the metropolitan region to a level that matches the degree of economic interdependence reached in metropolitan Vienna. Cooperative approaches to spatial and economic development in the region could include intermunicipal business parks, intra-metropolitan networking activities, joint master planning for city-regional target areas, joint marketing efforts for the metropolitan region, cooperative land management, and considerations on spatial industrial specialization within the metro region.

[106] The City of Vienna (as federal state as well as municipality) is in charge with the metropolitan core city, while the federal states of Lower Austria and Burgenland share authority in the commuting zone.

[107] Most of the municipalities in the metropolitan commuting zone have less than 1,000 inhabitants. In many cases, these municipalities barely reach one ten-thousandth of the population of the municipality of Vienna.

[108] These detrimental effects are because territorial fragmentation reduces efficiency-enhancing agglomeration economies of metropolitan regions. For an overview of the empirical literature on this topic, see Mayerhofer & Huber (2019).

6. Summary and policy conclusions

This study aimed to explore what lessons, if any, Vienna could learn from the experience of North American cities in developing new opportunities for export-oriented production that are compatible with a high quality of life in metropolitan regions. To this end, case studies on six North American metropolitan regions that combined a high level of economic development, and a high quality of life were conducted. These case study metropolitan regions were Atlanta, Boston, Montreal, Pittsburgh, San Francisco, and Seattle. The current report synthesizes these case studies, compares the respective case study metropolitan regions with Vienna based on data and discusses some experiences That could potentially benefit Vienna.

Both our own data analysis and the case studies in this project indicate that the metro regions studied are very different. This applies to virtually all indicators related to demography, land use, economic performance, labor market situation, and quality of life and is evident for comparisons between the North American metros as well as between this group and metropolitan Vienna. Compared to the selected US metros, the core of the Vienna metropolitan area, due to its historically grown borders, is much smaller and denser, which may pose greater challenges in providing land for both commercial and residential uses and in maintaining sufficient green spaces and a high environmental quality.

More importantly, at the level of the metropolitan region, which is a more suitable geographical unit for international comparisons, Vienna is smaller in terms of population than most of the selected North American metro regions and has lower GDP per capita and productivity levels than all the North American case study metros except for Montreal. Moreover, Vienna has the lowest GDP per capita as well as productivity growth among all the metro regions covered (including Montreal). This is remarkable from a policy perspective, as this growth disadvantage in both GDP per capita and productivity suggests that Vienna has not been able to exploit the recent demographic growth of the region economically. This contrasts with the North American case study metro regions that have experienced population growth on a similar or even larger scale.

When comparing Vienna to the selected North American metro regions, we are therefore looking at economically very successful locations, likely to have access to a much larger resource pool (e.g., in talent, research capabilities and funding) and facing rather different locational advantages and disadvantages. This focus on some of the economically most developed locations, together with the substantial heterogeneity between them, suggests that any solutions developed in the case study metropolitan regions are likely to be highly place specific. Therefore, issues of transferability must be taken very seriously when drawing policy conclusions for Vienna from the case study evidence.

6.1 Reducing the impact of deindustrialization

Despite this heterogeneity, all case study metropolitan regions as well as Vienna have seen substantial employment losses in manufacturing in recent decades. However, a detailed analysis of this deindustrialization process indicates that Vienna's experience has differed somewhat from that of the North American case study regions. In particular, employment losses in manufacturing in Vienna were slightly lower than those in the North American metropolitan. At the same time, the factors behind these employment losses were quite different. In the North American metropolitan, these losses were mainly due to productivity growth in manufacturing and thus a (labor-saving) "upgrading" in efficiency. Moreover, this happened in an environment where GVA growth in the metro region total exceeded national growth (in all case study metro regions except Pittsburgh). In Vienna, by contrast, productivity gains contributed less to manufacturing employment losses than in the North American case study metro regions, and genuine deindustrialization, also affecting the output side, was more significant. This was reinforced by a sluggish growth of metropolitan Vienna's economy total. This points to a weakness of Vienna (compared to the North American case study metropolitan regions) in fostering growth and the emergence of new economic activities, whether export-based or not, both within and outside the manufacturing sector.

This comparative disadvantage of Vienna only applies compared to the North American case study metropolitan regions, which are also the leaders in their respective countries. Compared to the EU27 1st-tier metro regions, Vienna has more similar characteristics in manufacturing evolutions as well as metropolitan performance (see Mayerhofer et al. 2021). Nonetheless, the big lead of the US metro-regions suggests that policies supporting innovation and entrepreneurship, along with education and active labor market policies aiming to ensure a sufficient supply of highly skilled workers, should be a high priority in Vienna. This is regardless of whether these policies target manufacturing and/or other export-based activities.

In terms of structural policies, a recent WIFO study (see Mayerhofer et al., 2021) provides detailed policy recommendations that follow three main strategic lines:

- Developing existing strengths in the export-oriented sector further by increasing their international visibility and supporting networking and thematic bundling, with the aim to diversify these strengths by cognitively related, but still little developed activities.
- Paying more attention to industries with medium skill requirements to prevent a further polarization of Vienna's employment structure and to ensure sufficient opportunities for upward mobility for employees in low-skill industries.
- Fostering the emergence and early development of startups more strongly, given low startup rates in a European comparison and hence low turnover at the firm level, which hampers a diversification into new activities.

In terms of labor market policies, the same study emphasizes the need for target-group specific education and active labor market policies directed especially at the low-qualified (mostly immigrant) workers to accompany these structural policies. While these policy considerations are not new to the Viennese debate and initiatives in this direction have already been implemented in many fields, the comparison with the North American case study regions highlights the importance of these ongoing activities.

Next to this, the evidence from the individual case studies also points to several policy-relevant practical issues related to the design of spatial planning procedures that impede the development of manufacturing in metropolitan regions. These issues essentially arise from a high competition for land in dense urban environments and, according to the interviews conducted, are often related to:

- Spatial and traffic planning taking too little account of the needs of manufacturing, due to a lack of involvement of entrepreneurs and firms;
- a lacking coordination of existing long-term economic development plans and existing zoning regulations;
- a sometimes rather haphazard approach to rezoning of land designated to commercial or manufacturing uses; and
- a lack of involvement of local actors in policies aiming at mobilizing land for commercial uses or intensifying land use.

This underscores the high importance of spatial planning and zoning regulations in promoting economic development in manufacturing and beyond. It also suggests that there is a strong need for improved coordination of economic development policies, as well as a high potential for local initiatives aiming at activating additional land for economic uses, as, for example, currently pursued in the framework of the Vienna Business districts project.

Finally, the case studies and a screening of some of the development strategies in the (especially US) case study city regions have revealed a much stronger emphasis on supporting entrepreneurial behavior than commonly seen in a European context. While this is likely related to cultural and institutional differences between the US and Europe in general, it does suggest that a stronger focus on entrepreneurship and on fostering startups might be an essential element of a successful development strategy for Vienna.

A more effective way to support startups would be to coordinate the existing efforts of various actors and to create a coherent and diverse "support chain" that covers all stages of development from seed to growth. The case studies (especially on the leading research regions of on Boston and San Francisco) highlight the importance of

a. offering a range of startup support that caters to both high-tech and less high-tech startups as well as startups in different phases of their development;
b. collaborating closely with universities to foster high-tech startups through such a diverse support system;
c. creating a startup-friendly environment that encourages experimentation and the co-creation of ideas and facilitates the commercialization of new solutions.

The flagship projects within Vienna's "areas of leadership" framework and the regional universities with their incubator programs could play a vital role in this regard. Additionally, startup-friendly (national) regulation and initiatives to encourage entrepreneurship already in elementary education as well as new financing options for young firms, are needed to overcome the potential barrier posed by the weak Austrian venture capital market.

6.2 Areas of continued employment growth and comparative advantage

All the case study metropolitan regions share the common feature of developing new activities outside manufacturing to offset and supplement the losses caused by deindustrialization, while some parts of the manufacturing sector still find locational advantages in metropolitan core cities. Based on our case study evidence, we suggest the following areas as potential areas to serve as the future export base of dense urban spaces:

1. **Skill- and technology-intensive (parts of) production, especially when strongly research-based**: This area mainly includes activities that require close proximity to R&D facilities, frequent face-to-face interaction with researchers, or a highly differentiated demand for certain inputs that necessitates coordination with and among various suppliers of components. Moreover, this area includes activities that demand highly specialized high-skilled personnel and benefit from being located near leading educational institutions in a specific field. Typically, these activities involve intensive research and produce limited batch sizes or only prototypes and blueprints. Therefore, while these activities are highly productive, they may provide only limited employment opportunities. Furthermore, these activities may tend to relocate from the city once they grow or stimulate production growth elsewhere. In any case, the long-term success in the development of such activities depends largely on the ability to provide an innovative environment (i.e., an innovative milieu) that ensures the continued development of innovative ideas in cities.
2. **Tradable services (in particular knowledge-intensive business services and information and communication technology services):** These services have been a major contributor to employment growth and the main drivers in all of the case study metro regions (and Vienna) and even more so in their core cities in the medium term. The locational advantages of core cities for these service industries stem from the access to high skilled labor and the high importance of uncodified (tacit) knowledge in the production processes. In addition, these services contribute to productivity gains in other sectors, due to their intermediary use, and they are (in some cases increasingly) tradable, so that they can make a decisive contribution to the metro region's export base.
3. **"Smart production":** The rise of digital technologies may create new opportunities for a "digitally enhanced" production even in metropolitan core cities. ICT and robotics, combined with big data and AI, may reduce the significance of labor costs in (automated) production, what may lead to a relocation of (parts of) manufacturing to consumer locations in high-wage countries. Moreover, digital technologies enable small batch production and thus a greater "customization" of products, which requires more interaction between producers and customers. A diminishing significance of labor costs may therefore increase the importance of proximity to demand as a locational factor, which may facilitate the (re-)location of production even to metropolitan cores.
4. **New urban crafts-oriented production**: This refers to customized small-scale production of (mostly) hand-crafted consumer products that appeal to a mostly affluent urban population who value high-quality, sustainable, regionally produced and (in part) design-oriented products. Cities provide locational advantages for these types of activities, due to better market access, material supply, cultural access, and brand origin. Moreover, the development of such production is supported by new technological tools (e.g., 3D printer, laser cutter) that enable low-emission processing and the manufacture of small batches and individual items, which in turn allow small-scale and urban-friendly production at small, decentralized production sites. Although these activities are arguably less inclined to

exporting, the case studies suggest that even such locally oriented production may become tradeable in certain contexts. This is the case, especially when the knowledge gained through such production can be codified (e.g., it in the form of trademarks, patents or copyrights) and traded. This suggests that ensuring the access of local producers to such forms of codification, in industries where the immediate product is not tradable, is a further possibility to support the development of urban export bases.

Of these areas in particular the last two mentioned ones are, however, likely to have only a limited impact on the export base of metropolitan regions and particularly of core cities. By contrast, the high technology and strongly research-based activities mentioned in points (1) and (3), while strongly compatible with a high quality of life and high environmental quality, are likely to be associated with only low employment volumes, due to their high productivity.

Therefore, the metropolitan export base relies not only on manufacturing industries, but also on tradable services. These sectors have different location requirements, which create opportunities for specialization and division of labor within the metropolitan area. A SWOT analysis for Vienna, complementing the case study evidence, reveals significant differences in industrial strengths and weaknesses between the core city and the commuting zone. These differences result from varying location conditions, as well as from different patterns of local industry networks and their "docking options" with cognitively/technologically "related" industries. The commuting zone has strengths in manufacturing, while the core city has advantages in knowledge-intensive (business) services and IC services. And while goods production finds a favorable industrial "ecosystem" only in a few, mostly innovation-intensive industries in the urban core, its network of related industries is much broader based in the commuting zone.

This implies that the City of Vienna (as the major policy actor in the metropolitan core) should focus its initiatives on strengthening the urban export base on tradable services, especially knowledge-intensive business services and IC services. These services are rapidly differentiating their products, creating new opportunities in niche markets. Such services can also be "door openers" for other internationalizing firms, generating self-reinforcing effects. Existing funding activities should therefore be adapted to the needs and specifics of knowledge-intensive (business) services. This can be done by expanding the scope of existing programs to include intangible investments and service innovations (e.g., in the transition from prototyping to production, market development, human resource management or internal organizational structure optimization), by removing any remaining barriers for these services in the eligibility criteria for some funding programs, and by encouraging regional agencies to provide more information and consulting services for service-oriented business models.

6.3 Strengthening the regional innovation system

The regional innovation system is one area where the North American case study metropolitan regions have a clear advantage over Vienna. This is especially true for the quality and impact of the local universities. All North American case study metropolitan regions have at least one university in the top 100 of the Shanghai ranking, which measures academic performance and excellence. San Francisco and Boston even have two institutions each in the top 5 of this ranking. Moreover, most of the universities in the North American case study metropolitan regions are also among the best in important and/or emerging research fields, such as in artificial intelligence. In contrast, Vienna has only one university in the top 200 of the global ranking.

Most other aspects of the innovation system also show a similar gap between Vienna and the North American metropolitan regions. For example, Vienna's R&D expenditure as a percentage of GDP is only average among the North American metropolitan regions, even though this indicator favors Vienna because it is measured at the TL2-level[109]. The same is true for the indicator on educational achievement, which also reveals a much higher share of Viennese residents with only compulsory education. Furthermore, the limited evidence on venture capital funded startups suggests that Vienna (and Austria) has a much less developed venture capital market than some North American metropolitan areas, most notably Boston, San Francisco, and Seattle[110].

This finding is largely influenced by the choice of the comparison group, which consists of some of the world's leading metropolitan regions in terms of research and innovation capacity. In a broader comparison of only the EU27 European 1st-tier metropolitan regions (50), Vienna ranks 6th in R&D expenditure share in GDP and among the top 20 in PhD students or scientific publications.

However, from a policy perspective, the significant gap with the North American metropolitan regions suggests that Vienna should adopt a more focused research and innovation strategy, aiming for excellence in some research fields or key technology areas, rather than trying to achieve technological leadership across a wide range of research field. In this respect, an analysis of European patenting data in the European 1st-tier European metro regions suggests four potential areas of emphasis:

1. **Biotechnology**, where the Vienna metropolitan region ranks among the top 10 percent of the EU 1st-tier metropolitan regions in (patented) research output. This is due to the Vienna biotech cluster, which consists of academic and corporate research institutions that collaborate in life sciences topics in close spatial proximity, supporting the strength of pharmaceutical industries in Vienna's industrial fabric.
2. **Information and communication technologies**, which have regained significant patent strength after a temporary decline and represent a stronghold of the corporate sector according to our empirical SWOT analysis.
3. **Green technologies**, where Vienna's patent yield is also well above average compared to the EU 1st-tier metros. These technologies are also crucial for achieving the goals of the "Smart City Wien Framework Strategy", which aims for the ecological transformation of the regional economy to cope with climate change.
4. **Quantum technologies**, which is closely related to quantum computing, quantum communication and quantum sensors, all fields that attracted the interest of some leading

[109] This level corresponds to the core city only in Vienna but exceeds even the FUA level in all the North American regions considered.

[110] For instance, the largest venture capital-funded project in Vienna has a lower financing volume than the tenth largest in Boston or San Francisco.

enterprises in Vienna as a result of the Nobel Prize awarded in 2022 to one of its pioneers, who works and teaches in Vienna.

All these research strongholds are considered in one or more of the thematic "areas of leadership" pursued by the City of Vienna[111]. Therefore, a strategy that focuses on strengthening the basic research institutions and their connections to the local economy is more likely to be successful than policies that try to "pick a winner" based on the experiences of other cities. Moreover, one important lesson from the case study regions is the high importance that universities have for the economic development of the North American regions. This suggests that Viennese policy makers could increase the emphasis given to cooperation with the existing universities in the city.

6.4 The most important takeaways

The main conclusions from the analyses in this project for Vienna are:

1. **New activities are essential**. Vienna has fallen behind the extremely advanced metropolitan regions in this study in economic growth and workforce integration, according to the case study and the empirical analyses. This indicates that Vienna (compared to the North American case study metropolitan regions) has a weakness in fostering growth and new high value-added activities (both export-based and non-export-based) in and outside of the manufacturing sector. To address this weakness, Vienna, needs to strengthen the regional research base, innovation and export orientation of existing firms, as well as startups and entrepreneurship to support their growth. This will create an environment that supports new industrial path developments. The different focus on these issues in regional development strategies and the policy discourse in general is perhaps the most noticeable difference between the North American case study metro regions and Vienna.
2. **Universities shape urban development**. The universities have a key role in shaping the economic development of the case study metropolitan regions, which is a common feature among all of them. This suggests that Viennese policy actors should increase their efforts to support knowledge spillovers and collaborations between academia and business. For example, in Boston, a highly specialized and targeted system of startup support through incubators has emerged from the cooperation between (profit and nonprofit) enterprises. Therefore, Vienna could also benefit from co-funding relevant transfer facilities and programs at the regional universities, providing pre-seed funding for advancing academic research results to market commercialization, and implementing specific incubation programs that promote entrepreneurial thinking at the universities. Moreover, it could be useful to steer the research agenda of Vienna's universities towards topics that are central to the further development of Vienna's economy and its digital and ecological transformation, by funding research chairs, PhD thesis and scholarships, financing mission-oriented research programs, and carrying out flagship projects in the "areas of leadership" defined.

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[111] For example, research in biotechnology seems closely linked with "Vienna as a metropolis of health" and "smart production", research on green technologies with "smart solutions for life in the 21st century city", and research on IC technologies with "digitalization, Vienna style", but also all the other thematic areas pursued.

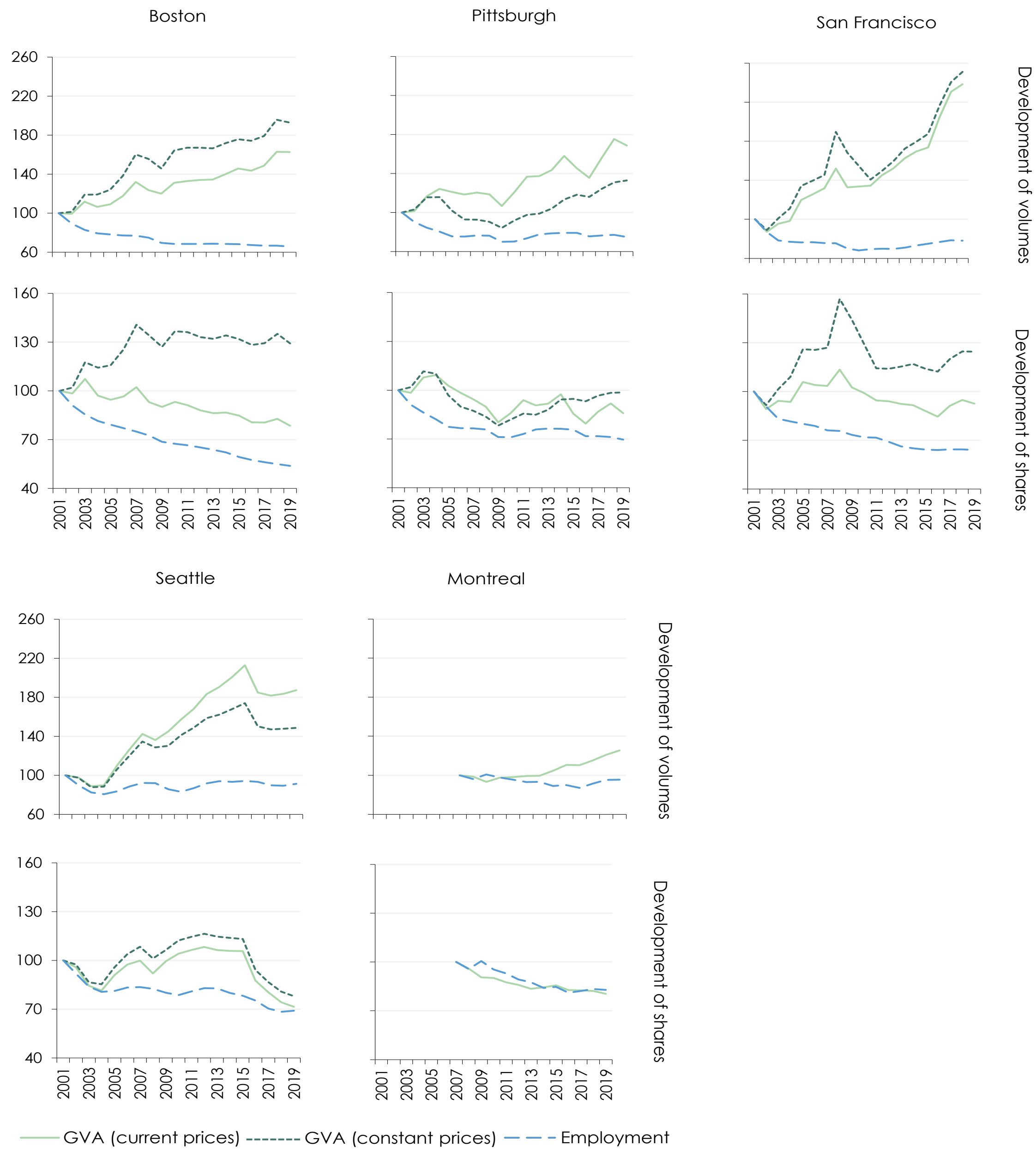
3. **Focus on regional research strengths**. Vienna's regional innovation system is not as strong as most of the North American case study metropolitan regions, which are among the world leaders in research and innovation, according to several key indicators. This is mainly due to the choice of the comparison group, as Vienna fares much better when compared to other EU 1st-tier metro regions. However, this also implies that Vienna has limited regional resources and a broad orientation of national basic research funding, unlike some of the North American case study regions. Therefore, Vienna would benefit more from a regional strategy that focuses on some of its existing or emerging research strengths, rather than trying to achieve technological leadership in a wide range of research or technology fields. International patenting data suggest that biotechnology, quantum technologies, information and communication technologies, and green technologies are some of the potential areas of strength in Vienna. These technology fields are closely related to the "areas of leadership" pursued by the City of Vienna.
4. **Openness to external knowledge is essential**. The North American case study regions may not be very comparable to Vienna in terms of research and innovation, but they still highlight the importance of openness of the regional innovation system and its actors to international influences and knowledge flows the success of research policy. This suggests that Vienna's support system should strongly emphasize international knowledge transfer and the adoptability of regional firms for external knowledge. More importantly, however, Vienna needs to increase the internationalization of its research and take a proactive stance in the international competition for highly qualified personnel. Initiatives that enhance the attractiveness of Viennese Universities for excellent international master's and PhD students in selected fields of study could be useful, as well as the establishment of circular "brain exchange" models of migration through the support of researcher exchange, sabbaticals, and scholarships for both incoming and outgoing researchers. Moreover, Vienna could learn from the "Welcome Services" standards of many North American universities and regions, which offer international researchers and expatriates individually tailored counseling services. Finally, it would be important to have a communication strategy that conveys to the general public the importance of openness and diversity for economic development and counters tendencies towards xenophobia.
5. **Manufacturing is no longer enough to secure the urban export base.** As in the case study metropolitan regions, manufacturing in the core city of Vienna has declined to a few high-tech industries and those serving the regional population, due to the lack of land and weak networks of related industries in some cases. However, some types of manufacturing may still thrive in high-density locations and create new urban dynamics, as shown by the case studies and our empirical analyses. These include new urban crafts-oriented production, skill-intensive or research-based production parts, and "digitally enhanced" production with a low labor cost share. These industries should be supported by combined research, innovation and qualification policy initiatives. However, these industries may have limited impact on employment growth and the urban export base, even though they are compatible with a high quality of life and environmental quality. Therefore, it is necessary to look beyond manufacturing proper for sustainable foundations for the export base in core cities.

6. **Tradable services are drivers of growth and potentially exports in metropolitan core regions.** Our evidence from the case studies and the empirical analysis on Vienna suggests that there is considerable potential in knowledge-intensive services, especially business services and IC services. These industries exploit the locational advantages of urban regions and were the main drivers of employment growth in all case study metro regions (and Vienna) in recent decades. They also contribute to productivity gains in other sectors due to their intermediary use, and they are tradable and can therefore make a significant contribution to the metro region's export base. In addition, in an era of increasingly servo-industrial modes of production, significant potentials for Vienna could arise from intra-metropolitan division of labor, as our empirical analysis has shown considerable strengths in these services in the core city and in manufacturing in the commuting zone. For the City of Vienna, it would make sense to tailor supporting initiatives to the needs and specifics of knowledge-intensive (business) services. This would require intangible investments and service innovations to be more firmly anchored in the regional funding portfolio, and to integrate service-oriented business models more strongly into the consulting activities of the regional agencies.
7. **Development strategies should be coordinated and have metropolitan scope**. Finally, all strategies to strengthen new, innovative activities and economic development must consider the institutional framework in which they are to be implemented. Both the research on other cities and our case studies highlight the need for alignment between spatial planning and economic policy strategies, as well as between the strategies of the core cities and their commuting zones. These are key areas that are often contentious, controversial, and conflict-ridden. It is hard to find sound examples from our case study regions or the broader literature where these coordination issues have been fully resolved. Compared to the case study metro regions, issues concerning intra-metropolitan cooperation and steering seem especially pressing in metropolitan Vienna, given its extremely complex and fragmented governance structure with many governmental actors, including three federal states and more than 300 communities in the agglomeration area. Therefore, consistent, and continuous efforts are required to coordinate the strategies and initiatives of the diverse economic policy actors, to align them with common development goals for the metropolitan region, and to implement cooperative projects, such as intermunicipal business parks, intra-metropolitan networking activities, cooperative land management, or joint location marketing efforts.

7. Annex

7.1 Annex to chapter 3

Figure A. 1: **Development of industry in the case study metropolitan regions in comparison**
FUA level, different performance indicators, Index 2001 = 100



Source: U.S. Bureau of Economic Analysis (Regional Economic Accounts); Institute de la statistique Quebec; WIFO calculations. Montreal: 2007 = 100; no data for real GVA.

7.1.1 Technical supplement to chapter 3: Derivation of the components of manufacturing employment change in the 4-way-decomposition used

The method used in chapter 3 decomposes the employment change in manufacturing into four components that are related to (1) output change in manufacturing; (2) manufacturing productivity gains; (3) the influence of the aggregate performance of the respective region; and (4) the influence of the performance of the respective country.

Starting point is a two-way decomposition of manufacturing employment change, proposed by Tregenna (2009) to analyze de-industrialization at the country level. Its basic idea is that the employment level (L) in a sector i (here: manufacturing) of a region j at time t is, by definition, given as the product of the labor intensity (as the inverse of productivity) in this sector (φ_{ijt}) and its value-added level (Q_{ijt}):

(1)

$$L_{ijt} = \varphi_{ijt} Q_{ijt} \ ;$$

whereby

$$\varphi_{ijt} = \frac{L_{ijt}}{Q_{ijt}}.$$

This implies that *changes* in manufacturing employment can be attributed to effects from changes in sectoral labor intensity (as the inverse of productivity; Equation 2, first term on the right) and from changes in industry output (as an indicator for the performance of the sector; Equation 2, second term on the right):

(2)

$$\Delta L_{ij} = \varphi_{ijt} Q_{ijt} - \varphi_{ijt-h} Q_{ijt-h} = \ (\varphi_{ijt} - \varphi_{ijt-h})\left(\frac{Q_{ijt-h} + Q_{ijt}}{2}\right) \ + (Q_{ijt} - Q_{ijt-h})\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)$$

This approach requires improvement in two aspects if to be applied to data at the regional (here metropolitan) level: Firstly, in a growing economy, an increasing manufacturing output is not a good indicator of manufacturing success. Rather, an increasing output *share* of manufacturing would be an indication of manufacturing prosperity, while an unfavorable development of manufacturing would be reflected in a decrease in this share. Secondly, the performance of manufacturing at the level of individual metropolitan regions is additionally influenced by the growth of the respective metropolitan economy and the respective country total[112]. We take this into account by expanding the two-way- to a 4-way-decomposition of the following form:

[112] The (net) effects from the development of the metropolitan as well as the national economy on employment dynamics in a metropolitan region's manufacturing sector are not clear from a theoretical point of view due to potentially opposing influences: From a demand-side perspective, a positive correlation between these developments and manufacturing employment change is likely, as an upward trend of the (local and/or national) economy total leads to increasing demand for goods from consumers and firms. However, supply-side effects are less clear: On the one hand, a favorable economic development can lead to a deeper and broader supply of inputs and complementary services that metropolitan manufacturing needs to prosper. On the other hand, a booming metropolitan/national economy may result in higher wages, which in turn may reduce incentives to create manufacturing jobs. Hence, only an empirical approach can reveal which of these forces dominate.

(3)

$$L_{ijt} = \varphi_{ijt}\,\delta_{ijt}\,\varepsilon_{jt}\,Q_t\ ;$$

whereby

$$\varphi_{ijt} = \frac{L_{ijt}}{Q_{ijt}};\ \delta_{ijt} = \frac{Q_{ijt}}{Q_{jt}};\ \varepsilon_{jt} = \frac{Q_{jt}}{Q_t}.$$

Based on this identity for the manufacturing employment level in our 4-way decomposition it is possible to derive the following relationships for the *change* in manufacturing employment in the metro region under review:

$$\Delta L_{ij} = \varphi_{ijt}\,\delta_{ijt}\,\varepsilon_{jt}\,Q_t - \varphi_{ijt-1}\delta_{ijt-h}\varepsilon_{jt-h}Q_{t-h} =$$

$$\begin{aligned}
= \left(\varphi_{ijt} - \varphi_{ijt-h}\right)&\left(\frac{\delta_{ijt-h}\varepsilon_{jt-h}Q_{t-h} + \delta_{ijt}\,\varepsilon_{jt}\,Q_t}{2}\right) + \left(\delta_{ijt} - \delta_{ijt-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}Q_{t-h} + \varepsilon_{jt}\,Q_t}{2}\right)\\
&+ \left(\varepsilon_{jt} - \varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{Q_{t-h} + Q_t}{2}\right)\\
&+ \left(Q_t - Q_{t-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h} + \varepsilon_{jt}}{2}\right) =
\end{aligned}$$

$$\begin{aligned}
= \left(\varphi_{ijt} - \varphi_{ijt-h}\right)&\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}Q_{t-h} + \varepsilon_{jt}\,Q_t}{2}\right) + \left(\delta_{ijt} - \delta_{ijt-h}\right)\left(\frac{\varphi_{ijt-h}\varepsilon_{jt-h}Q_{t-h} + \varphi_{ijt}\,\varepsilon_{jt}\,Q_t}{2}\right)\\
&+ \left(\varepsilon_{jt} - \varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{Q_{t-h} + Q_t}{2}\right)\\
&+ \left(Q_t - Q_{t-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h} + \varepsilon_{jt}}{2}\right) =
\end{aligned}$$

$$\begin{aligned}
= \left(\varphi_{ijt} - \varphi_{ijt-h}\right)&\left(\frac{\delta_{ijt-h} + \delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h} + \varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h} + Q_t}{2}\right)\\
&+ \left(\delta_{ijt} - \delta_{ijt-h}\right)\left(\frac{\varphi_{ijt-h} + \varphi_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h} + \varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h} + Q_t}{2}\right)\\
&+ \left(\varepsilon_{jt} - \varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h}Q_{t-h} + \varphi_{ijt}\delta_{ijt}\,Q_t}{2}\right)\\
&+ \left(Q_t - Q_{t-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h} + \varphi_{ijt}\,\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h} + \varepsilon_{jt}}{2}\right) =
\end{aligned}$$

$$\begin{aligned}
= \left(\varphi_{ijt} - \varphi_{ijt-h}\right)\left(\tfrac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\tfrac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\tfrac{Q_{t-h}+Q_t}{2}\right) + \left(\delta_{ijt} - \delta_{ijt-h}\right)\left(\tfrac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\tfrac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\tfrac{Q_{t-h}+Q_t}{2}\right) +\\
\left(\varepsilon_{jt} - \varepsilon_{jt-h}\right)\left(\tfrac{\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\,\delta_{ijt}}{2}\right)\left(\tfrac{Q_{t-h}+Q_t}{2}\right) + \left(Q_t - Q_{t-h}\right)\left(\tfrac{\varphi_{ijt-h}\delta_{ijt-h}\varepsilon_{jt-h}+\varphi_{ijt}\,\delta_{ijt}\,\varepsilon_{jt}}{2}\right),
\end{aligned}$$

Note that in each of these four breakdowns of employment change the components add up to the change in manufacturing employment but differ a little bit in detail. Therefore, the decomposition finally used is calculated by averaging the respective components. From this final decomposition, which fulfils additionality conditions, the 4 following effects can be derived, which in a normalized form sum up to the respective change in manufacturing employment in percentage points[113]:

[113] For an explanation of the meaning of these effects see the main text.

(1) A labor intensity effect, coined as "**labor productivity effect**" (as its inverse) in the main text in the form

$$\frac{1}{4}\left\{(\varphi_{ijt}-\varphi_{ijt-h})\left(\frac{\delta_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\delta_{ijt}\varepsilon_{jt}Q_t}{2}\right)+(\varphi_{ijt}-\varphi_{ijt-h})\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t}{2}\right)\right.$$
$$+(\varphi_{ijt}-\varphi_{ijt-h})\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h}+Q_t}{2}\right)$$
$$\left.+(\varphi_{ijt}-\varphi_{ijt-h})\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h}+Q_t}{2}\right)\right\}=$$

$$=\frac{1}{8}(\varphi_{ijt}-\varphi_{ijt-h})\left\{(\delta_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\delta_{ijt}\varepsilon_{jt}Q_t)+\frac{(\delta_{ijt-h}+\delta_{ijt})(\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t)}{2}\right.$$
$$\left.+\frac{(\delta_{ijt-h}+\delta_{ijt})(\varepsilon_{jt-h}+\varepsilon_{jt})(Q_{t-h}+Q_t)}{2}\right\}.$$

In its normalized version it is

$$\frac{1}{8}(\varphi_{ijt}-\varphi_{ijt-h})\left\{(\delta_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\delta_{ijt}\varepsilon_{jt}Q_t)+\frac{(\delta_{ijt-h}+\delta_{ijt})(\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t)}{2}\right.$$
$$\left.+\frac{(\delta_{ijt-h}+\delta_{ijt})(\varepsilon_{jt-h}+\varepsilon_{jt})(Q_{t-h}+Q_t)}{2}\right\}\left(\frac{100}{L_{ijt-h}}\right)$$

and represents the **contribution of productivity increases (i.e., "industrial up-grading")** to manufacturing employment change in the metro region (group) considered in percentage points.

(2) A sector share effect, named "**genuine de-industrialization effect**" in the text in the form

$$\frac{1}{4}\left\{(\delta_{ijt}-\delta_{ijt-h})\left(\frac{\varphi_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\varphi_{ijt}\varepsilon_{jt}Q_t}{2}\right)+(\delta_{ijt}-\delta_{ijt-h})\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t}{2}\right)\right.$$
$$+(\delta_{ijt}-\delta_{ijt-h})\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h}+Q_t}{2}\right)$$
$$\left.+(\delta_{ijt}-\delta_{ijt-h})\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\left(\frac{Q_{t-h}+Q_t}{2}\right)\right\}=$$

$$=\frac{1}{8}(\delta_{ijt}-\delta_{ijt-h})\left\{(\varphi_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\varphi_{ijt}\varepsilon_{jt}Q_t)+\frac{(\varphi_{ijt-h}+\varphi_{ijt})(\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t)}{2}\right.$$
$$\left.+\frac{(\varphi_{ijt-h}+\varphi_{ijt})(\varepsilon_{jt-h}+\varepsilon_{jt})(Q_{t-h}+Q_t)}{2}\right\}.$$

In its normalized version it is

$$\frac{1}{8}(\delta_{ijt}-\delta_{ijt-h})\left\{(\varphi_{ijt-h}\varepsilon_{jt-h}Q_{t-h}+\varphi_{ijt}\varepsilon_{jt}Q_t)+\frac{(\varphi_{ijt-h}+\varphi_{ijt})(\varepsilon_{jt-h}Q_{t-h}+\varepsilon_{jt}Q_t)}{2}\right.$$
$$\left.+\frac{(\varphi_{ijt-h}+\varphi_{ijt})(\varepsilon_{jt-h}+\varepsilon_{jt})(Q_{t-h}+Q_t)}{2}\right\}\left(\frac{100}{L_{ijt-h}}\right)$$

and represents the **contribution of a shrinking manufacturing output share and thus genuine de-industrialization** to manufacturing employment change in the metro region (group) considered in percentage points.

(3) A "**metro share effect**" in the form

$$\frac{1}{4}\left\{\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h}Q_{t-h}+\varphi_{ijt}\delta_{ijt}Q_{t}}{2}\right)+\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}}{2}\right)\left(\frac{Q_{t-h}+Q_{t}}{2}\right)\right.$$
$$+\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{Q_{t-h}+Q_{t}}{2}\right)$$
$$\left.+\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{Q_{t-h}+Q_{t}}{2}\right)\right\}=$$

$$=\frac{1}{8}\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left\{\left(\varphi_{ijt-h}\delta_{ijt-h}Q_{t-h}+\varphi_{ijt}\delta_{ijt}Q_{t}\right)+\frac{\left(\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}\right)\left(Q_{t-h}+Q_{t}\right)}{2}\right.$$
$$\left.+\frac{\left(\varphi_{ijt-h}+\varphi_{ijt}\right)\left(\delta_{ijt-h}+\delta_{ijt}\right)\left(Q_{t-h}+Q_{t}\right)}{2}\right\}.$$

In its normalized version it is

$$\frac{1}{8}\left(\varepsilon_{jt}-\varepsilon_{jt-h}\right)\left\{\left(\varphi_{ijt-h}\delta_{ijt-h}Q_{t-h}+\varphi_{ijt}\delta_{ijt}Q_{t}\right)+\frac{\left(\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}\right)\left(Q_{t-h}+Q_{t}\right)}{2}\right.$$
$$\left.+\frac{\left(\varphi_{ijt-h}+\varphi_{ijt}\right)\left(\delta_{ijt-h}+\delta_{ijt}\right)\left(Q_{t-h}+Q_{t}\right)}{2}\right\}\left(\frac{100}{L_{ijt-h}}\right)$$

and represents the **contribution of the (relative) performance of the metro region (group)** to manufacturing employment change in the metro region (group) considered in percentage points.

(4) An "**economic growth effect**" in the form

$$\frac{1}{4}\left\{\left(Q_{t}-Q_{t-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h}\varepsilon_{jt-h}+\varphi_{ijt}\delta_{ijt}\varepsilon_{jt}}{2}\right)+\left(Q_{t}-Q_{t-h}\right)\left(\frac{\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)\right.$$
$$+\left(Q_{t}-Q_{t-h}\right)\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{\varepsilon_{jt-h}+\varepsilon_{jt}}{2}\right)$$
$$\left.+\left(Q_{t}-Q_{t-h}\right)\left(\frac{\varphi_{ijt-h}+\varphi_{ijt}}{2}\right)\left(\frac{\delta_{ijt-h}+\delta_{ijt}}{2}\right)\left(\frac{\varepsilon j_{t-h}+\varepsilon_{jt}}{2}\right)\right\}=$$

$$=\frac{1}{8}\left(Q_{t}-Q_{t-h}\right)\left\{\left(\varphi_{ijt-h}\delta_{ijt-h}\varepsilon_{jt-h}+\varphi_{ijt}\delta_{ijt}\varepsilon_{jt}\right)+\frac{\left(\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}\right)\left(\varepsilon_{jt-h}+\varepsilon_{jt}\right)}{2}+\right.$$
$$\left.\frac{\left(\varphi_{ijt-h}+\varphi_{ijt}\right)\left(\delta_{ijt-h}+\delta_{ijt}\right)\left(\varepsilon_{jt-h}+\varepsilon_{jt}\right)}{2}\right\}.$$

In its normalized version it is

$$\frac{1}{8}\left(Q_{t}-Q_{t-h}\right)\left\{\left(\varphi_{ijt-h}\delta_{ijt-h}\varepsilon_{jt-h}+\varphi_{ijt}\delta_{ijt}\varepsilon_{jt}\right)+\frac{\left(\varphi_{ijt-h}\delta_{ijt-h}+\varphi_{ijt}\delta_{ijt}\right)\left(\varepsilon_{jt-h}+\varepsilon_{jt}\right)}{2}\right.$$
$$\left.+\frac{\left(\varphi_{ijt-h}+\varphi_{ijt}\right)\left(\delta_{ijt-h}+\delta_{ijt}\right)\left(\varepsilon_{jt-h}+\varepsilon_{jt}\right)}{2}\right\}\left(\frac{100}{L_{ijt-h}}\right)$$

and represents the **contribution of the performance of the respective country** to manufacturing employment change in the metro region (group) considered in percentage points.

7.2 Annex to chapter 4

Table A. 1: **10 most localized NAICS 3-digit branches in the US case study metropolitan areas, 2019**

Code	Industry	LQ
Atlanta		
517	Telecommunications	2.6
515	Broadcasting (except Internet)	2.3
512	Motion Picture and Sound Recording Industries	2.2
551	Management of Companies and Enterprises	2.0
518	Data Processing, Hosting, and Related Services	1.9
425	Wholesale Electronic Markets and Agents and Brokers	1.8
443	Electronics and Appliance Stores	1.6
511	Publishing Industries (except Internet)	1.6
493	Warehousing and Storage	1.6
423	Merchant Wholesalers, Durable Goods	1.5
Boston		
511	Publishing Industries (except Internet)	3.1
316	Leather and Allied Product Manufacturing	2.8
523	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	2.7
334	Computer and Electronic Product Manufacturing	2.5
487	Scenic and Sightseeing Transportation	2.2
925	Administration of Housing Programs, Urban Planning, and Community Development	2.1
541	Professional, Scientific, and Technical Services	1.8
519	Other Information Services	1.7
454	Non-store Retailers	1.7
551	Management of Companies and Enterprises	1.5
Pittsburgh		
331	Primary Metal Manufacturing	2.6
324	Petroleum and Coal Products Manufacturing	2.6
551	Management of Companies and Enterprises	2.4
711	Performing Arts, Spectator Sports, and Related Industries	1.8
485	Transit and Ground Passenger Transportation	1.8
213	Support Activities for Mining	1.7
522	Credit Intermediation and Related Activities	1.7
335	Electrical Equipment, Appliance, and Component Manufacturing	1.7
454	Non-store Retailers	1.6
524	Insurance Carriers and Related Activities	1.6
San Francisco		
519	Other Information Services	6.8
334	Computer and Electronic Product Manufacturing	6.1
511	Publishing Industries (except Internet)	4.1
518	Data Processing, Hosting, and Related Services	4.0
927	Space Research and Technology	3.0
541	Professional, Scientific, and Technical Services	2.2
324	Petroleum and Coal Products Manufacturing	1.9
814	Private Households	1.7
485	Transit and Ground Passenger Transportation	1.6
624	Social Assistance	1.6
Seattle		
454	Non-store Retailers	7.4
511	Publishing Industries (except Internet)	7.0
519	Other Information Services	4.0
336	Transportation Equipment Manufacturing	3.8
483	Water Transportation	3.4
518	Data Processing, Hosting, and Related Services	2.6
481	Air Transportation	2.2
425	Wholesale Electronic Markets and Agents and Brokers	1.7
517	Telecommunications	1.6
488	Support Activities for Transportation	1.5

Source: U.S. Bureau of Economic Analysis, WIFO calculations. – LQ: location quotient.

Table A. 2: **10 Fastest growing NAICS 3-digit branches in the US case study metropolitan areas**

Code	Industry	2012/19
Atlanta		
512	Motion Picture and Sound Recording Industries	3.2
518	Data Processing, Hosting, and Related Services	1.3
493	Warehousing and Storage	1.3
312	Beverage and Tobacco Product Manufacturing	1.2
335	Electrical Equipment, Appliance, and Component Manufacturing	1.2
336	Transportation Equipment Manufacturing	1.0
321	Wood Product Manufacturing	0.9
519	Other Information Services	0.8
551	Management of Companies and Enterprises	0.8
236	Construction of Buildings	0.6
Boston		
312	Beverage and Tobacco Product Manufacturing	1.6
454	Non-store Retailers	1.0
624	Social Assistance	1.0
611	Educational Services	0.6
238	Specialty Trade Contractors	0.5
236	Construction of Buildings	0.5
492	Couriers and Messengers	0.5
493	Warehousing and Storage	0.4
481	Air Transportation	0.4
711	Performing Arts, Spectator Sports, and Related Industries	0.4
Pittsburgh		
488	Support Activities for Transportation	0.6
519	Other Information Services	0.6
624	Social Assistance	0.4
454	Non-store Retailers	0.4
213	Support Activities for Mining	0.4
493	Warehousing and Storage	0.3
335	Electrical Equipment, Appliance, and Component Manufacturing	0.3
711	Performing Arts, Spectator Sports, and Related Industries	0.3
532	Rental and Leasing Services	0.2
523	Securities, Commodity Contracts, and Other Financial Investments and Related Activities	0.2
San Francisco		
518	Data Processing, Hosting, and Related Services	2.5
624	Social Assistance	2.0
519	Other Information Services	1.2
454	Non-store Retailers	0.9
312	Beverage and Tobacco Product Manufacturing	0.9
485	Transit and Ground Passenger Transportation	0.9
511	Publishing Industries (except Internet)	0.8
492	Couriers and Messengers	0.7
493	Warehousing and Storage	0.6
221	Utilities	0.6
Seattle		
454	Non-store Retailers	2.8
519	Other Information Services	2.2
518	Data Processing, Hosting, and Related Services	2.1
312	Beverage and Tobacco Product Manufacturing	1.2
712	Museums, Historical Sites, and Similar Institutions	0.9
624	Social Assistance	0.8
493	Warehousing and Storage	0.7
236	Construction of Buildings	0.7
238	Specialty Trade Contractors	0.6
813	Religious, Grantmaking, Civic, Professional, and Similar Organizations	0.6

Source: U.S. Bureau of Economic Analysis, WIFO calculations.

7.3 Annex: Additional information on the Crunchbase data

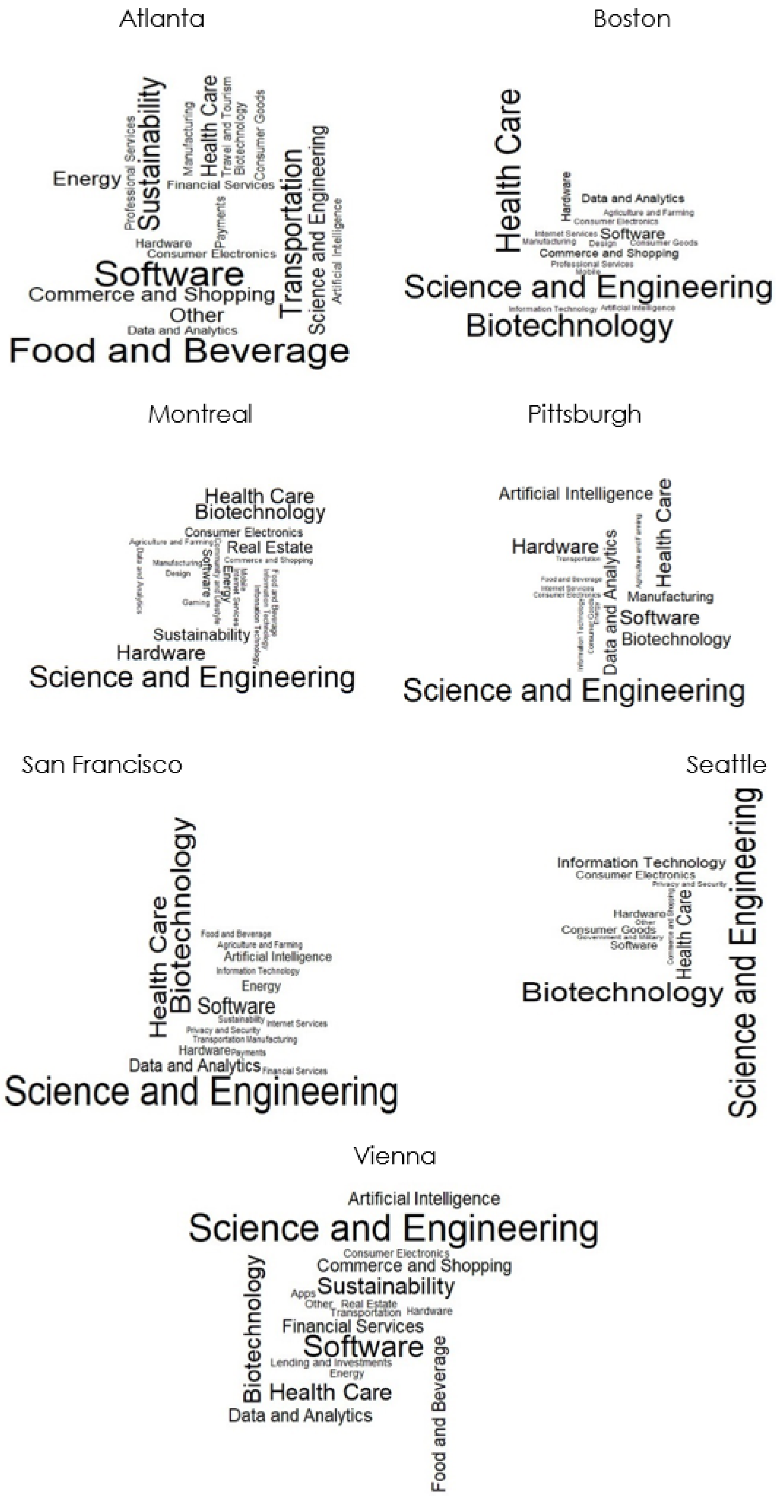
To take the analysis of the Crunchbase data a step further and to test its robustness to various methodological choices we conducted two additional variants of the analysis:

- in the first we limited the data to start-up companies that are active in fields that from an a-priory perspective have a high chance to provide products that are relevant for export related products. To this end, we chose only companies in the following industry groups: "Biotechnology", "Clothing and Apparel", "Consumer Electronics", "Consumer Goods", "Energy", "Food and Beverage", "Hardware", "Manufacturing", "Science and Engineering" and "Sustainability". From these groups, we excluded the lower-level industries "Artificial Intelligence", "Intelligent Systems", "Life Science" and "Neuroscience", and added "Pharmaceuticals". It is important to note that Crunchbase associates several industry groups to one company. Companies that are associated with an industry group that we did not select may still be included in the sample, if they are also associated with another industry group that we defined as export related (Figure A. 2).
- in the second by contrast we weighted the individual firms by the amount of funding they received (see Figure A. 3).

Figure A. 2 and Figure A. 3 show the results of these additional analyses. As can be seen, focusing on only export related venture capital financed startups reinforces the picture presented in the main text insofar as in both variants of the analysis, science and engineering, biotechnology, software, and health care emerge as the dominant descriptors of the startups across the metropolitan regions. Furthermore, in the metropolitan regions with many startups (i.e., Boston, San Francisco, and Seattle) also the importance of these fields is surprisingly similar to the baseline analysis presented in the main text.

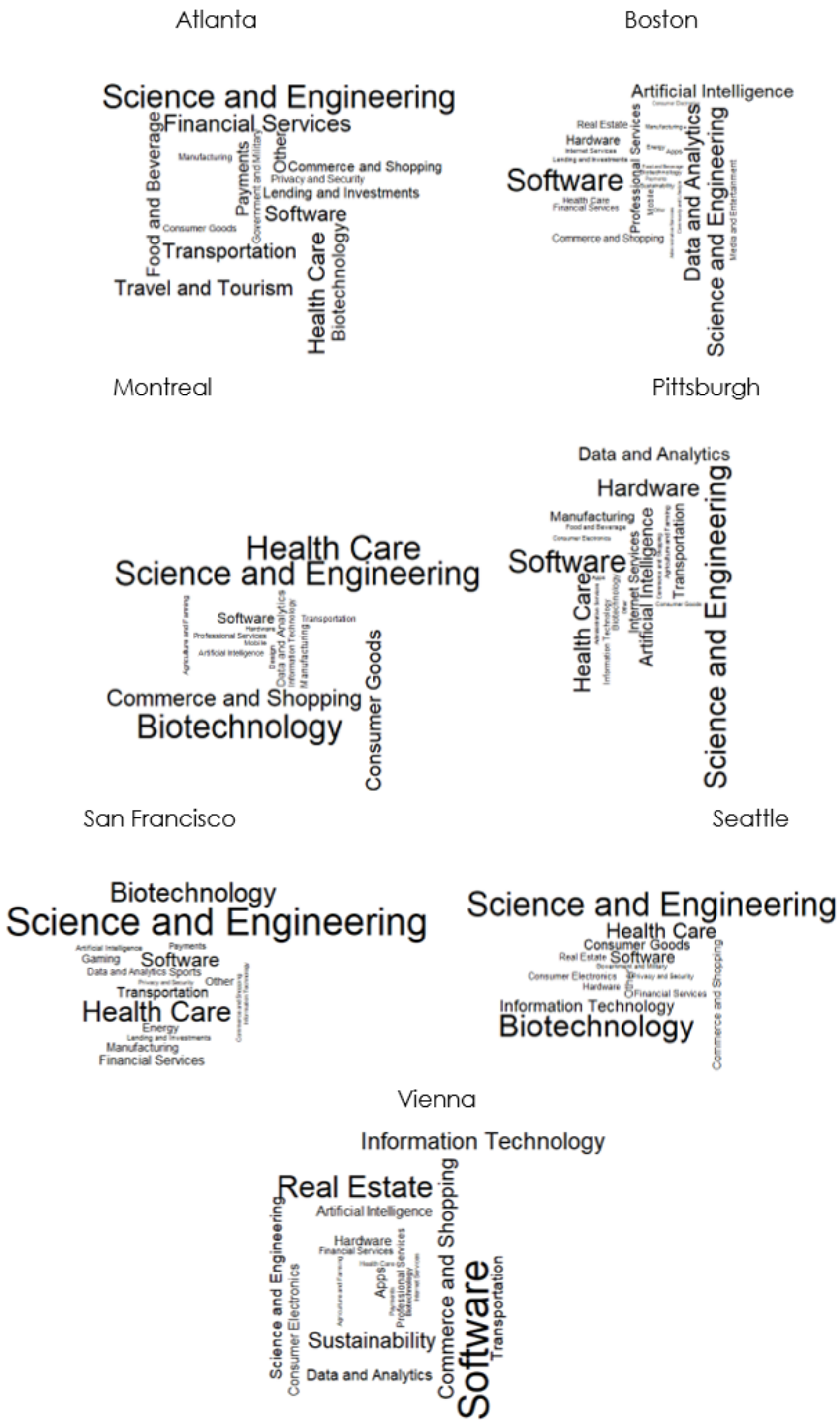
For the metropolitan regions with low venture capital financed startup activities, on account of the small number of projects, these changes in methodology do have an effect. In particular, when focusing on a weighted representation of the start-ups, real estate projects obtain a very dominant role on account of one very large start-up project in that area. By contrast when considering only export related start-ups for Vienna mainly science and engineering emerges as a main activity, on account of the many service sector startups that have information technology as a descriptor.

Figure A. 2: **Word cloud representation of major export related startup activities in the case study metros and Vienna**



Source: Crunchbase, WIFO calculations.

Figure A. 3: **Weighted word cloud representation of major startup activities in the case study metros and Vienna**



Source: Crunchbase, WIFO calculations. – Projects are weighted by the funding received.

Table A. 3: **Largest venture financed start-up activities in the case study metros and Vienna (including all sectors)**

Organization Name	Last Funding Type	Description	Total Funding
Atlanta			
Antios Therapeutics	Series B	Antios Therapeutics is a biopharmaceutical company developing innovative therapies for viral diseases.	200,399,999
Hermeus	Series B	Hermeus is developing Mach 5 aircraft to speed up the global transportation network.	176,000,000
Sundayapp	Series A	Sundayapp is a fully integrated solution built for restaurants, bars, pubs, cafes, and hotels Customers to pay for their food via a QR code.	124,000,000
Grayshift	Series A	Grayshift is a provider of mobile device digital forensics, specializing in lawful access and extraction.	94,000,000
Greenwood Bank	Series B	Greenwood Bank is a digital banking platform for Black and Latino people and business owners.	88,000,000
Lemon Perfect	Series B	Lemon Perfect is a beverage company that provides cold-pressed lemon water with essential electrolytes and a blast of antioxidant Vitamin C.	74,385,776
Genexa	Series A	Genexa is a clean medicine company that researches and develops medicine.	60,000,000
CharterUP	Series A	CharterUP is a fully integrated marketplace for charter bus reservations.	60,000,000
Yellow Card	Series B	Yellow Card develops an app-based cryptocurrency exchange platform to buy and seal bitcoin online.	56,500,000
Cypress.io	Series B	Cypress.io maintains an automated end-to-end and component testing solution for anything that runs in a browser.	54,809,298
Boston			
Perch	Series A	Perch is a technology-driven company that acquires direct-to-consumer businesses that are selling on Amazon and growing their operations.	908,750,000
SmartLabs	Series B	SmartLabs builds and operates enterprise-grade labs, including multi-use R&D labs, laboratories for various research and development activities, process development labs, and manufacturing suites.	354,600,000
Scorpion Therapeutics	Series B	Scorpion Therapeutics is a precision oncology company that broadens the reach and impact of precision medicine for cancer patients.	270,000,000
Vendr	Series B	Vendr is the leading SaaS buying & management platform that helps Companies find, buy, and manage their stack, money-back guaranteed.	216,000,000
Ensoma	Series B	Ensoma is a genomic medicine company that develops one-time in vivo treatments for immuno-oncology and other therapeutic applications.	205,000,000
Asimov	Series B	Asimov employs artificial Intelligence to develop tools for the design and manufacture of next-generation therapeutics.	205,000,000
Joyn Bio	Series A	A joint venture founded by Bayer and Ginkgo Bioworks developing probiotics for plants.	200,000,000
Aera Therapeutics	Series B	Aera Therapeutics is a biotechnology firm that employs its own protein nanoparticle (PNP) delivery platform.	193,000,000
Aktis Oncology	Series A	Aktis Oncology is a biotechnology Company discovering and developing a novel class of targeted radiopharmaceuticals.	156,000,000
NewStore	Series B	NewStore operates a platform for retailers to run their Stores on the iPhone.	155,399,998

Organization Name	Last Funding Type	Description	Total Funding
Montreal			
Element AI	Series B	Element AI is an artificial Intelligence Company that gives organizations access to technology.	257,483,994
RenoRun	Series B	RenoRun is budding a single source platform for general contractors to purchase materials.	163,727,561
Jasper	Series A	Jasper is an AI writing tool that helps businesses create content.	131,000,000
Flinks	Series B	Flinks is the financial data layer powering the internet. Flinks delivers tools for financial Innovation to businesses-big and small.	93,043,236
Congruence Therapeutics	Series A	Congruence Therapeutics operates as a biotechnology company.	64,581,196
SPARK Microsystems	Series B	SPARK Microsystems is the enabling wireless technology of the future.	47,745,069
Puzzle Medical Devices	Series A	Canadian company specializing in the development of a minimally invasive long-term hemodynamic transcatheter pump.	35,044,233
Shakepay	Series A	Shakepay is ushering in the Bitcoin Golden Age.	33,285,150
Airgraft	Series B	Airgraft is a clean vaporization technology company.	33,000,000
Unito	Series B	Unito automatically synchronizes your projects, tasks and conversations between different work management tools.	32,919,438
Pittsburgh			
Petuum	Series B	Petuum, Inc. is building a platform that serves the full spectrum of Artificial Intelligence.	108,000,000
Locomation	Seed	Locomation develops safe and reliable autonomous trucking solutions.	57,023,032
Novasenta	Series A	Novasenta develops treatments to transform the lives of patients with cancer.	40,000,000
Fifth Season	Series B	Fifth Season is a consumer tech company transforming modern indoor agriculture with automated robotics and software analytics.	35,000,000
Idelic	Series B	Idelic is a driver management platform designed to consolidate fleet data systems and automate compliance processes.	31,000,000
Apollo Neuroscience	Series A	Apollo is a wellness product, the first clinically validated wearable that actively helps the body recover from stress.	21,200,000
Gridwise	Series A	Gridwise is a business platform for economy drivers, helping them maximize their earnings and track their business performance.	20,400,000
Rimsys	Series A	Rimsys is a provider of Regulatory Information Management (RIM) Software for medical technology companies.	17,600,000
CytoAgents	Series A	CytoAgents is a biotechnology company focused on the treatment of COVID-19, Influenza, and other viral infectious diseases.	17,206,500
Gather AI	Series A	Gather AI is a provider software-only automated inventory monitoring solutions for modern warehouses.	17,067,900
San Francisco			
Altos Labs	Series A	Altos Labs focuses on cellular rejuvenation programming to restore cell health and resilience, to reverse disease to transform medicine.	3,000,000,000
TeraWatt Infrastructure	Series A	TeraWatt Infrastructure operates an electric vehicle charging infrastructure for medium and heavy-duty transport and fleets.	1,100,000,000
Forte	Series B	Forte is an economic technology for games that powers NFTs and rich token economies.	910,000,000
Secfi	Pre-Seed	Secfi works with startup employees and founders to provide equity planning and stock option financing.	707,000,000
Adept AI	Series B	Adept AI is a machine learning research and product lab that builds general artificial Intelligence.	415,000,000

Organization Name	Last Funding Type	Description	Total Funding
FTX US	Series A	FTX US allows users to trade a variety of digital assets like bitcoin, ethereum, solana, and dogecoin.	400,000,000
Elemy	Series B	Elemy is the nationwide provider of childhood mental and behavioral healthcare.	323,000,000
Kyte	Series B	Kyte unlocks the freedom to go places. Kyte offers cars delivered to people's doorsteps.	299,000,000
Alumis	Series B	Alumis is a precision medicine company focused on the discovery, development and treatment of autoimmune disorders.	270,000,000
Incode Technologies	Series B	Incode Technologies is a real-life verification company that specializes in omnichannel biometric identity.	257,050,000
Seattle			
Umoja Biopharma	Series B	Umoja Biopharma is a biopharmaceutical company developing next-generation immunotherapies intended to combat cancer.	263,000,000
Cap Hill Brands	Series B	Cap Hill Brands is a consumer products company that invests in and operates great e-commerce and DTC brands.	250,000,000
GentiBio	Series A	GentiBio is a biotherapeutics company developing engineered regulatory T cells programmed to treat autoimmune allergic diseases.	177,000,000
Arrived Homes	Series A	Arrived Homes provides rental home investment services to help people become financially independent.	162,120,000
Shape Therapeutics	Series B	A biotechnology company developing RNA technologies to shape the future of gene therapy.	147,500,000
Variant Bio	Series B	Variant Bio is leveraging the power of human genetic diversity to discover new therapeutics.	129,700,000
Cajal Neuroscience	Series A	Cajal Neuroscience is a drug discovery company focused on neurodegenerative disease.	96,000,000
Bonum Therapeutics	Series A	Bonum Therapeutics creates a technology platform to treat a wide range of diseases.	93,000,000
BRINC	Series B	BRINC is an aerospace company that builds technology in the service of public safety.	82,200,000
Edge Delta	Series B	Edge Delta is an observability platform offering Cloud-First Log Search, Analytics and Data Pipelines.	81,000,000
Vienna			
Gropyus	Series B	Creating sustainable living for everyone.	141,700,000
Refurbed	Series B	Refurbed is a marketplace for refurbished electronics.	73,239,652
Storebox	Series B	Storebox - We shape logistics of tomorrow.	62,130,000
Prewave	Series A	Prewave is an AI risk and sustainability monitoring platform for purchasing, supply chain, and sustainability managers.	31,610,000
MOSTLY AI	Series B	MOSTLY AI - leader in structured synthetic data.	31,145,550
Ribbon Biolabs	Series A	Ribbon Biolabs defines new standards for molecular biology by applying innovative methods for DNA synthesis.	19,620,000
Helu.io	Series A	Helu.io is a startup company that provides easy access to their financial data.	15,001,439
ToolSense	Series A	ToolSense is building the leading Asset Operations Platform to improve the productivity of asset-intensive companies	11,990,000
Finmatics	Series A	Finmatics is a self-learning, artificial Intelligence system that automates the activities of accounting service providers.	11,663,000
hi.health	Seed	We are reinventing the claims process in private health insurance combining payment cards with a pay&claim solution.	10,900,000

Source: Crunchbase.

Table A. 4: **Largest venture financed start-up activities in case study metros and Vienna (including export related sectors only)**

Organization Name	Last Funding Type	Description	Total Funding
Atlanta			
Antios Therapeutics	Series B	Antios Therapeutics is a biopharmaceutical company developing innovative therapies for viral diseases.	200,399,999
Hermeus	Series B	Hermeus is developing Mach S aircraft to speed up the global transportation network.	176,000,000
Sundayapp	Series A	Sundayapp is a fully integrated solution built for restaurants, bars, pubs, cafes, and hotels. Customers can pay for their food via a QR code.	124,000,000
Lemon Perfect	Series B	Lemon Perfect is a beverage company that provides cold-pressed lemon water with essential electrolytes and a blast of antioxidant Vitamin C.	74,385,776
Genexa	Series A	Genexa is a clean medicine company that researches and develops medicine.	60,000,000
Covetool	Series B	Covetool is a B2B SaaS company that helps make buildings energy efficient while saving on construction costs.	36,750,000
SluttyVegan	Series A	SluttyVegan is a plant-based burger restaurant.	25,000,000
Cloverly	Series A	Cloverly is a clean-tech startup that aims to neutralize emissions by bringing high-quality carbon credits to digital applications.	21,074,999
Grayscale	Series A	Grayscale is a unified frontline employee engagement platform to hire, onboard, and retain your hourly workers.	13,300,000
Goodr	Series A	Goodr is a sustainable surplus food management platform that leverages technology to reduce food waste and combat hunger.	12,271,556
Boston			
Perch	Series A	Perch is a technology-driven company that acquires direct-to-consumer businesses that are selling on Amazon and growing their operations.	908,750,000
SmartLabs	Series B	SmartLabs builds and operates enterprise-grade labs, including multi-use R&D labs, laboratories for various research and development activities, process development labs, and manufacturing suites.	354,600,000
Scorpion Therapeutics	Series B	Scorpion Therapeutics is a precision oncology company that broadens the reach and impact of precision medicine for cancer patients.	270,000,000
Ensoma	Series B	Ensoma is a genomic medicine company that develops one-time in vivo treatments for immuno-oncology and other therapeutic applications.	205,000,000
Asimov	Series B	Asimov employs artificial intelligence to develop tools for the design and manufacture of next-generation therapeutics.	205,000,000
Joyn Bio	Series A	A joint venture founded by Bayer and Ginkgo Bioworks, developing probiotics for plants.	200,000,000
Aera Therapeutics	Series B	Aera Therapeutics is a biotechnology firm that employs its own protein nanoparticle (PNP) delivery platform.	193,000,000
Aktis Oncology	Series A	Aktis Oncology is a biotechnology company discovering and developing a novel class of targeted radiopharmaceuticals.	156,000,000
NewStore	Series B	NewStore operates a platform for retailers to run their stores on the iPhone.	155,399,998
HYCU	Series B	HYCU, Inc., the world's fastest-growing multi-cloud and hybrid IT data protection as a Service company.	140,500,000

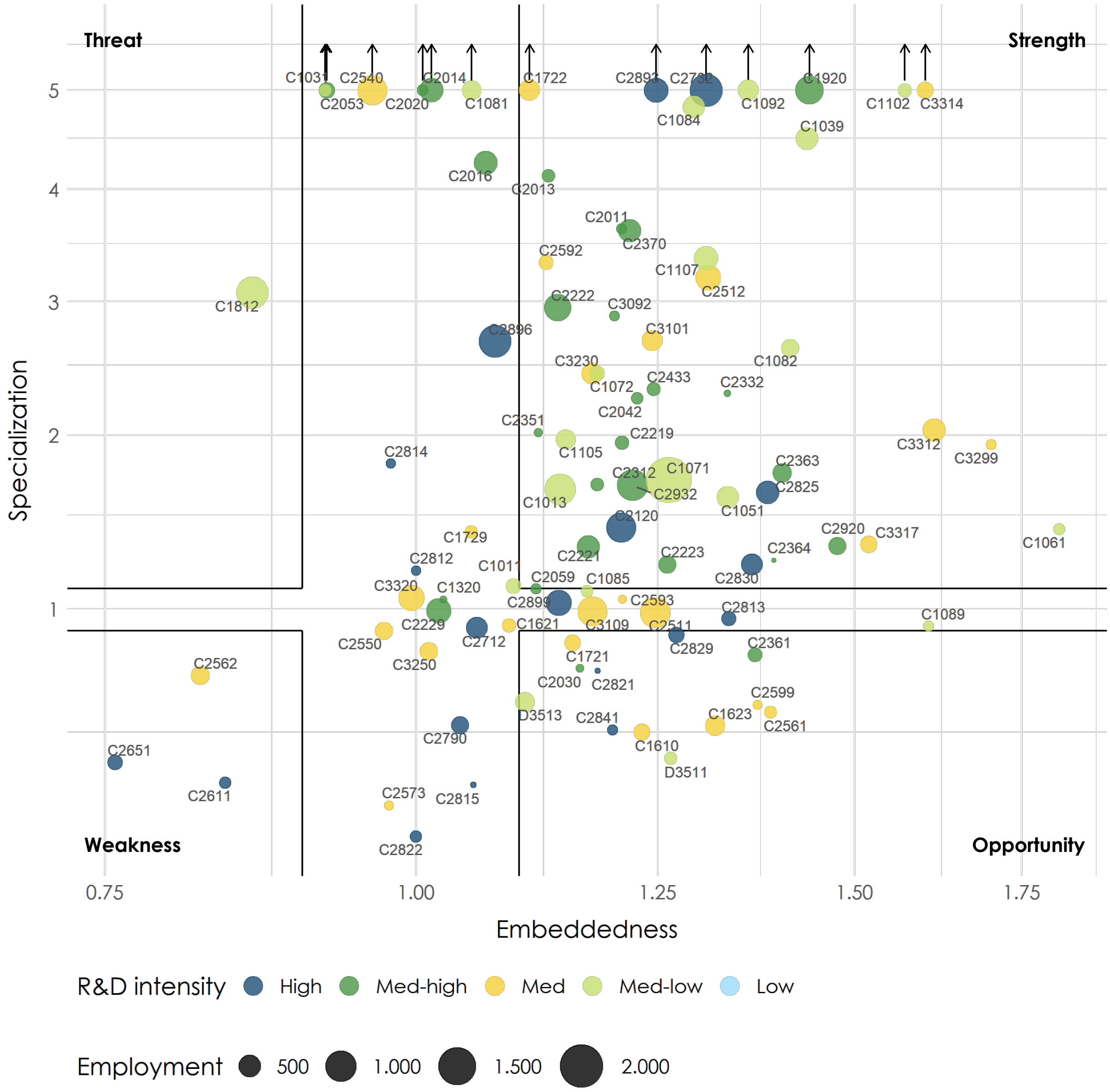
Organization Name	Last Funding Type	Description	Total Funding
Montreal			
RenoRun	Series B	RenoRun is building a single-source platform for general contractors to purchase materials.	163,727,561
Congruence Therapeutics	Series A	Congruence Therapeutics operates as a technology company.	64,581,196
SPARK Microsystems	Series B	SPARK Microsystems is enabling wireless technology of the future.	47,745,069
Airgraft	Series B	Airgraft is a clean vaporization technology company.	33,000,000
Novisto	Series B	Novisto is a SaaS platform for environmental, social, governance data management, and reporting.	28,403,328
PreciThera	Series A	PreciThera, Inc. is a biotechnology company.	26,628,120
Carbicrete	Series A	Carbicrete is a carbon removal technology company that develops innovative, low-cost building solutions that reduce greenhouse gas emissions.	22,320,762
Nomic	Series A	Nomic develops a proteomic technology platform designed to understand, detect, and treat diseases with DNA nanotechnology.	18,025,686
Airy:3D	Series A	Airy:3D is a startup based in Montreal bent on answering one question: our world has three dimensions, so why can't our pictures?	17,328,642
ChrysaLabs	Series A	ChrysaLabs develops real-time, portable, and accurate soil fertility assessment technology for precision agriculture.	16,217,264
Pittsburgh			
Petuum	Series B	Petuum, Inc. is building a platform that serves the full spectrum of Artificial Intelligence.	108,000,000
Locomation	Seed	Locomation develops safe and reliable autonomous trucking solutions.	57,023,032
Novasenta	Series A	Novasenta develops treatments to transform the lives of patients with cancer.	40,000,000
Fifth Season	Series B	Fifth Season is a consumer tech company transforming modern indoor agriculture with automated robotics and software analytics.	35,000,000
CytoAgents	Series A	CytoAgents is a biotechnology company focused on the treatment of COVID-19, Influenza, and other viral infectious diseases.	17,206,500
Gather AI	Series A	Gather AI is a provider of software-only automated inventory monitoring solutions for modern warehouses.	17,067,900
Free Market Health	Series A	Free Market Health is a healthcare technology company empowering payers and pharmacies with a care-driven marketplace platform.	13,500,000
Stratus Materials	Series A	Stratus Materials is a developer and manufacturer of manganese-rich, cobalt-free cathode active materials for lithium-ion batteries.	12,000,000
Mindstate Design Labs	Seed	Mindstate Design Labs is a preclinical-stage biotechnology company developing the next generation of psychedelic-inspired therapeutics.	11,625,000
Carnegie Foundry	Series A	Carnegie Foundry is a Robotics and AI venture studio accelerating and scaling industrial automation driven by advanced robotics and AI.	10,000,000
San Francisco			
Altos Labs	Series A	Altos Labs focuses on cellular rejuvenation programming to foster cell health and resilience, to reverse disease, and to transform medicine.	3,000,000,000
TeraWatt Infrastructure	Series A	TeraWatt Infrastructure operates an electric vehicle charging infrastructure for medium and heavy-duty transport and fleets.	1,100,000,000
Alumis	Series B	Alumis is a precision medicine company focused on the discovery, development, and treatment of autoimmune disorders.	270,000,000
Incode Technologies	Series B	Incode Technologies is a real-life verification company that specializes in omnichannel biometric identity.	257,050,000
Frontier Medicines	Series B	Frontier Medicines is a developer of a chemoproteomics platform intended to further accelerate the path to drug discovery.	244,000,000

Organization Name	Last Funding Type	Description	Total Funding
Span.IO	Series B	Span.IO develops residential energy storage devices that provide renewable electricity and charging services for electric vehicles.	230,300,000
Apogee Therapeutics	Series B	Apogee Therapeutics is a biotechnology company that offers therapies for immunological and inflammatory disorders.	169,000,000
Asher Bio	Series B	Asher Bio is a biotechnology company that specializes in the fields of therapeutics and builds better immunotherapy for cancer.	163,150,000
Loft Orbital	Series B	Loft Orbital leases space on satellites for any organization to collect information about the Earth from space.	156,200,000
Afresh	Series B	Afresh is an AI-powered company selling software to track demand and manage orders for fresh produce in grocery stores.	147,790,000
Seattle			
Umoja Biopharma	Series B	Umoja Biopharma is a biopharmaceutical company developing next-generation immunotherapies intended to combat cancer.	263,000,000
Cap Hill Brands	Series B	Cap Hill Brands is a consumer products company that invests in and operates great e-commerce and DTC brands.	250,000,000
GentiBio	Series A	GentiBio is a biotherapeutics company developing engineered regulatory T cells programmed to treat autoimmune allergic diseases.	177,000,000
Shape Therapeutics	Series B	Shape Therapeutics is a biotechnology company developing RNA technologies to shape the future of gene therapy.	147,500,000
Variant Bio	Series B	Variant Bio is leveraging the power of human genetic diversity to discover new therapeutics.	129,700,000
Cajal Neuroscience	Series A	Cajal Neuroscience is a drug discovery company focused on neurodegenerative disease.	96,000,000
Bonum Therapeutics	Series A	Bonum Therapeutics creates a technology platform to treat a wide range of diseases.	93,000,000
BRINC	Series B	BRINC is an aerospace company that builds technology in the service of public safety.	82,200,000
Edge Delta	Series B	Edge Delta is an observability platform offering cloud-first log search, analytics, and data pipelines.	81,000,000
Mozart Therapeutics	Series A	Mozart is a biotech startup focusing on the development of disease-modifying therapies for autoimmune and inflammatory diseases.	80,000,000
Vienna			
Gropyus	Series B	Creating sustainable living for everyone.	141,700,000
Refurbed	Series B	Refurbed is a marketplace for refurbished electronics.	73,239,652
Ribbon Biolabs	Series A	Ribbon Biolabs defines new standards for molecular biology by applying innovative methods for DNA synthesis.	19,620,000
LIVIN farms	Series A	LIVIN farms is a technology company in the alternative protein sector.	8,755,195
enspired	Series A	AI-powered energy trading services for global short-term power markets.	8,175,000
contextflow	Series A	contextflow uses AI imaging technology to support radiologists during their daily clinical routine.	7,303,000
XUND	Seed	We enable healthcare companies to digitize patient interactions and translate data into actionable insights.	6,540,000
PhagoMed	Seed	PhagoMed is a developer of a biotech platform designed to develop drugs and therapies.	5,995,000
Orderlion	Seed	Orderlion: e-Commerce OS for suppliers in the food supply chain.	5,101,846
a:head bio	Seed	Ahead is a biotech company that provides a unique approach to drug development services.	4,360,000

Source: Crunchbase.

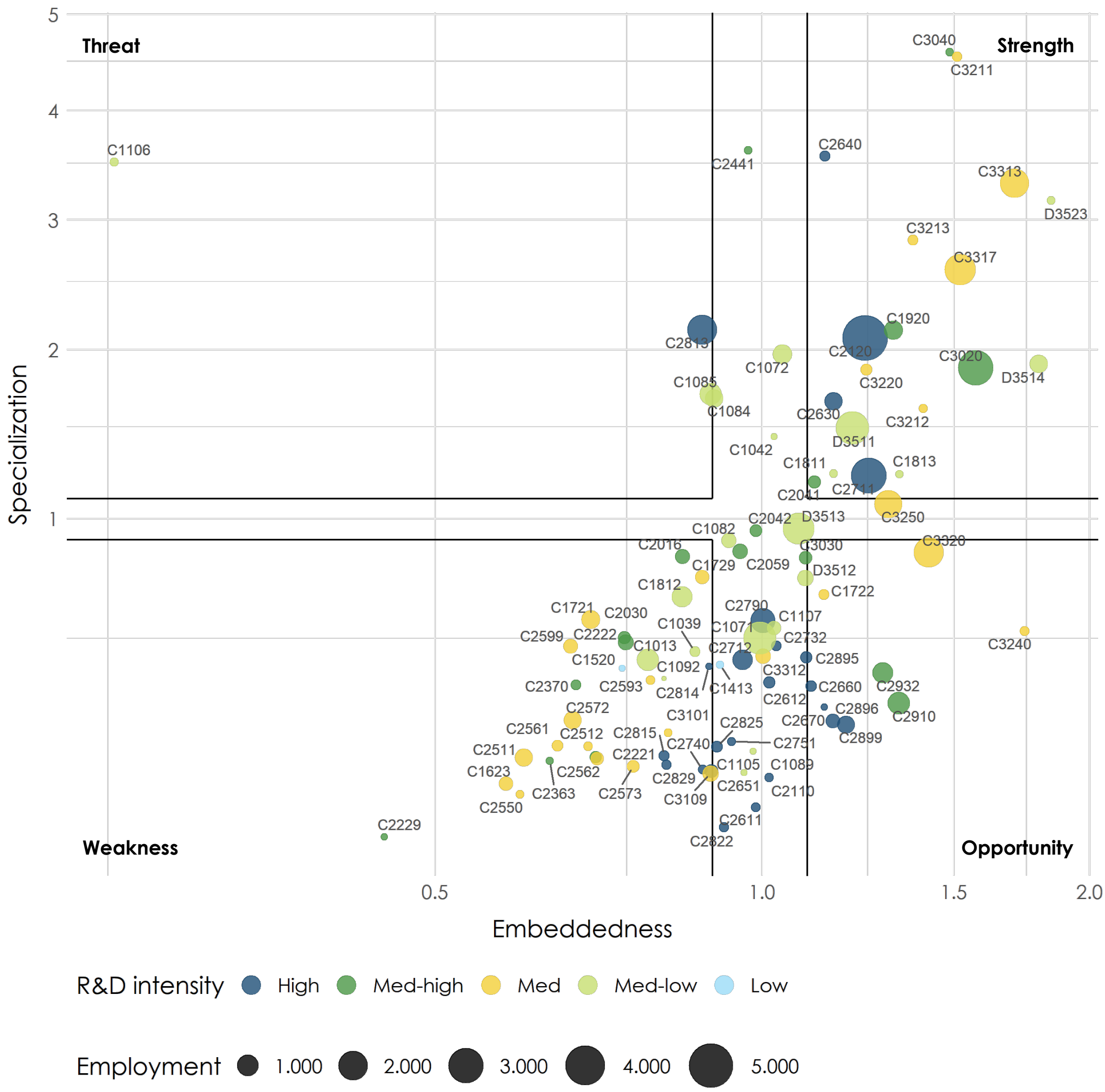
7.4 Annex to chapter 5

Figure A. 4: **SWOT position of the manufacturing industry classes in Vienna commuting zone**
Degree of specialization and embeddedness in the regional branch network; 4-digit-industries; 2022



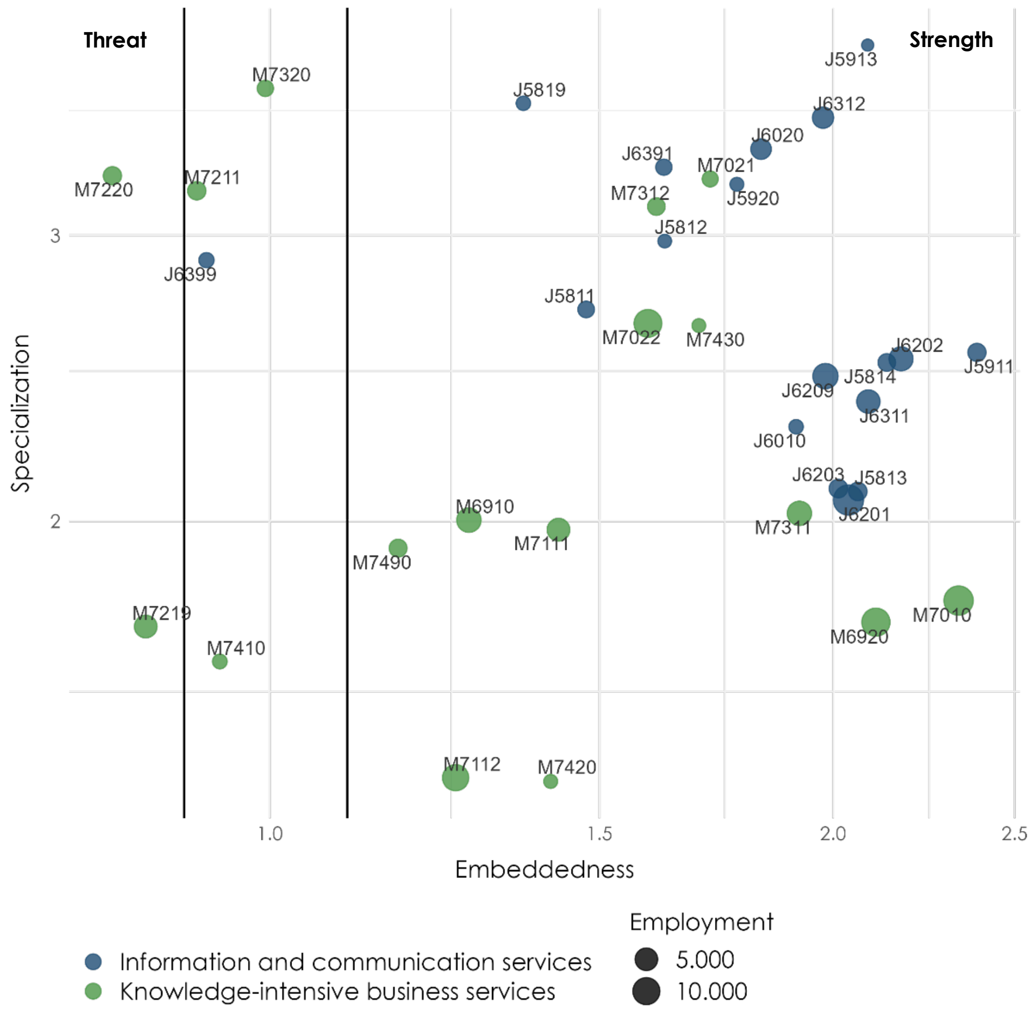
Source: Austrian Labor Market Service, Federal ministry of labor and economy; WIFO calculations. – Only industry classes with 100 or more employees in the regions are shown.

Figure A. 5: **SWOT position of the manufacturing industry classes in Vienna city core**
Degree of specialization and embeddedness in the regional branch network; 4-digit-industries; 2022



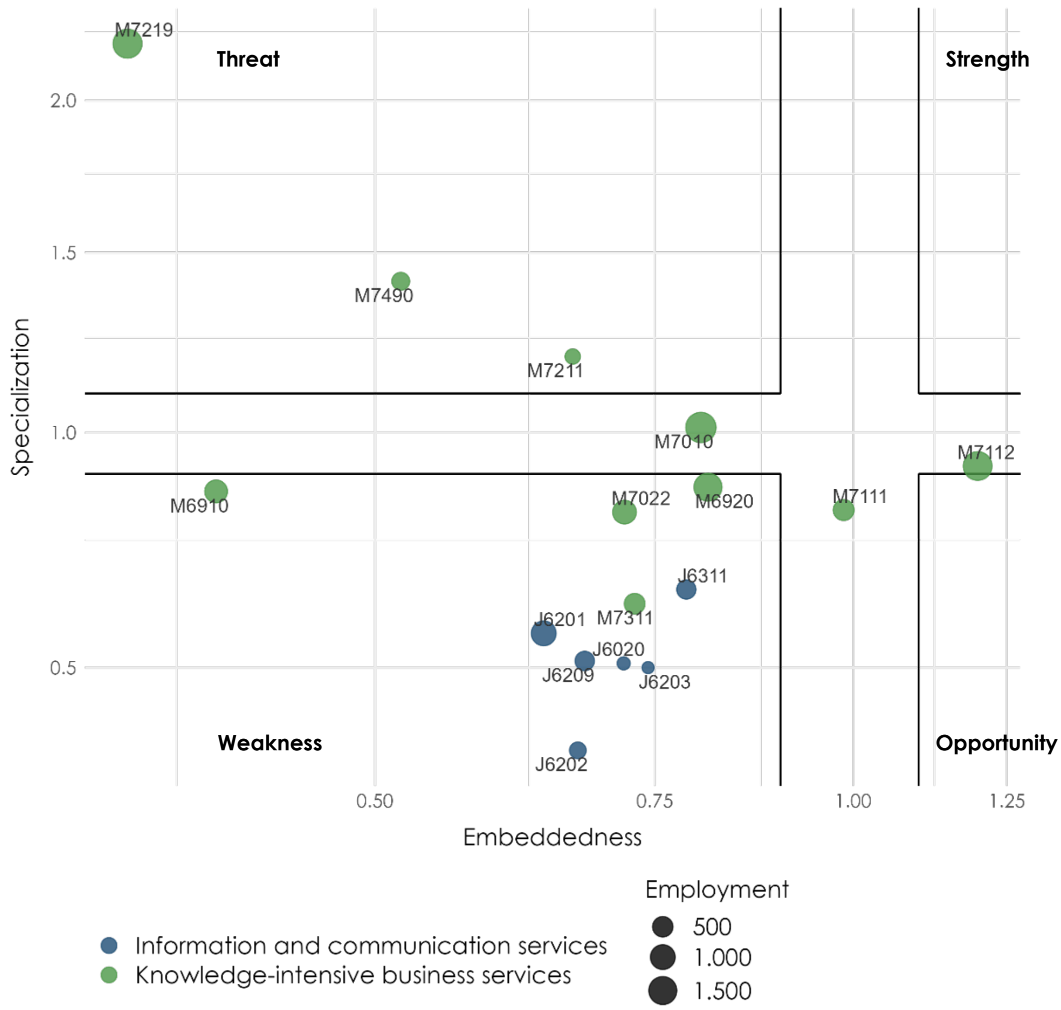
Source: Austrian Labor Market Service, Federal ministry of labor and economy; WIFO calculations. – Only industry classes with 100 or more employees in the regions are shown.

Figure A. 6: **SWOT position of ICS- and KIBS industry classes in Vienna city core**
Degree of specialization and embeddedness in the regional branch network; 4-digit-industries; 2022



Source: Austrian Labor Market Service, Federal ministry of labor and economy; WIFO calculations. – Only industry classes with 100 or more employees in the regions are shown.

Figure A. 7: **SWOT position of ICS- and KIBS industry classes in Vienna commuting zone**
Degree of specialization and embeddedness in the regional branch network; 4-digit-industries; 2022



Source: Austrian Labor Market Service, Federal ministry of labor and economy; WIFO calculations. – Only industry classes with 100 or more employees in the regions are shown.

Table A. 5: **SWOT position of all manufacturing industry sectors in Wien metropolitan region**

NACE Code	Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
D3523	Trade of gas through mains	192	3.3	1.7	4	S
D3514	Trade of electricity	688	1.5	1.7	4	S
C3240	Manuf of games and toys	193	0.5	1.6	3	O
C3313	Repair of electronic and optical equipment	1,978	2.7	1.6	3	S
C3020	Manuf of railway locomotives and rolling stock	2,993	1.5	1.5	2	S
C3317	Repair and maintenance of other transport equip.	2,562	2.3	1.5	3	S
C2352	Manuf of lime and plaster	-	0.0	1.5	2	O
C3040	Manuf of military fighting vehicles	143	3.7	1.5	2	S
C3212	Manuf of jewelry and related articles	166	1.5	1.4	3	S
C3211	Striking of coins	189	3.6	1.4	3	S
C1920	Manuf of refined petroleum products	1,569	3.5	1.3	2	S
C3316	Repair and maintenance of aircraft	65	1.2	1.3	3	S
C3320	Installation of industrial machinery and equipment	2,746	0.9	1.3	3	O
C2910	Manuf of motor vehicles	1,086	0.2	1.3	2	O
C3213	Manuf of imitation jewelry and related articles	206	2.3	1.3	3	S
D3530	Steam and air conditioning supply	116	0.4	1.3	4	O
C2932	Manuf of other parts for motor vehicles	1,910	0.6	1.3	2	O
C2314	Manuf of glass fibers	7	0.3	1.3	2	O
C3091	Manuf of motorcycles	7	0.0	1.3	2	O
D3522	Distribution of gaseous fuels through mains	31	0.1	1.2	4	O
C3250	Manuf of medical and dental instruments	2,121	1.0	1.2	3	Non
C2120	Manuf of pharmaceutical preparations	6,254	1.9	1.2	1	S
C3314	Repair of electrical equipment	376	1.9	1.2	3	S
D3511	Production of electricity	2,855	1.3	1.2	4	S
C2711	Manuf of electric motors, generators and transformers	3,179	1.0	1.2	1	Non
C1813	Pre-press and pre-media services	151	1.1	1.2	4	S
C3311	Repair of fabricated metal products	150	1.1	1.2	3	S
C2594	Manuf of fasteners and screw machine products	27	0.4	1.2	3	O
D3512	Transmission of electricity	496	0.6	1.2	4	O
C3220	Manuf of musical instruments	257	1.6	1.2	3	S
C2899	Manuf of other special-purpose machinery	1,303	0.4	1.2	1	O
C3299	Other manufacturing n.e.c.	191	0.5	1.2	3	O
C2931	Manuf of electrical/electronic equip. for motor vehicles	-	0.0	1.2	2	O
C1200	Manuf of tobacco products	2	3.7	1.2	4	S
C3012	Building of pleasure and sporting boats	7	0.1	1.2	2	O
C2630	Manuf of communication equipment	665	1.3	1.2	1	S
C1723	Manuf of paper stationery	70	1.3	1.1	3	S
C3319	Repair of other equipment	4	0.3	1.1	3	O
C2053	Manuf of essential oils	266	2.1	1.1	2	S
C2896	Manuf of plastics and rubber machinery	1,502	0.7	1.1	1	O
C2891	Manuf of machinery for metallurgy	4	0.0	1.1	1	O
C3103	Manuf of mattresses	4	0.0	1.1	3	O
C1722	Manuf of household and sanitary goods/toilet requisites	635	1.7	1.1	3	S
C1414	Manuf of underwear	27	0.5	1.1	5	O
C1394	Manuf of cordage, rope, twine and netting	13	0.4	1.1	2	O
C3312	Repair of machinery	967	0.8	1.1	3	O
C2640	Manuf of consumer electronics	219	2.9	1.1	1	S
C3030	Manuf of air and spacecraft and related machinery	400	0.8	1.1	2	O
C1089	Manuf of other food products	259	0.3	1.1	4	O
C2893	Manuf of machinery for food processing	635	1.4	1.1	1	Non
C2041	Manuf of soap, cleaning and polishing preparations	322	1.0	1.1	2	Non
C2841	Manuf of metal forming machinery	164	0.1	1.1	1	Non
C2652	Manuf of watches and clocks	7	0.4	1.1	1	Non
C1820	Reproduction of recorded media	6	0.1	1.1	4	Non
C2670	Manuf of optical instruments and photographic equip.	152	0.3	1.1	1	Non
C2732	Manuf of other electronic/electric wires and cables	1,324	2.5	1.1	1	Non
D3513	Distribution of electricity	2,722	0.9	1.1	4	Non
C2895	Manuf of machinery for paper and paperboard prod.	274	0.3	1.1	1	Non
C2660	Manuf of irradiation, electromedical equipment	253	0.3	1.1	1	Non
C1107	Manuf of soft drinks and mineral waters	938	1.1	1.1	4	Non

NACE Code and Name		Emp.	LQ	LQ_rel	Inno Type	SWOT
C2051	Manuf of explosives	1	0.0	1.1	2	Non
C1811	Printing of newspapers	168	1.2	1.1	4	Non
C1102	Manuf of wine from grape	289	1.7	1.1	4	Non
C1042	Manuf of margarine and editable fats	112	1.2	1.1	4	Non
C1020	Processing/preserving of fish	2	0.1	1.1	4	Non
C1041	Manuf of oils and fats	87	0.6	1.1	4	Non
C2343	Manuf of ceramic insulators and fittings	-	0.0	1.1	2	Non
C1072	Manuf of rusk, biscuits and preserved pastry goods	1,016	2.1	1.1	4	Non
C1101	Distilling, rectifying and blending of spirits	73	0.4	1.1	4	Non
C3092	Manuf of bicycles and invalid carriages	146	0.6	1.1	2	Non
C1062	Manuf of starches and starch products	26	0.1	1.1	4	Non
C2849	Manuf of other machine tools	27	0.0	1.1	1	Non
C2441	Precious metals production	143	2.9	1.1	2	Non
C1420	Manuf of articles of fur	5	1.1	1.1	5	Non
C1431	Manuf of knitted and crocheted hosiery	21	0.2	1.1	5	Non
C1071	Manuf of bread, pastry goods and cakes	4,857	0.7	1.0	4	Non
C2620	Manuf of computers and peripheral equipment	54	0.2	1.0	1	Non
C1083	Processing of tea and coffee	83	0.6	1.0	4	Non
C1419	Manuf of other wearing apparel	65	0.9	1.0	5	Non
C2052	Manuf of glues	-		1.0	2	Non
C1031	Procession/preserving of potatoes	171	1.4	1.0	4	Non
C2042	Manuf of perfumes and toilet preparations	451	1.2	1.0	2	Non
C2012	Manuf of dyes and pigments	23	0.4	1.0	2	Non
C3102	Manuf of kitchen furniture	37	0.1	1.0	3	Non
C1082	Manuf of coca, chocolate and sugar confectionery	745	1.2	1.0	4	Non
C2892	Manuf of machinery for mining and construction	50	0.0	1.0	1	Non
C2824	Manuf of power-driven hand tools	-	0.0	1.0	1	Non
C2211	Manuf of rubber tires and tubes	26	0.2	1.0	2	Non
C2894	Manuf of machinery for textile production	64	0.4	1.0	1	Non
C1439	Manuf of other knitted and crocheted apparel	7	0.3	1.0	5	Non
C1091	Manuf of prepared feeds for animals	74	0.2	1.0	4	Non
C2790	Manuf of other electric equipment	1,670	0.6	1.0	1	Non
C2680	Manuf of magnetic and optical media	-	0.0	1.0	1	Non
C1086	Manuf of homogenized and dietetic food	16	0.2	1.0	4	Non
C2110	Manuf of basic pharmaceutical products	242	0.2	1.0	1	Non
C2825	Manuf of non-domestic cooling and ventilation equip.	788	0.5	1.0	1	Non
C1105	Manuf of beer	515	0.5	1.0	4	Non
C2349	Manuf of other ceramic products	1	0.0	1.0	2	Non
C3315	Repair and maintenance of ships and boats	20	0.3	1.0	3	Non
C1412	Manuf of workwear	3	0.0	1.0	5	Non
C2341	Manuf of ceramic household and ornamental articles	57	1.4	1.0	2	Non
C2431	Cold drawing of bars	-	0.0	1.0	2	Non
C1393	Manuf of carpets and rugs	2	0.0	1.0	2	Non
C2219	Manuf of other rubber products	286	0.5	1.0	2	Non
C2751	Manuf of electric domestic appliances	168	0.2	1.0	1	Non
C2059	Manuf of other chemical products	596	0.9	1.0	2	Non
C1814	Binding and related services	122	1.4	1.0	4	Non
C3291	Manuf of brooms and brushes	32	1.3	1.0	3	Non
C1084	Manuf of condiments and seasonings	1,158	2.3	1.0	4	Non
C1039	Manuf of fruit and vegetable juice	707	1.3	1.0	4	Non
C2530	Manuf of steam generators	7	0.1	1.0	3	Non
C2452	Casting of steel	-	0.0	1.0	2	Non
C2712	Manuf of electricity distribution and control apparatus	1,320	0.5	1.0	1	Non
C2020	Manuf of pesticides and other agrochemicals	236	2.0	1.0	2	Non
C2823	Manuf of office machinery and equipment	7	0.7	1.0	1	Non
C1061	Manuf of grain mill products	158	0.3	1.0	4	Non
C2011	Manuf of industrial gases	183	0.9	1.0	2	Non
C2813	Manuf of other pumps and compressors	2,340	1.9	1.0	1	Non
C2612	Manuf of loaded electronic boards	317	0.3	1.0	1	Non
C3099	Manuf of other transport equipment	1	0.1	1.0	2	Non
C2611	Manuf of electronic components	338	0.1	1.0	1	Non
C2319	Manuf and processing of other glass, technical glass	2	0.0	1.0	2	Non
C3109	Manuf of other furniture	1,400	0.3	1.0	3	Non
C1413	Manuf of other outerwear	146	0.4	1.0	5	Non
C1085	Manuf of prepared meals and dishes	1,206	1.6	1.0	4	Non
C1399	Manuf of other textiles	20	0.2	1.0	2	Non
C2364	Manuf of mortars	101	0.3	0.9	2	Non
C2740	Manuf of electric lighting equipment	173	0.1	0.9	1	Non
C2830	Manuf of agricultural and forestry machinery	479	0.3	0.9	1	Non

NACE Code and Name		Emp.	LQ	LQ_rel	Inno Type	SWOT
C3230	Manuf of sports goods	506	0.6	0.9	3	Non
C2391	Production of abrasive products	-	0.0	0.9	2	Non
C2454	Casting of other non-ferrous metals	26	0.2	0.9	2	Non
C2822	Manuf of lifting and handling equipment	357	0.1	0.9	1	Non
C2434	Cold drawing of wire	0	0.0	0.9	2	Non
C2369	Manuf of other articles of concrete, plaster and cement	57	0.9	0.9	2	Non
C1073	Manuf of noodles and farinaceous products	26	0.2	0.9	4	Non
C1092	Manuf of prepared pet foods	536	1.5	0.9	4	Non
C2752	Manuf of non-electric domestic appliances	18	0.1	0.9	1	Non
C1729	Manuf of other articles of paper/paperboard	552	0.9	0.9	3	Non
C2821	Manuf of ovens, furnaces and furnace burners	133	0.2	0.9	1	Non
C1051	Operation of diaries and cheese making	496	0.3	0.9	4	Non
C1310	Preparation and spinning of textile fibers	-	0.0	0.9	2	Non
C2015	Manuf of fertilizers and nitrogen compounds	130	0.5	0.9	2	Non
C2814	Manuf of other taps and valves	254	0.7	0.9	1	Non
C2829	Manuf of other general-purpose machinery	465	0.3	0.9	1	Non
C3101	Manuf of office and shop furniture	580	0.7	0.9	3	Non
C1012	Processing/preserving of poultry meat	63	0.1	0.9	4	Non
C2433	Cold forming or folding	203	0.5	0.9	2	Non
C2331	Manuf of ceramic tiles and flags	0	0.0	0.9	2	W
C1624	Manuf of wooden containers	123	0.4	0.9	3	W
C1052	Manuf of ice cream	36	0.6	0.9	4	W
C2344	Manuf of other technical ceramic products	1	0.0	0.9	2	W
C1711	Manuf of pulp	10	0.1	0.9	3	W
C2016	Manuf of plastics in primary forms	1,003	1.5	0.9	2	T
C2592	Manuf of light metal packaging	226	0.7	0.9	3	W
C2920	Manuf of bodies for motor vehicles, trailers	377	0.3	0.9	2	W
C2442	Aluminium production	23	0.0	0.9	2	W
C2811	Manuf of engines and turbines	49	0.1	0.9	1	W
C2733	Manuf of wiring devices	45	0.1	0.9	1	W
C1081	Manuf of sugar	387	3.7	0.9	4	T
C1396	Manuf of other technical and industrial textiles	59	0.2	0.9	2	W
C2593	Manuf of wire products, chain and springs	276	0.5	0.9	3	W
C2332	Manuf of bricks, tiles and construction products	184	0.8	0.9	2	W
C2651	Manuf of instruments for measuring, testing,	582	0.2	0.9	1	W
	navigation					
C2342	Manuf of ceramic sanitary fixtures	5	0.1	0.9	2	W
C2361	Manuf of concrete products for construction	252	0.2	0.9	2	W
C1395	Manuf of non-woven and articles made from	-	0.0	0.9	2	W
C2720	Manuf of batteries and accumulators	9	0.0	0.9	1	W
C2399	Manuf of other non-metallic mineral products	23	0.1	0.9	2	W
C2815	Manuf of bearings, gears and driving elements	315	0.2	0.9	1	W
C2812	Manuf of fluid power equipment	169	0.3	0.9	1	W
C1013	Prod. Of meat and poultry meat products	2,020	0.7	0.9	4	W
C1011	Processing/preserving of meat	243	0.2	0.9	4	W
C2365	Manuf of fiber cement	15	0.1	0.8	2	W
C1812	Other printing	1,943	1.1	0.8	4	T
C2443	Lead, zinc and tin production	-	0.0	0.8	2	W
C1032	Manuf of fruit and vegetable juice	43	0.1	0.8	4	W
C1520	Manuf of footwear	116	0.3	0.8	5	W
C2529	Manuf of other tanks and containers of metal	14	0.0	0.8	3	W
C2030	Manuf of paints, varnishes, printing ink and mastics	426	0.6	0.8	2	W
C2222	Manuf of plastic packing goods	1,220	1.0	0.8	2	Non
C2013	Manuf of other inorganic basic chemicals	283	1.2	0.8	2	T
C2521	Manuf of central heating radiators and boilers	41	0.1	0.8	3	W
C2512	Manuf of doors and windows of metal	806	0.8	0.8	3	W
C2410	Manuf of basic iron and steel and ferro-alloys	15	0.0	0.8	2	W
C2599	Manuf of other fabricated metal products	538	0.5	0.8	3	W
C2362	Manuf of plaster products for construction	117	0.8	0.8	2	W
C2573	Manuf of tools	403	0.2	0.8	3	W
C2540	Manuf of weapons and ammunition	884	1.5	0.8	3	T
C2451	Casting of iron	117	0.3	0.8	2	W
C2221	Manuf of plastic plates, sheets, tubes and profiles	797	0.4	0.8	2	W
C2561	Treatment and coating of metals	410	0.3	0.8	3	W
C1320	Weaving of textiles	128	0.2	0.8	2	W
C2363	Manuf of ready-mixed concrete	501	0.5	0.8	2	W
C2060	Manuf of man-made fibers	1	0.0	0.8	2	W
C2445	Other non-ferrous metal production	12	0.0	0.8	2	W
C1721	Manuf of corrugated paper and of containers of paper	961	0.6	0.8	3	W
C1512	Manuf of luggage, handbags, saddlery and	18	0.6	0.8	5	W

	NACE Code and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
	harness					
C2351	Manuf of cement	170	0.6	0.8	2	W
C2370	Cutting, shaping and finishing of stone	720	1.0	0.8	2	Non
C1629	Manuf of other products of wood	146	0.7	0.8	3	W
C1391	Manuf of knitted and crocheted fabrics	28	0.2	0.8	2	W
C1330	Finishing of textiles	22	0.2	0.8	2	W
C2312	Shaping and processing of flat glass	221	0.4	0.8	2	W
C2572	Manuf of locks and hinges	688	0.2	0.8	3	W
C1712	Manuf of paper and paperboard	28	0.0	0.8	3	W
C2014	Manuf of other organic basic chemicals	599	1.1	0.8	2	T
C1621	Manuf of veneer sheets and wood-based panels	198	0.2	0.8	3	W
C2432	Cold rolling of narrow strip	-	0.0	0.8	2	W
C1511	Tanning and dressing of leather	-	0.0	0.8	5	W
C2017	Manuf of synthetic rubber in primary form	5	0.5	0.7	2	W
C1622	Manuf of assembled parquet floors	18	0.1	0.7	3	W
C2320	Manuf of refractory products	34	0.1	0.7	2	W
C2511	Manuf of metal structures and parts	1,575	0.3	0.7	3	W
C2444	Copper production	11	0.0	0.7	2	W
C1623	Manuf of other builders' carpentry and joinery	759	0.2	0.7	3	W
C2562	Machining	679	0.3	0.7	3	W
C2223	Manuf of builders' ware of plastic	372	0.3	0.7	2	W
C1392	Manuf of made-up textile articles	113	0.3	0.7	2	W
C2313	Manuf of hollow glass	66	0.2	0.7	2	W
C2453	Casting of light metals	1	0.0	0.7	2	W
C2420	Manuf of tubes, pipes, profiles of steel	106	0.1	0.7	2	W
C2550	Forging/pressing/forming of metal; powder metallurgy	461	0.3	0.7	3	W
C1610	Sawmilling and planing of wood	281	0.1	0.7	3	W
C2229	Manuf of other plastic products	751	0.2	0.6	2	W
C2591	Manuf of steel drums and similar containers	-	0.0	0.5	3	W
C1106	Manuf of malt	155	2.8	0.4	4	T
C1103	Manuf of cider and other fruit wines	7	0.5		4	Non
C1104	Manuf of other non-distilled fermented beverage	-	0.0		4	Non
C1411	Manuf of leather clothes	5	1.3		5	Non
C1724	Manuf of wallpaper	-			3	Non
C2311	Manuf of flat glass	1	0.0		2	Non
C2571	Manuf of cutlery	5	0.5		3	Non
C2731	Manuf of fiber optic cables	-	0.0		1	Non
C3011	Building of ships and floating structures	-			2	Non
D3521	Manuf of gas	10	0.7		4	Non

Source: Austrian Labor Market Service / Federal ministry of labor and economy; WIFO calculations. – Only industry groups with 100 or more employees in the regions are shown.

Table A. 6: **SWOT position of all manufacturing industry sectors in Wien core city**

NACE Code	and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
D3523	Trade of gas through mains	145	3.2	1.8	4	S
D3514	Trade of electricity	676	1.9	1.8	4	S
C3240	Manuf of games and toys	172	0.5	1.7	3	O
C3313	Repair of electronic and optical equipment	1,940	3.3	1.7	3	S
C2352	Manuf of lime and plaster	-	-	1.6	2	O
C3020	Manuf of railway locomotives and rolling stock	2,990	1.9	1.6	2	S
C3317	Repair and maintenance of other transport equip.	2,266	2.6	1.5	3	S
C3211	Striking of coins	189	4.5	1.5	3	S
C3040	Manuf of military fighting vehicles	142	4.6	1.5	2	S
C3320	Installation of industrial machinery and equipment	2,083	0.8	1.4	3	O
C3212	Manuf of jewelry and related articles	147	1.6	1.4	3	S
C3213	Manuf of imitation jewelry and related articles	203	2.8	1.4	3	S
C1813	Pre-press and pre-media services	131	1.2	1.3	4	S
C2910	Manuf of motor vehicles	1,086	0.3	1.3	2	O
C1920	Manuf of refined petroleum products	755	2.1	1.3	2	S
C2314	Manuf of glass fibers	7	0.4	1.3	2	O
C3250	Manuf of medical and dental instruments	1,780	1.1	1.3	3	Non
D3530	Steam and air conditioning supply	65	0.3	1.3	4	O
C2932	Manuf of other parts for motor vehicles	910	0.4	1.3	2	O
C3091	Manuf of motorcycles	7	0.0	1.3	2	O
D3522	Distribution of gaseous fuels through mains	24	0.1	1.3	4	O
C2711	Manuf of electric motors, generators and transformers	3,127	1.2	1.3	1	S
C3220	Manuf of musical instruments	244	1.9	1.2	3	S
C2120	Manuf of pharmaceutical preparations	5,328	2.1	1.2	1	S
C3316	Repair and maintenance of aircraft	10	0.2	1.2	3	O
C1394	Manuf of cordage, rope, twine and netting	13	0.5	1.2	2	O
D3511	Production of electricity	2,666	1.5	1.2	4	S
C2053	Manuf of essential oils	3	0.0	1.2	2	O
C2931	Manuf of electrical/electronic equip. for motor vehicles	-	-	1.2	2	O
C2899	Manuf of other special-purpose machinery	631	0.2	1.2	1	O
C3103	Manuf of mattresses	4	0.0	1.2	3	O
C1811	Printing of newspapers	138	1.2	1.2	4	S
C2630	Manuf of communication equipment	658	1.7	1.2	1	S
C1200	Manuf of tobacco products	-	-	1.2	4	O
C2896	Manuf of plastics and rubber machinery	408	0.3	1.2	1	O
C1414	Manuf of underwear	25	0.6	1.1	5	O
C2640	Manuf of consumer electronics	212	3.6	1.1	1	S
C1820	Reproduction of recorded media	6	0.1	1.1	4	O
C3311	Repair of fabricated metal products	64	0.6	1.1	3	O
C2670	Manuf of optical instruments and photographic equip.	119	0.3	1.1	1	O
C1722	Manuf of household and sanitary goods/toilet requisites	198	0.7	1.1	3	O
C3314	Repair of electrical equipment	90	0.6	1.1	3	O
C3012	Building of pleasure and sporting boats	0	0.0	1.1	2	O
C2652	Manuf of watches and clocks	3	0.2	1.1	1	O
C2041	Manuf of soap, cleaning and polishing preparations	313	1.2	1.1	2	S
C2660	Manuf of irradiation, electromedical equipment	233	0.3	1.1	1	O
C2891	Manuf of machinery for metallurgy	1	0.0	1.1	1	O
C2895	Manuf of machinery for paper and paperboard prod.	274	0.4	1.1	1	Non
C3030	Manuf of air and spacecraft and related machinery	322	0.8	1.1	2	Non
D3512	Transmission of electricity	495	0.7	1.1	4	Non
C2620	Manuf of computers and peripheral equipment	47	0.2	1.1	1	Non
C2051	Manuf of explosives	-	-	1.1	2	Non
C1814	Binding and related services	70	1.0	1.1	4	Non
C2594	Manuf of fasteners and screw machine products	3	0.1	1.1	3	Non
D3513	Distribution of electricity	2,342	1.0	1.1	4	Non
C1723	Manuf of paper stationery	-	-	1.1	3	Non
C1420	Manuf of articles of fur	5	1.4	1.1	5	Non
C1101	Distilling, rectifying and blending of spirits	35	0.2	1.1	4	Non
C2841	Manuf of metal forming machinery	16	0.0	1.1	1	Non
C1031	Procession/preserving of potatoes	-	-	1.1	4	Non
C1020	Processing/preserving of fish	2	0.1	1.1	4	Non
C2893	Manuf of machinery for food processing	25	0.1	1.1	1	Non
C2343	Manuf of ceramic insulators and fittings	-	-	1.0	2	Non
C3299	Other manufacturing n.e.c.	49	0.2	1.0	3	Non

NACE Code and Name		Emp.	LQ	LQ_rel	Inno Type	SWOT
C1072	Manuf of rusk, biscuits and preserved pastry goods	773	2.0	1.0	4	Non
C2431	Cold drawing of bars	-	-	1.0	2	Non
C3092	Manuf of bicycles and invalid carriages	2	0.0	1.0	2	Non
C1431	Manuf of knitted and crocheted hosiery	21	0.2	1.0	5	Non
C1412	Manuf of workwear	3	0.0	1.0	5	Non
C2732	Manuf of other electronic/electric wires and cables	203	0.5	1.0	1	Non
C3102	Manuf of kitchen furniture	24	0.1	1.0	3	Non
C1042	Manuf of margarine and editable fats	112	1.4	1.0	4	Non
C1107	Manuf of soft drinks and mineral waters	361	0.5	1.0	4	Non
C1419	Manuf of other wearing apparel	60	1.0	1.0	5	Non
C1083	Processing of tea and coffee	53	0.5	1.0	4	Non
C2052	Manuf of glues	-		1.0	2	Non
C2612	Manuf of loaded electronic boards	270	0.4	1.0	1	Non
C2110	Manuf of basic pharmaceutical products	162	0.1	1.0	1	Non
C1439	Manuf of other knitted and crocheted apparel	7	0.4	1.0	5	Non
C1086	Manuf of homogenized and dietetic food	9	0.1	1.0	4	Non
C2824	Manuf of power-driven hand tools	-	-	1.0	1	Non
C2452	Casting of steel	-	-	1.0	2	Non
C3312	Repair of machinery	444	0.4	1.0	3	Non
C3319	Repair of other equipment	3	0.3	1.0	3	Non
C2790	Manuf of other electric equipment	1,350	0.6	1.0	1	Non
C1062	Manuf of starches and starch products	26	0.1	1.0	4	Non
C1071	Manuf of bread, pastry goods and cakes	2,599	0.5	1.0	4	Non
C2434	Cold drawing of wire	0	0.0	1.0	2	Non
C2042	Manuf of perfumes and toilet preparations	280	0.9	1.0	2	Non
C2611	Manuf of electronic components	167	0.1	1.0	1	Non
C2341	Manuf of ceramic household and ornamental articles	55	1.6	1.0	2	Non
C1089	Manuf of other food products	114	0.2	1.0	4	Non
C1393	Manuf of carpets and rugs	2	0.0	1.0	2	Non
C2849	Manuf of other machine tools	25	0.0	1.0	1	Non
C1041	Manuf of oils and fats	7	0.1	1.0	4	Non
C2020	Manuf of pesticides and other agrochemicals	79	0.8	1.0	2	Non
C2441	Precious metals production	140	3.6	1.0	2	Non
C2823	Manuf of office machinery and equipment	7	0.8	1.0	1	Non
C1105	Manuf of beer	114	0.1	1.0	4	Non

NACE Code and Name		Emp.	LQ	LQ_rel	Inno Type	SWOT
C2712	Manuf of electricity distribution and control apparatus	856	0.4	1.0	1	Non
C2012	Manuf of dyes and pigments	-	-	1.0	2	Non
C2530	Manuf of steam generators	7	0.1	1.0	3	Non
C2059	Manuf of other chemical products	449	0.8	1.0	2	Non
C2319	Manuf and processing of other glass, technical glass	2	0.0	1.0	2	Non
C1102	Manuf of wine from grape	91	0.7	1.0	4	Non
C2894	Manuf of machinery for textile production	-	-	0.9	1	Non
C1399	Manuf of other textiles	17	0.2	0.9	2	Non
C2751	Manuf of electric domestic appliances	151	0.2	0.9	1	Non
C2349	Manuf of other ceramic products	1	0.0	0.9	2	Non
C2219	Manuf of other rubber products	73	0.2	0.9	2	Non
C3291	Manuf of brooms and brushes	4	0.2	0.9	3	Non
C1082	Manuf of coca, chocolate and sugar confectionery	427	0.9	0.9	4	Non
C2211	Manuf of rubber tires and tubes	24	0.3	0.9	2	Non
C1091	Manuf of prepared feeds for animals	0	0.0	0.9	4	Non
C2391	Production of abrasive products	-	-	0.9	2	Non
C2822	Manuf of lifting and handling equipment	188	0.1	0.9	1	Non
C1413	manuf of other outerwear	132	0.4	0.9	5	Non
C2011	Manuf of industrial gases	37	0.2	0.9	2	Non
C2825	Manuf of non-domestic cooling and ventilation equip.	252	0.2	0.9	1	Non
C2892	Manuf of machinery for mining and construction	9	0.0	0.9	1	Non
C1084	Manuf of condiments and seasonings	669	1.7	0.9	4	Non
C1052	Manuf of ice cream	29	0.6	0.9	4	Non
C2651	Manuf of instruments for measuring, testing, navigation	342	0.1	0.9	1	W
C1073	Manuf of noodles and farinaceous products	18	0.2	0.9	4	W
C1085	Manuf of prepared meals and dishes	1,038	1.7	0.9	4	T
C3109	Manuf of other furniture	504	0.1	0.9	3	W
C2814	Manuf of other taps and valves	119	0.4	0.9	1	W
C1310	Preparation and spinning of textile fibers	-	-	0.9	2	W
C3230	Manuf of sports goods	55	0.1	0.9	3	W
C2740	Manuf of electric lighting equipment	168	0.1	0.9	1	W
C2813	Manuf of other pumps and compressors	2,102	2.1	0.9	1	T
C1729	Manuf of other articles of paper/paperboard	371	0.7	0.9	3	W

NACE Code	and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
C2811	Manuf of engines and turbines	48	0.1	0.9	1	W
C1039	Manuf of fruit and vegetable juice	201	0.5	0.9	4	W
C2369	Manuf of other articles of concrete, plaster and cement	16	0.3	0.9	2	W
C2821	Manuf of ovens, furnaces and furnace burners	31	0.1	0.8	1	W
C2016	Manuf of plastics in primary forms	433	0.8	0.8	2	W
C1812	Other printing	885	0.7	0.8	4	W
C2830	Manuf of agricultural and forestry machinery	10	0.0	0.8	1	W
C2364	Manuf of mortars	0	0.0	0.8	2	W
C1081	Manuf of sugar	-	-	0.8	4	W
C2015	Manuf of fertilizers and nitrogen compounds	39	0.2	0.8	2	W
C2344	Manuf of other technical ceramic products	1	0.0	0.8	2	W
C2592	Manuf of light metal packaging	-	-	0.8	3	W
C2752	Manuf of non-electric domestic appliances	16	0.1	0.8	1	W
C2812	Manuf of fluid power equipment	33	0.1	0.8	1	W
C3315	Repair and maintenance of ships and boats	14	0.3	0.8	3	W
C3101	Manuf of office and shop furniture	144	0.2	0.8	3	W
C2331	Manuf of ceramic tiles and flags	-	-	0.8	2	W
C2829	Manuf of other general-purpose machinery	192	0.2	0.8	1	W
C2720	Manuf of batteries and accumulators	1	0.0	0.8	1	W
C1711	Manuf of pulp	10	0.1	0.8	3	W
C2433	Cold forming or folding	0	0.0	0.8	2	W
C2410	Manuf of basic iron and steel and ferro-alloys	14	0.0	0.8	2	W
C2815	Manuf of bearings, gears and driving elements	212	0.2	0.8	1	W
C1396	Manuf of other technical and industrial textiles	59	0.2	0.8	2	W
C1092	Manuf of prepared pet foods	105	0.4	0.8	4	W
C2442	Aluminium production	-	-	0.8	2	W
C1051	Operation of diaries and cheese making	22	0.0	0.8	4	W
C2521	Manuf of central heating radiators and boilers	14	0.0	0.8	3	W
C3099	Manuf of other transport equipment	1	0.1	0.8	2	W
C2443	Lead, zinc and tin production	-	-	0.8	2	W
C1011	Processing/preserving of meat	4	0.0	0.8	4	W
C2593	Manuf of wire products, chain and springs	160	0.4	0.8	3	W
C2733	Manuf of wiring devices	45	0.1	0.8	1	W
C1013	Prod. Of meat and poultry meat products	1,021	0.4	0.8	4	W
C2399	Manuf of other non-metallic mineral products	3	0.0	0.8	2	W

NACE Code	and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
C2454	Casting of other non-ferrous metals	1	0.0	0.8	2	W
C2680	Manuf of magnetic and optical media	-	-	0.8	1	W
C1061	Manuf of grain mill products	0	0.0	0.8	4	W
C2573	Manuf of tools	275	0.2	0.8	3	W
C1624	Manuf of wooden containers	31	0.1	0.8	3	W
C2451	Casting of iron	37	0.1	0.8	2	W
C2540	Manuf of weapons and ammunition	2	0.0	0.8	3	W
C2342	Manuf of ceramic sanitary fixtures	5	0.1	0.8	2	W
C1395	Manuf of non-woven and articles made from	-	-	0.8	2	W
C2332	Manuf of bricks, tiles and construction products	76	0.4	0.8	2	W
C2529	Manuf of other tanks and containers of metal	1	0.0	0.8	3	W
C2222	Manuf of plastic packing goods	480	0.5	0.7	2	W
C2060	Manuf of man-made fibers	1	0.0	0.7	2	W
C2013	Manuf of other inorganic basic chemicals	89	0.5	0.7	2	W
C2030	Manuf of paints, varnishes, printing ink and mastics	311	0.5	0.7	2	W
C1520	Manuf of footwear	114	0.4	0.7	5	W
C1032	Manuf of fruit and vegetable juice	30	0.1	0.7	4	W
C2365	Manuf of fibre cement	1	0.0	0.7	2	W
C1012	Processing/preserving of poultry meat	-	-	0.7	4	W
C2445	Other non-ferrous metal production	5	0.0	0.7	2	W
C2361	Manuf of concrete products for construction	34	0.0	0.7	2	W
C1320	Weaving of textiles	19	0.0	0.7	2	W
C2920	Manuf of bodies for motor vehicles, trailers	53	0.1	0.7	2	W
C1629	Manuf of other products of wood	97	0.6	0.7	3	W
C1511	Tanning and dressing of leather	-	-	0.7	5	W
C1391	Manuf of knitted and crocheted fabrics	16	0.2	0.7	2	W
C1330	Finishing of textiles	17	0.2	0.7	2	W
C2562	Machining	329	0.2	0.7	3	W
C2221	Manuf of plastic plates, sheets, tubes and profiles	271	0.2	0.7	2	W
C2351	Manuf of cement	51	0.2	0.7	2	W
C2014	Manuf of other organic basic chemicals	25	0.1	0.7	2	W
C1721	Manuf of corrugated paper and of containers of paper	696	0.6	0.7	3	W
C2512	Manuf of doors and windows of metal	156	0.2	0.7	3	W
C1392	Manuf of made-up textile articles	79	0.3	0.7	2	W
C2432	Cold rolling of narrow strip	-	-	0.7	2	W

NACE Code	and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
C2370	Cutting, shaping and finishing of stone	199	0.4	0.7	2	W
C2313	Manuf of hollow glass	62	0.2	0.7	2	W
C1512	Manuf of luggage, handbags, saddlery and harness	5	0.2	0.7	5	W
C2572	Manuf of locks and hinges	647	0.3	0.7	3	W
C1621	Manuf of veneer sheets and wood-based panels	-	-	0.7	3	W
C2599	Manuf of other fabricated metal products	408	0.5	0.7	3	W
C2312	Shaping and processing of flat glass	25	0.1	0.7	2	W
C2017	Manuf of synthetic rubber in primary form	2	0.2	0.7	2	W
C2561	Treatment and coating of metals	236	0.2	0.6	3	W
C1712	Manuf of paper and paperboard	8	0.0	0.6	3	W
C2363	Manuf of ready-mixed concrete	136	0.2	0.6	2	W
C2444	Copper production	-	-	0.6	2	W
C2362	Manuf of plaster products for construction	67	0.5	0.6	2	W
C2320	Manuf of refractory products	32	0.1	0.6	2	W
C2453	Casting of light metals	1	0.0	0.6	2	W
C2511	Manuf of metal structures and parts	641	0.2	0.6	3	W
C2550	Forging/pressing/forming of metal; powder metallurgy	146	0.1	0.6	3	W

NACE Code	and Name	Emp.	LQ	LQ_rel	Inno Type	SWOT
C1622	Manuf of assembled parquet floors	15	0.1	0.6	3	W
C2223	Manuf of builders' ware of plastic	55	0.1	0.6	2	W
C1623	Manuf of other builders' carpentry and joinery	365	0.1	0.6	3	W
C2420	Manuf of tubes, pipes, profiles of steel	12	0.0	0.6	2	W
C1610	Sawmilling and planing of wood	2	0.0	0.5	3	W
C2229	Manuf of other plastic products	122	0.0	0.4	2	W
C2591	Manuf of steel drums and similar containers	-	-	0.4	3	W
C1106	Manuf of malt	155	3.5	0.3	4	T
C1103	Manuf of cider and other fruit wines	-	-	-	4	Non
C1104	Manuf of other non-distilled fermented beverage	-	-	-	4	Non
C1411	Manuf of leather clothes	5	1.6	-	5	Non
C1724	Manuf of wallpaper	-		-	3	Non
C2311	Manuf of flat glass	1	0.0	-	2	Non
C2571	Manuf of cutlery	5	0.6	-	3	Non
C2731	Manuf of fibre optic cables	-	-	-	1	Non
C3011	Building of ships and floating structures	-		-	2	Non
D3521	Manuf of gas	4	0.4	-	4	Non

Source: Austrian Labor Market Service / Federal ministry of labor and economy; WIFO calculations. – Only industry groups with 100 or more employees in the regions are shown.

7.4.1 Technical supplement to chapter 5: Methodical basics of the empirical SWOT analyses of industry classes

The location quotient used in the empirical SWOT analyses of chapter 5 is calculated as

$$LQ_{ir} = \frac{emp_{ir}}{emp_r} \Big/ \frac{emp_i}{emp}$$

with *emp* the number of employees, *i* the NACE-4-digit industry class and *r* the region under consideration (here: Vienna metropolitan region or its subregions), i.e., as the quotient of the industry class share in the region's employment and the same class share in the employment of the reference area (here: Austria). As a relative concentration measure, the location quotient takes a value of one for a regional employment share of industry class *i* as in the reference region, whereas larger/smaller values indicate a regional specialization or shortage of the industry class, as compared to the benchmark.

The degree of embeddedness in these analyses can be expressed as

$$LQ_{ir}^{rel} = \frac{emp_{ir}^{rel}}{emp_r} \Big/ \frac{emp_i^{rel}}{emp}$$

With emp_{ir}^{rel} the employment in all the industry classes "related" to industry class *i* in region *r* and emp_i^{rel} the employment in these industry classes close to industry class *i* in Austria. If this degree of embeddedness is > 1, industry class *i* is well embedded in the regional economy because it can draw on a large pool of related industries with similar capabilities and knowledge bases. Values < 1, in contrast, denote industry classes that lack such a supporting "ecosystem" of related industries in the region.

Combining these indicators allows a SWOT (Strength, Weakness, Opportunity, Threat) profile to be assigned to each industry class within predefined bandwiths, as shown in the following table.

Table A. 7: Typology for classifying the industry classes in our empirical SWOT analysis
Development potentials according to degree of specialization and embeddedness

		Regional embeddedness of industry class *i*	
		Low $LQ_{ir}^{rel} < 0.9$	high $LQ_{ir}^{rel} > 1.1$
Regional specialization of industry class *i*	Low $LQ_{ir} < 0.9$	Weakness (W)	Opportunity (O)
	High $LQ_{ir} > 1.1$	Threat (T)	Strength (S)

Source: Otto et al. (2014); WIFO illustration.

A prerequisite for implementing the approach is, of course, a clear (and if possible, evidence-based) idea of which industries (in producing and/or services sectors) an industry to be analyzed is actually "related" to.

Several approaches have been developed in the literature to identify this (cognitive) "proximity" between industries[114]. Following Frenken et al. (2007), a large part of the related literature uses (ad-hoc) measures of inter-industry relatedness derived from the hierarchical structure of official industrial classification systems (i.e., SIC, HS, NAICS or NACE), assuming that industries (and their capabilities) are increasingly similar the more digits they share in the respective classification. Easy to implement (and therefore widely used), this measure does not sufficiently reflect the breath of possible industry links and the variety of channels responsible for them (Ejermo, 2005; Desrochers & Leppälä, 2011)[115]. Recent work therefore suggests measuring relatedness via empirical methods, which also allows to determine relatedness between industries distant in industry classification systems. Scholars inferred a relatedness between industries from a similar input use in terms of resources (Fan & Lang, 2000) or skills (Brachert et al., 2013), from observed inter-industry input flows (Essletzbichler, 2015), the co-patenting behavior between industries (Balland & Boschma, 2021), but also the co-occurrence of products from different industries at the plant level (Neffke & Henning, 2008) or the probability that countries develop joint comparative advantages in two specific products (Hidalgo et al., 2007; Boschma et al., 2012).

In our empirical exercise we use a method proposed by Neffke & Henning (2013), deriving the technological or cognitive proximity of industries from the number of job switches between them. The basic idea is that labor flows will primarily take place between jobs with similar skill requirements because the human capital of (particularly) higher-skilled workers is strongly job-specific. Thus, these workers lose part of their human capital when moving to an industry in which they cannot or can only hardly utilize their previously accumulated knowledge (Parent, 2000). Job switches between industries requiring completely different skills and capabilities will therefore remain rare. Rather, employees will prefer to switch between industries that are based on a common knowledge base (i.e., are technologically or cognitively "related"), as in this case they can transfer large parts of their human capital, and thus avoid income losses. Therefore, the degree of "relatedness" between industries should be inferable from the size of the labor flows between them.

A necessary condition for useful results from this approach is complete information on all job switches between industries at a very disaggregated level. Here, we can draw on results from a large WIFO project (Klien et al., 2021), in which inter-sectoral labor flows in Austria were examined at a highly disaggregated level to identify technologically or cognitively related industries, using a comprehensive (micro-)data base from the Austrian Federation of Social

[114] For a survey of these approaches and a discussion of their methodological (dis-)advantages, see, e.g., Firgo & Mayerhofer (2015, 2017).

[115] Note, for example, that manufacturing and service classes are always unrelated in this approach as they do not share the same division in industrial classification systems even at the 1-digit-level. This implies, for instance, that manufacturing and R&D as well as manufacturing and business services are considered in this approach as unrelated by definition.

Insurances (Dachverband der Sozialversicherungsträger)[116]. In this database, 601 industry classes (NACE-4-digit) can be distinguished, resulting in a total of 361,201 source-destination relationships in the universe of industry classes in a symmetric matrix. For each of these bilateral relationships we calculate a "skill-relatedness index" (SR_{ij}) that depicts the relative magnitude of the respective labor flow between industries *i* and *j*. This indicator is denoted as

$$SR_{ij} = \frac{F_{ij}}{\hat{F}_{ij}}$$

and serves as a measure of the cognitive proximity between the industry pairs. F_{ij} denotes the number of observed job switches between the industry classes *i* and *j* here, while $\hat{F}_{ij}$ depicts the "expected" number of job switches that would have occurred between these classes in the case of completely random switches[117]. If this skill-relatedness-index is >1, the actual number of identified job switches between two industry classes is larger than would have been expected in case of random entries and exits. In this case, the industry pair is considered related. Based on the matrix of the 361,201 indicator values formed in this way for the 601 NACE 4-digit industries in the economy total, it was possible to draw the entire network of related industries for metropolitan Vienna and its sub-regions, and subsequently to use this for calculating the degree of embeddedness for the (236) industry classes of the manufacturing sector (NACE C+D) as part of our empirical SWOT analysis.

[116] The Dachverband's database contains the complete employment histories of all employees subject to social insurance contributions in Austria in an anonymized form on a micro-data basis. It provides an anonymized person-ID for everyone appearing on the Austrian labor market, which can be assigned to the NACE-4-digit industry class of the employing firm via an anonymized firm-ID. This assignment can be used to calculate the frequency of job switches between industries for each industry pair.

[117] The latter number can be derived from the total of (observed) job outflows in both industries.

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Urban Manufacturing in Atlanta

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

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A note about geographic definitions. The report uses a flexible definition of the city region, depending on data availability and the analysis level.

- MSA: The broadest definition is the Metropolitan Statistical Area (MSA). An MSA is a multi-county geographic construct that attempts to encompass areas of urban concentration in terms of population and economic activity. The MSA definition is a statistical unit of analysis assigned by the U.S. Census Bureau, not a political unit. While MSAs generally include counties that form the region's industrial core, they may also include counties that are mainly residential, commercial, or governmental and, therefore, outside the main scope of analysis. However, because some economic data are readily available at the level of MSAs, the designation is used as a matter of convenience for some of the analyses.
- CORE CITY-REGION: A more focused geographic designation is the "Core Region." This consists of several counties surrounding the primary city containing the most industrial activity. Since more detailed sectoral statistics tend to be available at the county level, this customized collection of countries is used to reduce "noise" in the analysis.
- CITY: The most constrained geographic definition used in the study is the jurisdiction of the region's primary city, which is generally the most densely developed, most congested, has the highest operating costs, and has the highest level of contention over land uses. We mainly focus on industrial policies at this level.

We will use these designations throughout, although the MSA has been shortened after initial use, and Core City-Region has been shortened to Core Region. Our analytic strategy begins at the MSA level to pick up broader regional trends, then focuses on the Core Region to investigate industrial structure in detail, and finally to conduct interviews and investigate policies as close to the City level as possible to observe the position of urban manufacturing where it is likely to come under the most extreme pressure. The logic is that if manufacturing occurs in high-cost urban settings, there must be good reasons for it! **In the case of Atlanta, the Atlanta-Sandy Springs-Alpharetta MSA includes 29 counties: Barrow, Bartow, Butts, Carroll, Cherokee, Clayton, Cobb, Coweta, Dawson, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Haralson, Heard, Henry, Jasper, Lamar, Meriwether, Morgan, Newton, Paulding, Pickens, Pike, Rockdale, Spalding, and Walton. The more focused City-Region excludes counties in the MSA that are mainly residential or rural to arrive at a three-county area consisting of Fulton, Forsyth, and Cobb counties. We refer to this more focused region colloquially as the San Atlanta Core Region.**

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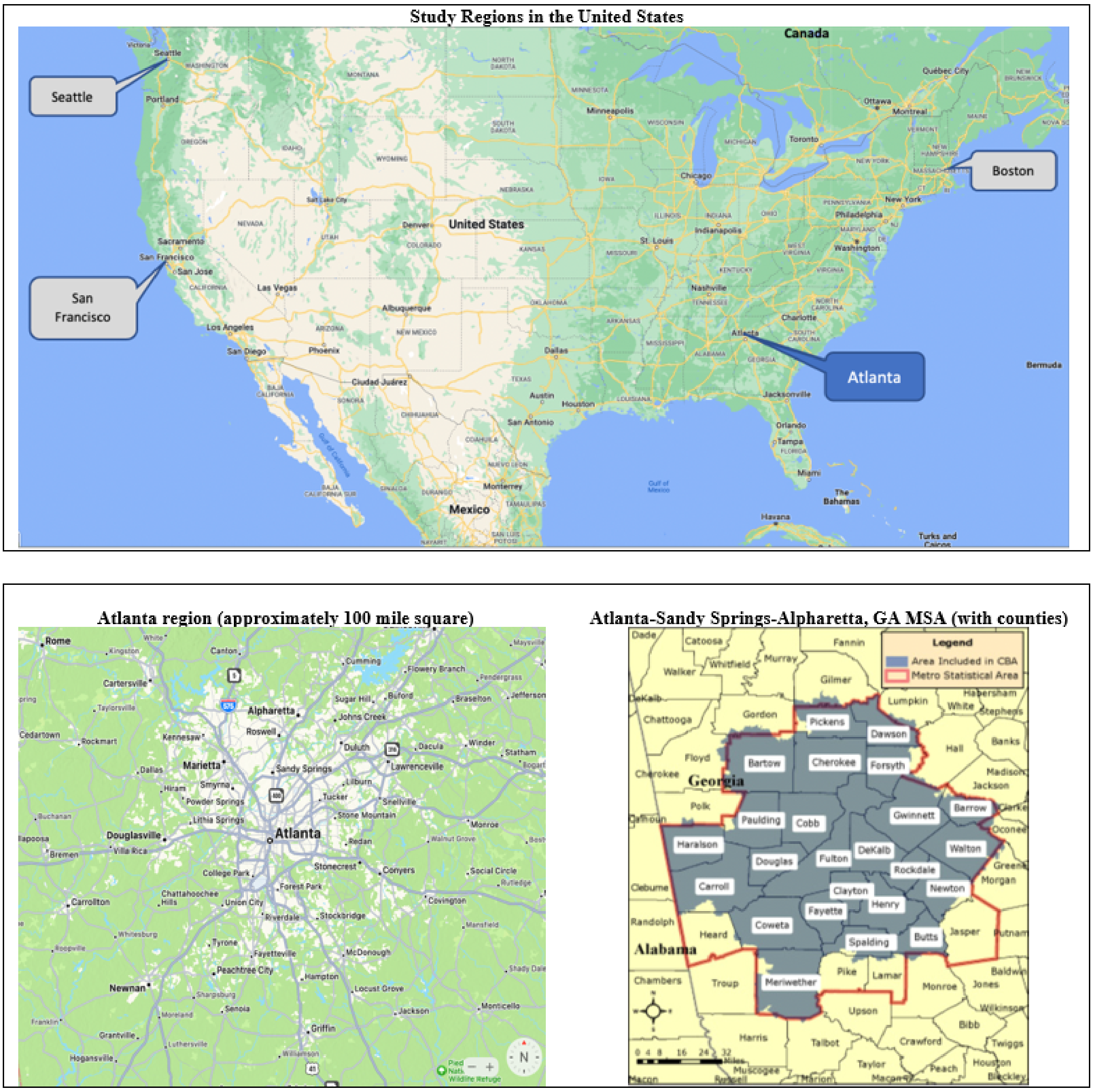
1. Geographic situation

The geographic situation of the Atlanta study area relative to the United States and the other regions included in the four regions studied by our team is shown in Figure 1.1. This analysis includes Atlanta-Sandy Springs-Alpharetta MSA in the broad analysis and a Core Region defined by the twenty-four-county area of Atlanta.

Figure 1.1: Atlanta in geographic context



Sources: Google Maps, Apple Maps, U.S. Centers for Medicare & Medicaid Services (https://www.dmecompetitivebid.com/palmetto/cbicrd2.nsf/DocsCat/Round%202~Competitive%20Bidding%20Areas~Boston-Cambridge-Quincy%20MA-NH~9K3PZB7325?open&navmenu=| |)

The large number of counties in Georgia date back to the original partitioning of the state. Then, in 1962, Georgia used the County Unit System to choose many elected officials. The system gave more political power to urban counties over city governments. Also, it benefited rural Georgia, awarding them political power above what might be expected given their sparse populations. [1] This has resulted in an easier path for state- and regional-level economic development actors seeking to develop industrial and infrastructure projects, given that they have fewer parties to negotiate with. In the other city regions examined by our team, a multitude of affected towns and cities have the opportunity to block projects. In New England, where Boston is located, some towns continue the tradition of using open town meetings where citizens can vote projects up or down directly.

2. Background

Atlanta is the primate city in Georgia and the broader Southeastern U.S. outside Florida. The city has the most significant federal agencies outside the nation's capital. The regional economy is tied to government, transportation, and hospitality services. Growth and renovation of downtown started in the 1980s, and now the city has 75,000 hotel rooms, the third highest among U.S. cities. Atlanta also hosts a full complement of civic activities with two major sports stadiums, more than 20 professional theatre venues, and 40 museums. A confluence of rail and highways, along with Hartsfield-Jackson Airport – the largest in the world – make the city one of the best-connected urban centers in the U.S.[2] Aside from some early growth in the textile industry, the region's economy outside of services has historically been tied to agriculture and population-serving industries. In recent years, relatively low costs, business-friendly institutions, and the availability of rural land for development have made the broader region a target for large-scale investments in automotive assembly, batteries, and solar panels. However, the lack of deep roots in industrialization is still evident in the region's industrial and economic structure, institutions, and labor force.

Early History

In the early 19th century, the area out of which the city of Atlanta sprouted, located at the confluence of the Chattahoochee River and Peachtree creeks, was at a railroad crossroads surrounded by agricultural land.[3] Unlike the other city regions examined by our team, Atlanta has no ocean access; it was the first land-locked major American city.[4] However, like the other cities our team investigated, and in fact like the entire U.S., Atlanta's land area was taken from indigenous people – in this case the Muscogee (Creek) and Cherokee nations.[5]

1 See: https://cviog.uga.edu/news/061319-counties.html#:~:text=Until%201962%2C%20Georgia%20used%20the,counties%20and%20therefore%20more%20muscle

2 See: https://original.newsbreak.com/@informed-insight-1604935/2922836457884-why-atlanta-is-a-thriving-hub-for-business-and-investment

3 https://www.atlantaga.gov/visitors/history

4 https://www.u-s-history.com/pages/h2736.html

5 https://www.roundaboutatlanta.com/the-history-of-atlanta

Atlanta has long been known as the "Queen City" of the South. Like the rest of the U.S. South before the Civil War (1861-1865), Atlanta had a "plantation economy" based on the labor of enslaved Africans. During the Civil War, it quickly became a mercantile center and was a key location for war material transport, manufacturing, and storage. Most industries were converted to wartime production, such as clothing and shoes for Confederate soldiers.

The Union Army's General Sherman burnt the city to the ground. Afterward, it was rebuilt, and the surrounding agricultural lands filled with small settlements, eventually evolving into more substantial villages and towns. In the "Jim Crow" South[6], African Americans continued to be denied voting rights, economic opportunity and the ability to accumulate generational wealth. Nevertheless, the city maintained its central role in the region's economy, with the railroads playing an instrumental role by connecting Atlanta with the rest of the state and country.[7]

After the war, the city continued to serve as the central south's most important center of mercantilism. The city's economic base was motivated by political boosterism led by white business interests, which set industrial priorities. Continued transportation infrastructure development enabled the city to grow internally and outwardly toward surrounding counties. The electric streetcar enabled the city to form adjacent suburbs.[8]

After the Civil War, the Freedman's Bureau, a governmental entity under the War Department, was established to provide relief services to more than four million formerly enslaved people, including food, clothing, shelter, medical supplies, education, legal services, and land distribution. However, the organization was subjected to political manipulation and eventually shut down.[9] Regulations on black citizens' residency in the inner-city forced black residents to live on one side of the city core, resulting in two regions of the city that evolved into a center of black and white institutions, respectively. Several important Black institutions were established and occupied land on the budding city's southwest side.

Early Era of Segregation

By 1900 more than a third of the city's population was African American. Before the 1906 Race Massacre, Black families could be found throughout the city, even within neighborhoods considered "white." Afterwards, the real estate industry blocked Black businesses and residents from living along Auburn Avenue, and they were forced further west and south to the city's edges into low-lying, flood-prone areas.

Despite Jim Crow Laws, African Americans created their own economic, social, and residential enclaves. Several historically Black universities (Spellman, Clark Atlanta, Morehouse College) were born in these areas, and religious and medical entities also remained clustered in the

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[6] The "Jim Crow" laws were a collection of state and local statutes that legalized racial segregation in the southern states of the US from just after the Civil War until 1968

[7] https://www.atlantaga.gov/visitors/history

[8] https://www.stache.com/blog/history-atlanta-ga-1836-2020/

[9] https://www.u-s-history.com/pages/h410.html

area, forming the core of the Black community of Atlanta.[10] For those outside of Georgia, Atlanta was considered a "Black Mecca" that would eventually evolve into a city region of African American political power.

By 1930, half of Atlantans had moved to more exclusive areas away from downtown and black neighborhoods, causing Atlanta became even more segregated than it had been. Planning and other public entities pushed Black residents into more confined spaces, believing the city would be more congenial and socially healthier by retaining its segregated pattern.[11] At the same time, leading African American thinkers such as Booker T Washington also encouraged segregation in support of a black middle class.

Before World War II, many Atlantans were convinced of the value of shifting away from the old culture of the South, which from an economic perspective meant a move away from agriculture toward the industry. City leaders sponsored major international expositions to demonstrate progress.

Core Elements of the City's 20th-Century Economy

Three core elements have helped to drive Atlanta's emergence as the capital city of the South and shape its growth over time: transportation, federal spending, and civil rights.

Atlanta as a Transportation Hub

Despite being one of the most congested cities in the U.S., Atlanta owes much of its success as the capital of the South due to transportation innovation and infrastructure expansion.[12] Transportation infrastructure has always been a part of Atlanta's growth planning. In the 1920s, far away from airplane production, the city had the foresight to build the Hartsfield-Jackson airport. Today it is the busiest airport in the world, with five runways and 195 gates. The airport employs 55,000 employees with a $2.5 billion payroll.[13] According to the Atlanta Chamber of Commerce, eighty percent of U.S. major cities are within a 2-hour flight or 2-day truck drive from Atlanta.[14]

Federal Investments and Wartime Production

The depression era hit Atlanta hard, given its role as a transport hub and, at the time, a center for manufacturing – mainly textiles, food processing, and armaments. The federal government provided considerable funding to help the city during the Depression. Still, its recovery did not come until the Second World War, as the Atlanta region won many defense contracts for armaments, materiel, and other goods supporting the war effort. During wartime, between 1940

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[10] https://www.u-s-history.com/pages/h2736.html

[11] https://www.stache.com/blog/history-atlanta-ga-1836-2020/

[12] https://www.historians.org/research-and-publications/perspectives-on-history/november-2015/on-the-move-atlantas-history-told-in-transportation

[13] https://www.historians.org/research-and-publications/perspectives-on-history/november-2015/on-the-move-atlantas-history-told-in-transportation

[14] https://www.metroatlantachamber.com/built-for-business/key-industries/supply-chain-advanced-manufacturing/

and 1945, $10 billion was spent setting up headquarters in the South to decentralize federal military infrastructure should an enemy attempt to attack U.S. eastern coastal resources (the same trend helped to spur manufacturing in cities across the South and West, including the San Francisco Bay area and Seattle). Local companies switched to wartime production. Bell Aircraft established an Atlanta facility, followed by other defense contractors that built factories outside the city.[15]

The Civil Right Movement Transforms the City

After World War II, the city's economy recovered, and like many cities around the country, the interstate highway project pumped additional federal resources into the region. "Urban renewal," an idea intended to improve U.S. cities by demolishing "blighted" areas, most often where poor residents lived, was just around the corner. Too often, these programs stalled after demolition, leaving gaping holes in the urban fabric. The new highway program also destroyed Black neighborhoods, displacing 67k people by 1959. As a result, African Americans were pushed onto smaller and smaller portions of the city's land area; 36% of Atlanta's population was Black but occupied only 16% of the city's land area. After living in sub-standard housing with inadequate infrastructure for the first part of the century, the Civil Rights Movement of the 1960s prompted white civic leaders to provide more resources to traditionally Black neighborhoods, including funds to desegregate the schools. The poll tax, which made it difficult for poor blacks to vote, was repealed in 1945, and one thousand nine hundred sixty-two physical barriers formerly placed to separate blacks and whites were finally torn down.[16] As whites moved out to the outer suburbs, more middle-class black families began to occupy the inner suburbs. By the early 1970s, black civic leaders were being elected to more political offices, including the mayor, vice mayor, and members of Congress.

Stronger Local Government Helps City Grow

From the late 1960s onward, Atlanta's weak city manager model was abandoned. A mayor and city council were elected to avoid many racial flash points threatening other southern cities at the time. Business leaders wanted to prevent urban clashes, and the town was mainly spared significant racial violence.

New public facilities were also being built in the 1960s. The federal government funded additional low-income housing and the city made plans to build a mass transit system. Sports stadiums were put on the drawing board, enabling the town to attract major league sports teams. These gestures underline that Atlanta saw itself as a city apart from its region and the strife experienced in many other southern cities. Atlanta leaders pushed hard on the idea of "Forward Atlanta" As more businesses came, the town gained a new title: "the Capital of the South."

By the 1970s, the city was well on its way to having a multi-county road expressway system. In 1971 a narrow majority voted to fund the rapid transit system, with plans to include bus and rail.

[15] https://www.atlantafed.org/economy-matters/regional-economics/2017/07/13/transportation-has-long-fueled-atlanta

[16] https://www.georgiaencyclopedia.org/articles/arts-culture/henry-w-grady-1850-1889

Prominent skyscrapers like the Peach Tree Plaza Hotel were built starting that decade. The city grew from 2 million to four million between 1980 and 2000. Today, the city's freeway system is one of the largest in the country, second only to Los Angeles.[17]

Corporate Headquarters and The City's Growing International Connections

By 1995 more than 1,000 international companies from 35 different countries had been located in the City of Atlanta. The civic infrastructure built over the last 30 years made thriving tourism possible. Extensive facilities were designed to draw travelers to the south and create conditions for the once-urban and mostly suburban residents to use the city's resources.[18]

The award of the 1996 Atlanta Olympics to Atlanta was a sure sign that the city was the central urban complex of the south. The city had spruced itself up in the 1970s, and the aftermath of the Games reused event infrastructure for college dorms and other university-related accommodations.

From 2000 to 2010, the metro area grew from 1.2 million to 5.2 million, continuing to drive dispersion to an ever-larger suburban ring. The city has become increasingly diverse, with people arriving worldwide. The migrants reduced the percentage of African Americans living in the city from 67% in 1990 to 54 % in 2010. Most of the change comprises persons 25-34 with a college education. However, the city remains predominantly white and black, with blacks about 50% of Atlanta being the second most segregated city in the U.S.[19]

The 21st Century Industrial Structure

Recovery After the Financial Crisis and Limited Impact of COVID

While like other major metropolitan in the U.S., Atlanta lost residents areas during the financial crisis of 2007-2009, and population growth declined, though during the COVID-19 pandemic of 2020-2021, the city added 41k residents. In recent years, middle-class and upper-class African Americans began to move to selected suburbs.

Another significant change was Mayor Renee Glover's elimination of the city's public housing stock.[20] Seventeen thousand available units were torn down in the 2010s. With Hope Six Federal funding from the Department of Housing and Urban Development, the city plans to create "Mixed-Income Communities" mixed-use developments combining higher and lower-income residents, owners and renters, and housing and commercial activities. Some of the housing is subsidized for very low-income residents. Mayor Glover also placed a stipulation on occupancy, requiring persons accepting new residences to demonstrate employability.

Another city-wide urban development effort developing over the last ten years is the Beltline project, which channels development along an abandoned train track encircling the

[17] https://original.newsbreak.com/@informed-insight-1604935/2922836457884-why-atlanta-is-a-thriving-hub-for-business-and-investment

[18] https://en.wikipedia.org/wiki/Economy_of_Atlanta

[19] https://worldpopulationreview.com/us-cities/atlanta-ga-population#

[20] https://en.wikipedia.org/wiki/Atlanta_Housing_Authority

downtown that is being converted to parks, trails, and other public uses. When completed, combined with another rail trail, the system will cover 300 miles, making it the most extended rails-to-trails project in America.[21]

3. Major Companies and Industries

According to the Atlanta Chamber of Commerce, Atlanta is home to the headquarters of 31 Fortune 1,000 and 500 companies.[22] Major home-grown employers in Atlanta fall into several categories: transportation and goods shipping (Delta Air Lines, Norfolk Southern, and United Parcel Service), utilities (The Southern Company), packaging and consumer goods (Graphic Packaging, Newell Brands, WestRock, and Veritiv), construction (Pulte Group), food and beverage (The Coca-Cola Company), automotive parts and agricultural machinery (Genuine Parts Company and AGCO Corporation), and retail and automotive dealerships (The Home Depot and Asbury Automotive Group). Unlike the other three cities examined by our research team, the region's economy is not generally driven by technology-intensive companies and industries. Today, Hartfield airport is the busiest airport in the U.S. It has five runways and 195 gates, the most in the world. The airport employs 55,000 employees with a $2.5 billion payroll.[23]

Because of its "positive business climate" the State of Georgia and broader region around Atlanta have been successful in attracting several large manufacturing investments, including South Korean automakers Kia and Hyundai (for its EV line) near the Port of Savannah. SK Battery America, owned by South Korean firm SK Innovation, employs 3,000 workers in Commerce, Georgia, located about 70 miles northeast of Atlanta. The plant complex, established in 2019, represents an investment of $2.6 billion.[24] Hanwha Qcells, a South Korean solar panel manufacturer with an existing plant in Dalton, Georgia, also established in 2019, located about 90 miles north of Atlanta, has announced a second factor in Cartersville, located about 50 miles north of Atlanta, near Marietta. The new investments are expected to create about 2,500 jobs and start in 2024.[25] This expanded investment has been motivated in part by subsidies from the federal government. Jon Ossof, the new Senator from Georgia, is a sponsor of the Solar Energy Manufacturing for America Act, which offers tax incentives to solar manufacturers. The bill was later incorporated into the Biden Administration's bi-partisan Inflation Reduction Act, passed in 2022. Electric SUV and truck start-up Rivian has announced its intention to build a $5 billion

[21] The Atlanta Beltline is one of the largest, most wide-ranging urban redevelopment programs in the United States. This network of public parks, multi-use trails, transit, and affordable housing along a historic 22-mile railroad corridor is enhancing mobility, connecting intown neighborhoods, and improving economic opportunity and sustainability (from: https://beltline.org/about-us/)

[22] https://www.metroatlantachamber.com/built-for-business/

[23] https://www.historians.org/research-and-publications/perspectives-on-history/november-2015/on-the-move-atlantas-history-told-in-transportation

[24] https://www.ajc.com/news/business/sk-boosts-hiring-plans-for-georgia-battery-plant/BBUP7AKM6NA75CRJM36J36MH5I/

[25] See: https://www.nytimes.com/2023/01/11/business/energy-environment/qcells-solar-panel-factory-georgia.html

factory in,[26] but the company's prospects have waned recently and the site development plan has received strong opposition based on environmental concerns.[27]

- *According to our interview with a Professor from Georgia Tech involved with state and regional economic development, the Q-Cell plant is the largest producer of solar panels in the Western Hemisphere. The big companies making new investments in EVs and clean energy technology need better workforces and local supply chains. However, these technologies are more modular, so there are opportunities for skills and suppliers to be more generic than with internal combustion engine vehicles, for example. The federally-funded Manufacturing Extension Partnership is based at Georgia Tech and is helping on both these fronts. We have mock up lines for worker training and are developing concepts such as the "hyper-connected" supply chain. There is concern that these big companies will poach workers from smaller companies in the area. There is also a push to increase inventory to improve supply chain resiliency, but in practice inventory simply gets push up the chain onto suppliers.*

4. Regional statistical profile

At the state level, Georgia doubled in population between 1980 and 2022, from 5.7 million to 10.7 million.[28] Forty percent of the growth resulted from natural increases, while 60% resulted from in-migration outside the state. Significant changes in land use in major cities such as Atlanta have come from the in-filling of more distant suburbs combined with the relocation from higher value inner city suburbs to outlying residential developments in adjacent counties with more oversized lots and square footage per residence.[29] From 1980 to 2010, the Atlanta-Sandy Springs-Alpharetta MSA (hereafter Atlanta MSA) grew from 2 million to 5.2 million, and the urban portions of the region continued to sprawl outward from the City of Atlanta (ibid, 2022). Unlike our team's other three city-region studies, Atlanta has room to grow, as rural communities surrounding it and are not hemmed in by mountains, an ocean, or dense prior development (see Figure 1.1).

In November 2022, the civilian labor force (employment outside of government and military) in the Atlanta MSA numbered 3,208,700, with 3,122,200 employed (see Table 4.1). The unemployment rate of 2.7% was well below the 3.6% rate for the United States. Labor markets have been tightening in the United States since the Global Financial Crisis in November 2009, when they reached 9.9%, with a brief spike to 14.7% at the onset of the Covid-19 pandemic in April 2020.

[26] See:https://www.ajc.com/news/rivian-names-leader-for-future-5b-factory-in-georgia/RVBU7NKVY5EK-BIPHVSSTPMN6HM/

[27] See: https://pantagraph.com/business/local/in-georgia-rivian-opponents-continue-fight-against-5-billion-plant/article_55b3b660-d4a3-11ed-8463-3f1df3033c68.html

[28] https://worldpopulationreview.com

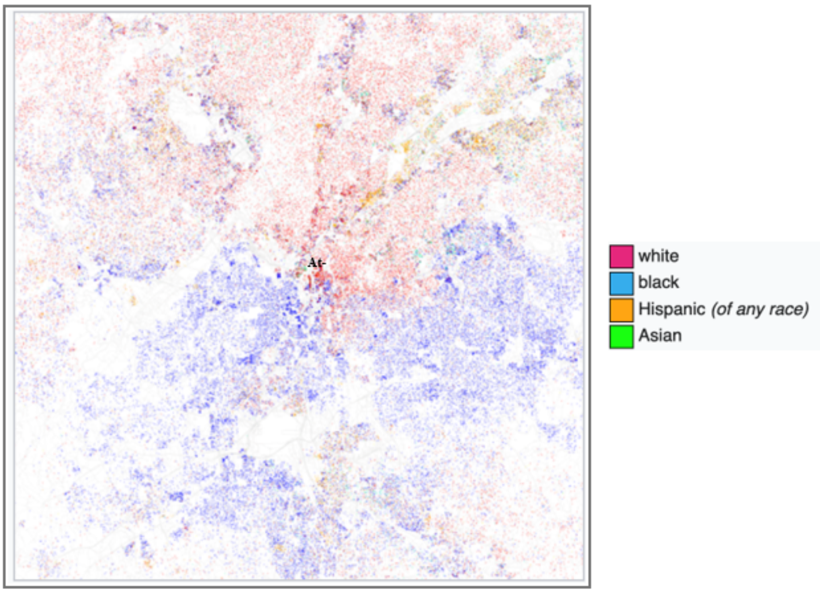
[29] https://www.11alive.com/article/money/business/metro-atlantas-population-surges/85-f30e84e8-822f-427d-b51f-28e4921b6cce

Table 4.1: Labor force statistics, Atlanta-Sandy Springs-Alpharetta MSA compared with three other city-regions, November 2022, thousands of jobs

	Atlanta MSA	Seattle MSA	Boston MSA	San Francisco/ San Jose
Civilian Labor Force	**3,208.70**	2,788.20	2,536.20	3,291.80
Employment	**3,122.20**	2,714.30	2,465.00	3,189.60
Unemployed	**86.5**	73.9	71.2	102.20
Unemployment Rate	**2.7%**	2.7%	2.8%	5.8%

According to the 2020 Census, the Atlanta MSA had an estimated population of more than six million. Table 4.2 provides a general statistical profile of the MSA. The racial and ethnic makeup of the MSA is 46% White, 34% Black, and otherwise shows less racial and ethnic diversity than the other three city-regions studied by our team, with just 12% Latinx and 7% Asian. The region's lack of ethnic diversity is partially due to the low level of immigration relative to the other three city-regions studied by our team. The percent of foreign-born residents in the MSA in 2020, 13.8%, was nearly identical to the national average, and the share of residents that speak a language other than English at home, 18.6%, is significantly lower than the U.S. (21.6%). These figures are notable for a large urban area, given the size of the United States and the many rural and geographically isolated communities in the country. However, the MSA is becoming increasingly diverse as the population grows and people arrive from other parts of the U.S. and worldwide.[30]

Figure 4.1: Map of race and ethnicity in Atlanta in 2010



Source: Erica Fischer. Each dot is 25 residents. Data from Census 2010.

[30] https://tadeosilvalaw.com/2022-immigration-statistics-atlanta/#:~:text=The%20City%20of%20Atlanta%20added,to%20Atlanta%20during%20that%20period.

Table 4.2: Atlanta-Sandy Springs-Alpharetta MSA basic statistics (2020/2021)

Indicator	Value
Population	6,089,815
Employer establishments	152,690
Race and ethnicity	
White	2,773,249 (45.5%)
Black	2,048,212 (33.6%)
Latinx	730,470 (12.0%)
Asian	399,211 (6.5%)
Language other than English spoken at home	18.6% (U.S. = 21.6%)
Foreign-born	13.8% (U.S. = 13.6%)
Median household income	$77,589 (U.S. = $69,717)
Employment rate	62.8% (U.S. = 58.6%)
Poverty rate	11.9% (U.S. = 12.8%)
Bachelor's degree or higher	35.0% (U.S. = 35.0%)
Median gross rent	$1,370 (U.S. = $1,191)
Home ownership rate	66.9% (U.S. = 65.4%)
Without health insurance	11.9% (U.S. = 8.6%)
Without an internet subscription	6.6% (U.S. = 9.7%)

Sources: U.S. Census Bureau: https://data.census.gov/profile

The population of the Atlanta MSA is less wealthy and educated than the other three city regions studied by our team. Instead of being richer and more educated than the nation as a whole, key indicators for the MSA are only marginally above to the national average. The median household income of $77,589 is slightly above the national average of about $70,000; the employment rate of 63% is only somewhat higher than the national average of 58.6%; and the poverty rate[31] of nearly 12% is slightly lower than the national average of 13%; and the percentage of the MSA's residents holding a Bachelor's Degree or higher is no higher than the national average of only 35%. A positive indicator is that only 6.6 % of households lack internet, compared with 10% nationally, a figure similar to the other MSA's examined by our team (except San Jose, where only 3.7% of households lack an internet connection). One indicator where the Atlanta MSA falls particularly short is the percentage of MSA's population is without health insurance: nearly 12%, compared with 8.6% nationally.

However, these relative economic challenges come with advantages in terms of housing costs, especially in comparison to other major U.S. cities. Median gross rent in the Atlanta MSA is only slightly above the national average at $1,370 per month vs. $1,191 nationally; and the homeownership rate of 67% is nearly identical to the national average of 65.4%. This is striking because the national average takes into account many rural and sparsely populated states and regions.

[31] According to the U.S. Census Bureau, a household is considered poor if its income is below a specific threshold set according to the Consumer Price Index. In 2021, this threshold was set at a total annual income of $36,500, or slightly more than $3,000 per month (see: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html).

5. Why manufacturing is important

To provide a broader context for trends at the city-region level, this section asks why manufacturing is essential. The section is included in all four reports prepared by our team with the reasoning that the national situation with manufacturing in the United States will go a long way toward making sense of our finding in each of the city-regions we examined in our research. However, readers may skip this section. The main finding is that manufacturing employment has been declining in most OECD countries for many decades, driven partly by automation but, in the past 20 years and especially for the United States, by the rise of export manufacturing in China and other low-income countries.

The benefits of manufacturing for economic and social development are long-heralded as a mechanism for shifting resources from low- to higher-productivity activities (Kuznets, 1971).[32] The faster the growth of the manufacturing sector, the more productivity is enhanced because resources – significantly labor – are shifted away from traditional sectors such as agriculture, where technology is applied to maintain (or increase) output. As labor shifts out of agriculture, manufacturing takes up the slack, creating solid middle-class employment in urban areas, especially for workers without high levels of education, along with large-scale workplaces suitable for union organizing.

Kaldor (1967) focused more on productivity and exports within manufacturing than labor. He argued that GDP growth is higher when manufacturing's share is rising because it has increasing returns to scale and because of manufacturing's disproportionate contribution to a country's balance of payments through exports, which can be intra-regional or international. So, rising manufacturing output can generate regional and national wealth because of high value-added, steady productivity increases, and exports that create a positive revenue flow, even if manufacturing employment eventually grows more slowly or turns negative. This sectoral succession model assumes that once labor has been all but wrung out of agriculture through productivity increases, the same can happen with manufacturing, as jobs in the services sector can take over as the engine of job creation, productivity increases, and export growth.

Manufacturing trends globally and in the United States

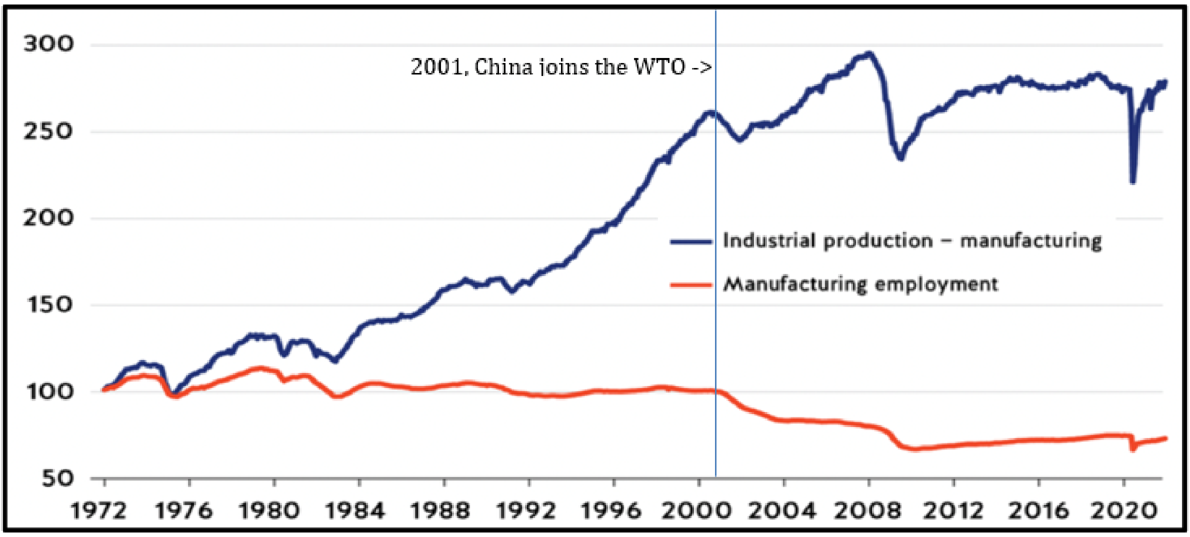
This process is ongoing in the United States and most other large OECD countries, where manufacturing output continues to grow, but employment is shrinking (Figure 5.1). At its peak in 1979, manufacturing employment in the United States reached 19.5 million, representing 22 percent of nonfarm jobs. Forty years later, manufacturing employment stood at only 13 million, and its share fell to nine percent. The dichotomy between output growth and employment decline is explained by productivity increases from automation, computerization, and better work organization and management practices, as predicted by models of sectoral succession.

However, the trend was super-charged for the United States in the 2000s by migrating large-scale export-oriented production to lower-cost countries in the developing world, especially

[32] For example, with the shift of labor and capital from agriculture to manufacturing through industrialization.

China. This shift simultaneously increased import competition for remaining manufacturing plants, lowered prices, and increased consumer product variety in the United States.

Figure 5.1: US industrial production and manufacturing employment index, 1972-2020 (1972=100)

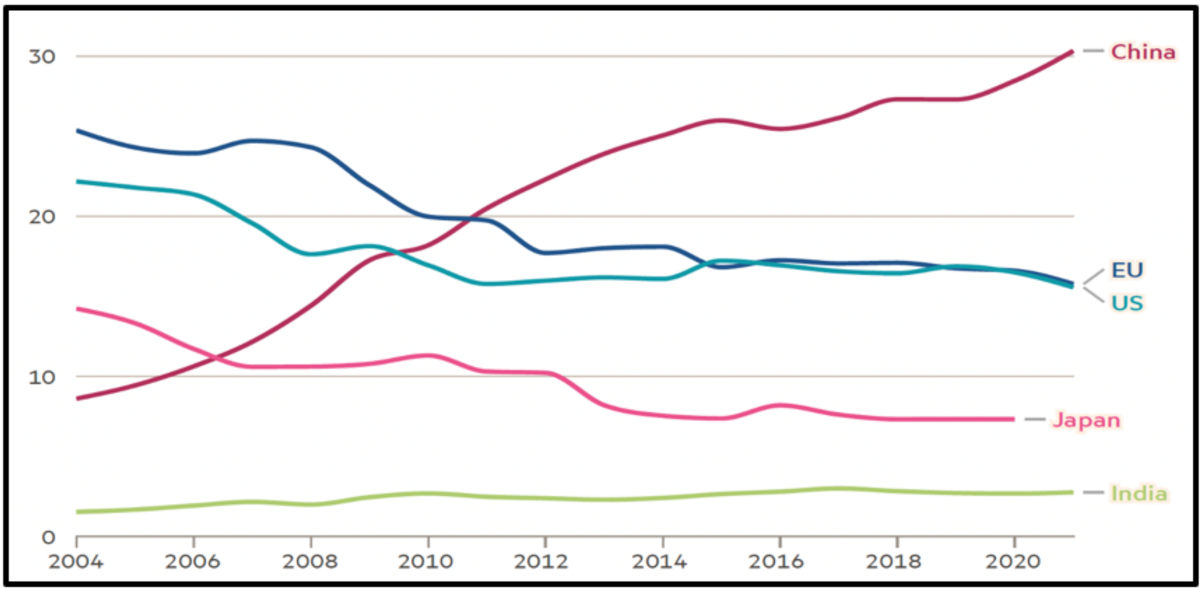


Source: Federal Reserve Bank of St Louis FRED database. Notes: Industrial Production: Manufacturing (NAICS), Index Jan 1972=100, Monthly, Seasonally Adjusted; Employment: All Employees, Manufacturing, Index Jan 1972=100, Monthly, Seasonally Adjusted.

The China Shock

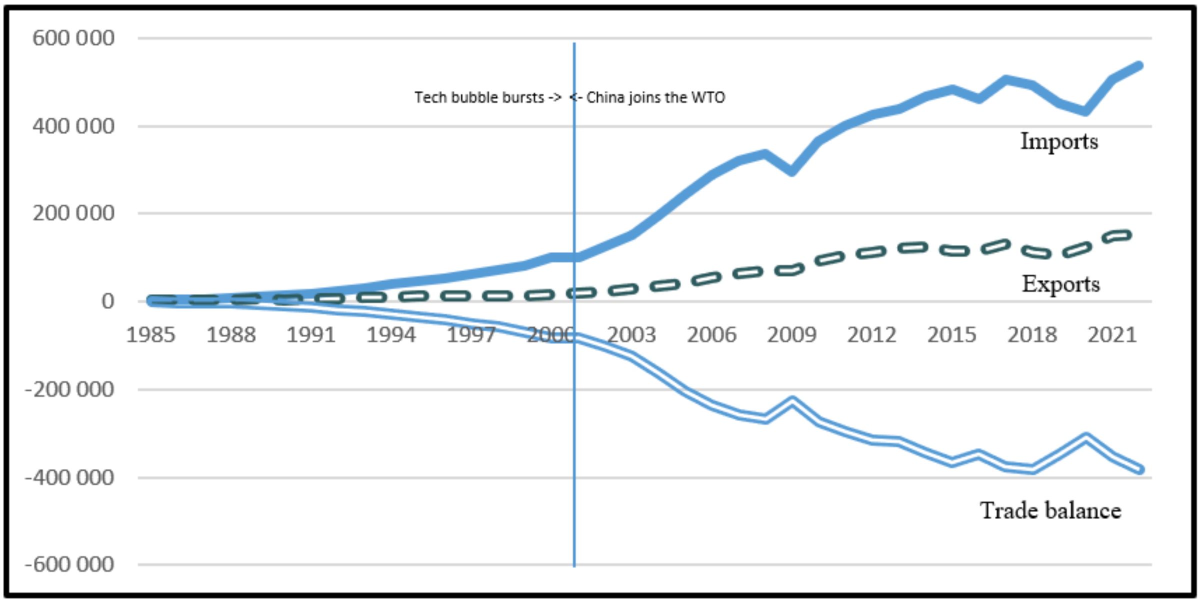
The net impact of offshoring manufacturing jobs on economic and social development is still being determined (Kirchner, 2022). Uneven effects are being felt in the manufacturing employment decline in the United States. Regions of historic manufacturing concentration are suffering greatly. Offshoring pushed China's share of global manufacturing value added to nearly 30% in 2021 from less than 10% in 2004 (Figure 5.2). This extraordinary rise created a massive trade deficit for the United States with China (see Figure 5.3).

Figure 5.2: Share of Global Manufacturing Value Added, 2004-2021 (percent)



Source: McGee (2023) for Financial Times based on World Bank data.

Figure 5.3: US trade with China, 1985-2022



Source: U.S. Census Bureau: https://www.census.gov/foreign-trade/balance/c5700.html. Note: Figures are in U.S. million dollars on a nominal basis, not seasonally adjusted.

China's role as an export platform role exploded after it acceded to the WTO in 2001. This led to huge trade deficits with trading partners, especially the United States (see Figure 5.3). While the U.S. trade balance in services (including technology licenses, an indicator of China's technological dependence on the United States) has remained positive, the deficit with China in goods soared to US $382 billion in 2018 and leveled off since. Not coincidentally, this came on the heels of the bursting of the 'technology bubble' in the U.S. in 2001, which sent U.S. manufacturers scrambling to cut costs and access 'big emerging markets' in China, India, and Brazil – moves that often come with requirements to set up local production, conduct R&D, and (reluctantly and partially, at best) transfer technology to local joint venture partners.

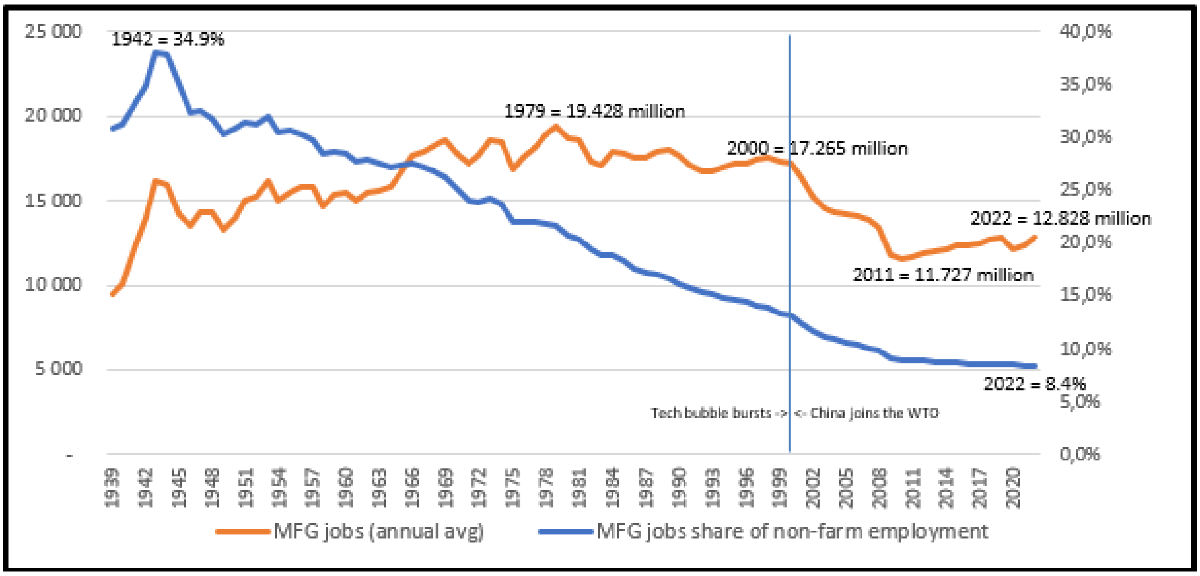
In this way, the 'China shock' set the stage for the political upheavals of 2016 and beyond. Autor et al. (2016, abstract) frame it this way:

> *China's emergence as a great economic power has induced an epochal shift in world trade patterns. Simultaneously, it has challenged much empirical wisdom about how labor markets adjust to trade shocks. Alongside the heralded consumer benefits of expanded trade are substantial adjustment costs and distributional consequences. These impacts are most visible in the local labor markets where the industries exposed to foreign competition are concentrated. Adjustment in local labor markets is prolonged, with wages and labor-force participation rates remaining depressed and unemployment rates remaining elevated for at least an entire decade after the China trade shock commenced. Exposed workers experience more significant job churning and reduced lifetime income. At the national level, employment has fallen in U.S. industries more exposed to import competition, as expected, but offsetting employment gains in other industries have yet to materialize*.

Manufacturing employment in the United States

Since its peak in 34% of total non-farm employment in 1942, during the height of World War Two, the share of manufacturing jobs in the United States workforce declined to its current low of 8.4% in 2022. However, this is mainly due to robust job growth in other sectors. The number of manufacturing jobs in the United States grew steadily after World War Two, peaking cyclically to a peak of 19.428 million in 1979, dropping gradually to 17.265 million in 2000, and then rapidly after China joined the WTO, to its modern low of 11.727 million in 2011. After that, manufacturing employment has been on a gradual rebound, to 12.828 in 2022 (see Figure 5.4).

Figure 5.4: US manufacturing jobs (thousands), and share of non-farm employment, 1939-2022

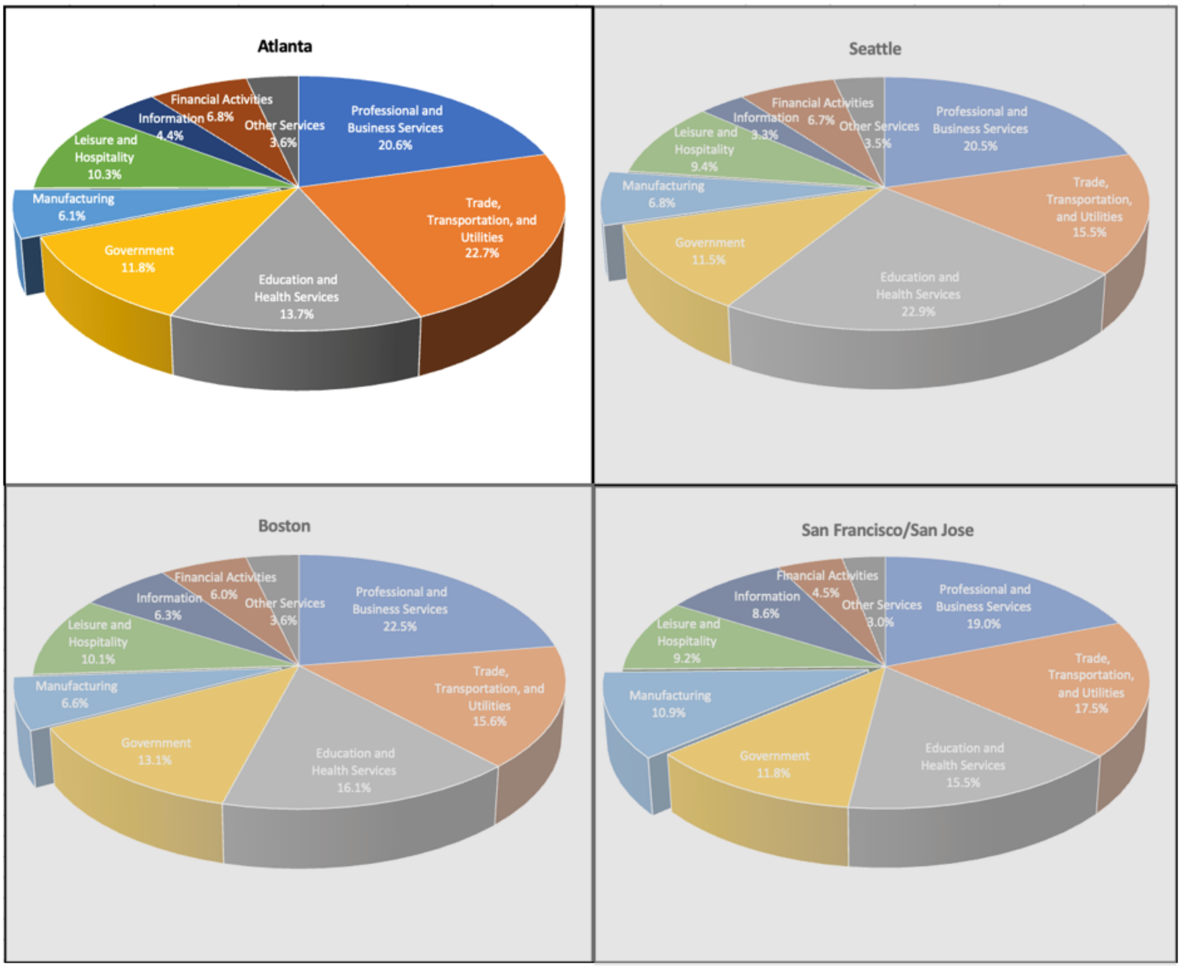


Source: Employment, Hours, and Earnings from the Current Employment Statistics Survey (National), U.S. Bureau of Labor Statistics

6. Manufacturing trends in Atlanta

This section discusses trends in manufacturing in the Atlanta MSA. In December 2020, manufacturing employment in the U.S. stood at 13 million, 8.4% of non-farm employment. Figure 6.1 shows that manufacturing employment was 6.1% of non-farm employment in the Atlanta MSA, lower than the other three city regions in our research.

Figure 6.1: Jobs in the Atlanta-Sandy Springs-Alpharetta MSA by primary industry compared with three other city regions, November, 2022



Source: MSA data from U.S. Bureau of Labor Statistics Regional Dataset, https://www.bls.gov/regions/

While the sectoral mix is similar across all four regions, reflecting their roles as core governmental, educational, transportation, financial, trade, and tourism hubs for their states and surrounding areas, the Atlanta MSA's current role as a trade transportation hub for the Southeastern U.S. explains the significantly higher share of employment in the Trade, Transportation, and Utilities primary industry sector.

How is manufacturing faring in Atlanta?

In December 2022, the Atlanta MSA had about 176,000 manufacturing jobs, down 9.8% from 186,000 in 1990, as shown in and the upper panel of Figure 6.2. This is the least percentage loss of the four regions studied by our team (although from a lower base). However, the region was hard hit by the 2008 housing and global financial crisis, with manufacturing employment bottoming out at just 141,000 in 2010, a loss of 45,100 manufacturing jobs, a 24% loss from 1990.

Since then, however, manufacturing employment has rebounded by 35,500 jobs, a 25% increase.

Table 6.1: Manufacturing employment in the Atlanta-Sandy Springs-Alpharetta MSA compared with three other U.S. city regions, total U.S. manufacturing employment, and total U.S. nonfarm employment, 1990-2022, thousands of jobs (only even years shown through 2010)

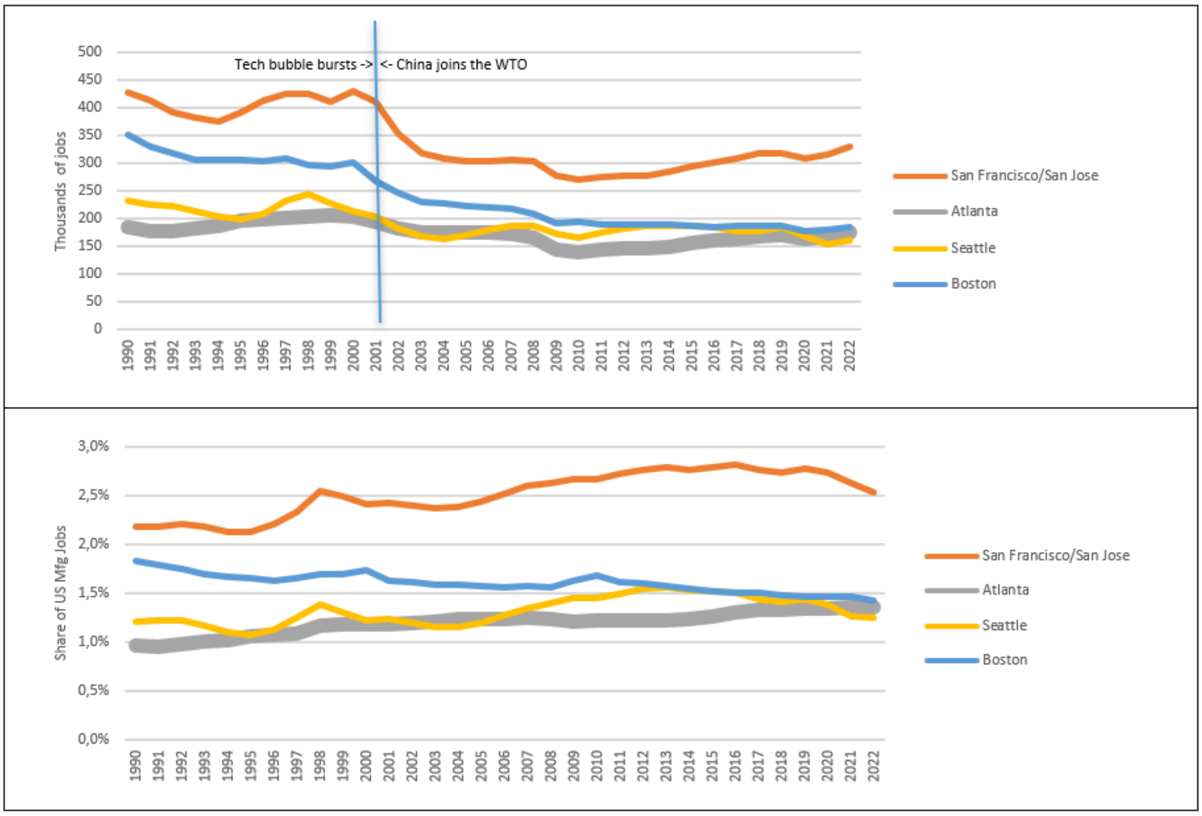
Year	Atlanta MSA	Seattle MSA	Boston MSA	San Francisco and San Jose MSAs	San Jose MSA	San Francisco MSA	US Mfg Emp	US Nonfarm Emp
1990	186	232	351.2	427	255	172	19,173	116,964
1992	179	222	317.5	393	230	163	18,149	115,968
1994	189	203	306.4	375	217	158	18,388	120,379
1996	200	209	302.9	413	241	171	18,527	125,461
1998	205	244	297.8	426	246	180	17,606	131,563
2000	204	213	301.0	431	252	179	17,288	137,228
2002	183	184	246.2	354	201	153	15,265	135,840
2004	176	165	228.1	310	168	142	14,302	136,851
2006	176	181	221.6	304	164	140	14,153	141,153
2008	166	187	208.8	304	168	136	13,412	141,576
2010	141	167	193.9	271	154	118	11,516	134,714
2011	144	175	190.2	276	158	118	11,729	136,258
2012	146	184	190.9	277	158	119	11,935	138,885
2013	147	188	190.0	278	158	120	12,023	141,103
2014	150	187	189.4	286	162	124	12,189	143,758
2015	156	188	187.0	295	165	130	12,332	146,634
2016	161	186	185.2	302	167	135	12,335	148,735
2017	165	179	187.2	308	167	141	12,440	150,654
2018	169	179	188.5	318	172	146	12,672	153,176
2019	172	184	188.4	319	172	147	12,806	155,324
2020	163	169	177.7	309	168	141	12,111	146,542
2021	168	155	181.5	316	169	147	12,331	150,740
2022	176	162	185.9	329	175	155	12,980	155,173
Emp. change 1990-2010	**(45.1)**	**(65.2)**	**(157.3)**	**(155.7)**	**(101.1)**	**(54.6)**	**(7,657.0)**	**17,750.0**
% change 1990-2010	**-24%**	**-28%**	**-45%**	**-36%**	**-40%**	**-32%**	**-40%**	**15%**
Emp. change 2010-2022	**35.3**	**(4.7)**	**(8.0)**	**58.0**	**21.0**	**37.0**	**1,464.0**	**20,459.0**
% change 2010-2022	**25%**	**-3%**	**-4%**	**21%**	**14%**	**31%**	**13%**	**15%**
Emp. change 1990-2022	**(9.8)**	**(69.9)**	**(165.3)**	**(97.7)**	**(80.1)**	**(17.6)**	**(6,193.0)**	**38,209.0**
% change 1990-2022	**-5%**	**-30%**	**-47%**	**-23%**	**-31%**	**-10%**	**-32%**	**33%**

Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

So, we conclude that the Atlanta MSA has participated in the national rebound in manufacturing employment after 2010 evident in the national figures in Figure 5.4 and the 8th column of

Table 6.1. The rebound was not as strong as was experienced in the combined San Francisco/San Jose MSA, but it was more significant than in Boston or Seattle, both of which continued to lose manufacturing jobs after 2010.

Figure 6.2: Manufacturing employment and share of U.S. manufacturing employment in the Atlanta-Sandy Springs-Alpharetta MSA compared with three other U.S. city regions, 1990-2022



Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

Which manufacturing sectors are important in the Atlanta Core Region?

As mentioned in the introduction, we define Atlanta's Core Region as consisting of Fulton (which includes the City of Atlanta), Cobb, and Forsyth Counties. Table 6.2 lists the active manufacturing sectors in the three counties, ranked by June 2022 employment, with employment location quotients (LQs) of greater than 2.0 shaded for emphasis.

Atlanta's urban core has a low concentration of manufacturing employment relative to other parts of the United States. Unlike the other three regions we studied, the present activities are not technology-intensive. The largest manufacturing employer in Fulton Country is NAICS 311, Food manufacturing, followed by NAICS 312, Beverage and tobacco manufacturing and NAICS 326, Plastics and rubber manufacturing. No three-digit manufacturing activity in Fulton County has an LQ of more than .6 except for NAICS 312, with an LQ of 1.3, likely reflecting the heavy presence of the Coca-Cola Company, which has its headquarters in Atlanta. There are even fewer manufacturing jobs in Cobb County.

Table 6.2: Employment and wages by three-digit NAICS manufacturing industry, Atlanta Core Region, 2nd quarter 2022, ranked by June employment in each county (employment LOQs above 2.0 in shaded rows)

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
Fulton County (includes Atlanta and Alpharetta)							
NAICS 311 Food mfg.	155	4,302	28	67,220,571	1,194	0.4	0.4
NAICS 312 Beverage and tobacco product mfg.	50	2,694	54	40,128,773	1,154	1.3	1.1
NAICS 326 Plastics and rubber products mfg.	50	2,371	47	38,098,621	1,218	0.5	0.4
NAICS 339 Miscellaneous mfg.	135	2,311	17	53,549,648	1,760	0.6	0.6
NAICS 332 Fabricated metal product mfg.	101	1,991	20	33,776,309	1,330	0.2	0.2
NAICS 334 Computer and electronic product mfg.	110	1,831	17	51,113,612	2,211	0.3	0.2
NAICS 325 Chemical mfg.	125	1,818	15	49,745,161	2,096	0.3	0.3
NAICS 335 Electrical equipment, etc.	30	1,441	48	33,069,354	1,762	0.6	0.5
NAICS 327 Nonmetallic mineral product mfg.	57	1,407	25	27,569,254	1,501	0.5	0.5
NAICS 322 Paper mfg.	27	1,402	52	33,524,111	1,838	0.6	0.6
NAICS 323 Printing and related support activities	111	1,348	12	22,252,326	1,231	0.6	0.5
NAICS 321 Wood product mfg.	36	1,316	37	29,183,231	1,645	0.5	0.6
NAICS 336 Transportation equipment mfg.	35	1,247	36	45,940,614	3,074	0.1	0.2
NAICS 333 Machinery mfg.	46	996	22	16,604,631	1,282	0.2	0.1
NAICS 337 Furniture and related product mfg.	56	875	16	13,433,845	1,164	0.4	0.3
NAICS 314 Textile product mills	17	387	23	4,813,897	909	0.6	0.5
NAICS 324 Petroleum and coal products mfg.	7	213	30	4,410,956	1,608	0.3	0.2
NAICS 313 Textile mills	15	199	13	5,991,722	2,070	0.3	0.6
NAICS 331 Primary metal mfg.	9	63	7	2,392,093	3,033	0.0	0.0
NAICS 315 Apparel mfg.	21	47	2	671,283	1,054	0.1	0.1
NAICS 316 Leather and allied product mfg.	5	33	7	917,287	2,182	0.2	0.3
Cobb County (includes Marietta)							
NAICS 325 Chemical mfg.	68	2,013	30	62,612,222	2,387	0.9	1.1
NAICS 332 Fabricated metal product mfg.	87	1,919	22	30,554,811	1,229	0.5	0.5
NAICS 311 Food mfg.	55	1,696	31	18,405,087	840	0.4	0.3
NAICS 323 Printing and related support activities	107	1,297	12	18,306,736	1,078	1.4	1.4
NAICS 333 Machinery mfg.	63	1,265	20	27,374,630	1,748	0.5	0.5
NAICS 326 Plastics and rubber products mfg.	21	954	45	15,296,202	1,200	0.5	0.5
NAICS 334 Computer and electronic product mfg.	59	916	16	19,935,657	1,667	0.3	0.2
NAICS 322 Paper mfg.	16	889	56	15,322,926	1,306	1.0	0.9
NAICS 339 Miscellaneous mfg.	75	765	10	12,620,839	1,269	0.5	0.4
NAICS 327 Nonmetallic mineral product mfg.	36	666	19	10,437,495	1,194	0.6	0.6
NAICS 321 Wood product mfg.	27	573	21	8,100,020	1,034	0.5	0.5
NAICS 335 Electrical equipment, etc.	19	444	23	16,167,208	2,795	0.4	0.8
NAICS 337 Furniture and related product mfg.	23	354	15	4,485,053	994	0.4	0.4
NAICS 312 Beverage and tobacco product mfg.	21	269	13	2,951,788	827	0.3	0.3
NAICS 314 Textile product mills	22	204	9	5,010,156	1,940	0.8	1.5
NAICS 315 Apparel mfg.	10	128	13	1,601,018	955	0.6	0.5

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
NAICS 313 Textile mills	4	43	11	987,927	1,839	0.2	0.3
Forsyth County (includes Cumming)							
NAICS 311 Food processing	22	2,574	117	28,724,285	858	2.9	2.5
NAICS 334 Computer and electronic product mfg.	33	1,224	37	59,517,242	3,753	2.1	3.0
NAICS 332 Fabricated metal product mfg.	30	806	27	12,630,200	1,217	1.1	1.1
NAICS 323 Printing and related support activities	27	751	28	12,898,629	1,301	3.7	5.1
NAICS 339 Miscellaneous mfg.	37	451	12	5,354,315	936	1.4	1.0
NAICS 335 Electrical equipment, etc.	14	416	30	12,530,217	2,295	1.9	3.4
NAICS 321 Wood product mfg.	13	274	21	3,535,426	975	1.2	1.2
NAICS 326 Plastics and rubber products mfg.	9	273	30	4,681,092	1,271	0.7	0.8
NAICS 333 Machinery mfg.	23	248	11	3,880,019	1,163	0.4	0.4
NAICS 325 Chemical mfg.	17	201	12	4,865,115	1,473	0.4	0.5
NAICS 337 Furniture and related product mfg.	12	195	16	2,581,158	1,032	1.0	1.1
NAICS 336 Transportation equipment mfg.	9	193	21	3,041,449	1,188	0.2	0.2
NAICS 327 Nonmetallic mineral product mfg.	15	170	11	2,360,491	1,072	0.8	0.7
NAICS 314 Textile product mills	13	139	11	1,335,550	741	2.5	2.1
Core region total	**2,185**	**50,602**	.	**1,002,512,262**	.	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

A manufacturing cluster in Forsyth County is anchored again by NAICS 311 Food processing (with 2,574 jobs and an LQ of 2.9) and NAICS 334 Computer and electronic product manufacturing (with 1,224 employees and an LQ of 2.1). The county also has a significant concentration of NAICS 323 Printing and related support activities (an LQ of 3.7) and NAICS 314 Textile product mills (LQ=2.5). Still, combined employment in these two industries is fewer than 900.

Which manufacturing and non-manufacturing industries does the Atlanta Core Region specialize in?

This section highlights the industries that the Core Atlanta Region does specialize in. As already discussed, Atlanta has a significant role in the U.S. Southeast as a center for corporate headquarters, business services, and road transportation. This is reflected in the Core Region's employment in four-digit NAICS industries where the LQ is 2.0 or above, shown in Table 6.3. The largest employer in Fulton Country is NAICS 5511, Management of companies with 46,339 employees. Large companies with headquarters in Atlanta include Coca-Cola, Home Depot, UPS, Delta Airlines, AT&T, and Newell Brands, owner of a variety of consumer brands including Rubbermaid, Sharpie, Paper Mate, Oster, Sunbeam and Yankee Candle.[33] Related to this are relatively large employment figures for NAICS 5416, Management, Scientific, and Technical Consulting Services, which employs nearly 25,000 and offers services that are demanded by personnel at corporate headquarters, as are NAICS 5412, Accounting & bookkeeping (17,306 Employees), NAICS 5411, Legal services (16,300 employees) and NAICS 5418, Advertising and related services (6,698. employees). The County also has significant employment in NAICS 5132

[33] https://www.indeed.com/career-advice/finding-a-job/companies-headquartered-in-atlanta

Software publishers (15,982) and NAICS 5182 Computing infrastructure providers (10,661), also services consumed by corporate headquarters.

Atlanta's region's historical role as a transportation hub is also reflected in the data in Table 6.3. The second largest employer in Fulton County is NAICS 4931, Warehousing and storage, with more than 25,000 employed, and NAICS 4885 Freight transportation arrangement has the county's sixth higher LQ (3.1). NAICS 4884 Road transportation support has an LQ in Forsyth County of 17.1, the highest of any industry in the three-county Core Region.

The second highest industry LQ in Fulton County (5.2) is NAICS 5161 Radio & TV broadcasting stations, reflecting the headquarters and main operating locations of Turner Broadcasting System (parent of the TNT cable empire).

The region's successful initiatives in attracting motion picture development are reflected in the LQs for NAICS 5121, Motion picture and video industries of 3.0 in Fulton County and 3.5 in Cobb County

Overall, employment in Fulton County dwarfs employment in the other two countries in the Core Region, Cobb and Forsyth.

Table 6.3: Employment and wages by four-digit NAICS industry, Atlanta Core Region, 2nd quarter 2022, with employment LOQ >2.0, ranked (mfg. shaded)

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages (in $)	Emp. location quotient	Wages location quotient
Fulton County (includes Atlanta and Alpharetta)							
NAICS 5251 Insurance & employee benefit funds	14	571	41	14,524,583	2,018	9.1	8.0
NAICS 5161 Radio & TV broadcasting stations	31	3,785	122	273,565,415	5,463	5.2	12.6
NAICS 5132 Software publishers	434	15,982	37	637,221,697	3,118	4.1	2.7
NAICS 5182 Computing infrastructure providers	331	10,661	32	420,894,603	3,048	3.7	2.9
NAICS 7113 Event promoters	60	2,816	47	24,464,951	789	3.2	1.6
NAICS 4885 Freight transportation arrangement	190	5,136	27	94,912,133	1,421	3.1	2.1
NAICS 5511 Management of companies	428	46,339	108	1,800,747,569	3,038	3.0	2.7
NAICS 5121 Motion picture and video industries	273	7,753	28	209,040,197	2,145	3.0	3.1
NAICS 4881 Support activities for air transport	38	4,176	110	33,367,132	632	2.9	1.2
NAICS 5171 Wired and wireless telecom	216	10,007	46	307,016,309	2,351	2.7	2.6
NAICS 5321 Automotive equipment rental	111	3,292	30	47,756,472	1,091	2.7	2.1
NAICS 5412 Accounting & bookkeeping	787	17,306	22	532,427,927	2,390	2.6	2.7
NAICS 5223 Credit intermediation	204	4,850	24	135,406,211	2,152	2.4	1.8
NAICS 5239 Other financial investment activities	813	8,032	10	359,610,620	3,502	2.3	1.7
NAICS 2372 Land subdivision	66	535	8	14,683,240	2,051	2.3	1.8
NAICS 5416 Management, sci., tech, consulting	2,416	24,758	10	894,589,541	2,803	2.3	2.3
NAICS 5411 Legal services	1,855	16,300	9	517,415,958	2,462	2.2	2.0
NAICS 5418 Advertising and related services	622	6,698	11	206,821,890	2,408	2.2	2.1
NAICS 4931 Warehousing and storage	159	25,164	158	255,592,438	769	2.2	1.4
NAICS 8129 Other personal services	344	4,860	14	42,682,982	677	2.1	1.6
NAICS 5242 Insurance and related services	964	15,870	16	471,458,043	2,302	2.0	2.1
Cobb County (includes Marietta)							
NAICS 5418 Advertising and related services	206	5,995	29	177,848,455	2,277	4.9	5.7
NAICS 5323 General rental centers	11	305	28	6,723,805	1,656	3.7	5.5
NAICS 5121 Motion picture and video industries	82	3,648	44	134,929,707	2,422	3.5	6.4
NAICS 7131 Amusement parks and arcades	14	2,060	147	9,495,274	422	3.2	2.1

	Number of establish -ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages (in $)	Emp. location quotient	Wages location quotient
NAICS 6114 Business and computer training	59	468	8	10,947,577	1,713	2.4	2.5
NAICS 4251 Wholesale trade agents and brokers	704	3,015	4	83,046,700	2,105	2.4	2.2
NAICS 3256 Soap & cleaning preparation mfg.	16	681	43	13,908,210	1,555	2.3	2.5
NAICS 5511 Management of companies	144	14,144	98	364,521,647	1,995	2.3	1.7
NAICS 2362 Nonresidential building construction	189	4,626	24	102,624,734	1,720	2.2	2.2
NAICS 4233 Lumber & const. materials wholesale	72	1,387	19	38,352,636	2,135	2.2	3.0
NAICS 4236 Household appliance wholesale	113	1,857	16	52,561,187	2,138	2.1	2.2
NAICS 8112 Electronic equip. repair & maint.	57	541	9	7,896,065	1,028	2.1	1.6
NAICS 6211 Offices of physicians	605	14,091	23	344,734,623	1,884	2.0	1.9
Forsyth County (includes Cumming)							
NAICS 4884 Road transportation support	6	1,020	170	15,548,937	1,171	17.1	21.9
NAICS 3341 Computer & peripheral equip. mfg.	10	924	92	53,436,464	4,455	10.6	8.6
NAICS 3141 Textile furnishings mills	8	121	15	1,199,939	757	5.1	4.4
NAICS 5182 Computing infrastructure providers	33	1,263	38	22,468,654	1,380	5.0	2.6
NAICS 3255 Paint, coating, and adhesive mfg.	8	239	30	3,861,262	1,388	4.5	5.5
NAICS 3231 Printing and related activities	27	765	28	12,898,629	1,301	3.7	5.1
NAICS 2381 Building contractors	111	1,716	15	35,748,240	1,587	3.4	5.0
NAICS 4238 Machinery wholesalers	55	1,106	20	45,681,128	3,144	3.0	6.2
NAICS 4232 Furniture wholesalers	15	175	12	2,702,420	1,181	2.8	2.6
NAICS 9999 Unclassified	714	500	1	9,440,463	1,389	2.6	3.1
NAICS 4251 Wholesale trade agents and brokers	199	706	4	21,036,259	2,299	2.5	2.9
NAICS 5629 Remediation and waste mgmt.	16	226	14	3,313,862	1,130	2.5	2.4
NAICS 6215 Medical and diagnostic laboratories	32	402	13	6,811,028	1,300	2.4	2.4
NAICS 6116 Other schools and instruction	81	592	597	2,720,648	354	2.4	1.9
NAICS 3329 Other fabricated metal mfg.	6	357	343	5,613,652	1,236	2.4	2.4
NAICS 4234 Commercial equipment wholesalers	63	955	947	15,875,993	1,300	2.4	1.5
NAICS 4599 Other miscellaneous retailers	32	486	527	3,983,779	574	2.3	1.4
NAICS 5419 Other prof., sci. & tech. services	78	841	869	9,872,094	859	2.2	1.5
NAICS 4233 Lumber & const. materials wholesale	21	292	290	6,271,365	1,656	2.1	2.6
NAICS 8112 Electronic equip. repair and maint.	11	117	116	2,058,451	1,353	2.1	2.3
NAICS 4237 Hardware supplies wholesalers	24	331	332	5,847,637	1,349	2.1	2.0
NAICS 6233 Retirement facilities for the elderly	19	950	968	7,560,762	601	2.1	1.9
NAICS 6244 Child care services	46	1,082	1,079	6,547,044	482	2.1	2.0
NAICS 5621 Waste collection	23	218	214	3,374,871	1,195	2.0	2.1
Core region total	**14,266**	**303,093**	.	**8,945,664,112**	.	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

To sum up, Atlanta is not, and has never been, an important center for export manufacturing. With exceptions (such as production for the military), sectors such as food processing, materials, and energy have largely been produced mainly for local and regional consumption. Even hugely successful global brands, such as Coca-Cola, do not produce for export but use a franchise bottling model to supply worldwide production. However, Atlanta is the most important center for corporate headquarters, business services, media, and entertainment in the coastal South, and many of its services are exported nationally and internationally.

7. Policy institutions and practices

State and regional policy institutions

The state of Georgia has multiple overlapping economic development organizations. Businesses and communities recognize Georgia Power (GP) as an influential development actor in the state since the state-level electric power provider has been engaged in investment attraction for over 100 years. First and foremost, GP is a power company with a progressive strategic attitude toward infrastructure maintenance. The organization works in the background to help coordinate of development activities, unfettered by the common development problem of jurisdictional fragmentation, where competition among geographically linked organizations leads to suboptimal outcomes. The planning process works through partners, with various organizations taking the lead when to pursuing specific targets for new investment. GP also conducts long-range planning activities as the state continues to build beyond the core counties of the Atlanta region. Projects range from small-town downtown redevelopment projects to major intercounty infrastructure projects to the attraction of significant manufacturing investments from national and global firms, GP partners with state, regional, and local entities. This level of involvement of a regional power company in economic development is unique to Georgia.

- *According to our interview with Georgia Power, the company has a community development team devoted to working with other economic development actors on site selection and workforce development, regional promotion, among other things. They help companies evaluate Georgia as a site location. If there is interest, they help with a site search and then hone in on specific communities. GP or the State of Georgia Office of Economic Development can take the lead. GP offers electrical supply as needed, but does not monopolize power supplies; they also work with electricity co-ops and city power departments as needed. They are agnostic as to which company supplies power. All power companies they work with sell power only within the state of Georgia, so interests are aligned. The goal is to support investment attraction to Georgia.*
- *The process is as follows: 1) Companies sometimes engage a site selection vendor such as Deloitte or undertake the process themselves, 2) the site selection vendor or company will send an email with criteria to Georgia Power, 3) Georgia Power will suggest several sites that meet these criteria, specifying acreage, proximity to transport, and existing utilities (power, water, and sewer capacities), permitting times lines and the labor pool in each location, pull in local economic development actors, and 4) then hand the list back to the target company for assessment. GP has been doing this for a long time. This provides a lot of consistency; what they do will doesn't change as political administrations change.*

The State of Georgia Office of Economic Development is a full-service organization that reports to a board of directors, which includes representation from the Governor's office. The Georgia Department of Economic Development is the state's sales and marketing arm, which replicates many of the functions commonly found in economic development organizations at the state level. The offices share many responsibilities. Indeed, an outside observer would think that duplicative layers and multiple access points lead to confusion in finding the correct pathway to access required services.[34]

At a regional scale, the Appalachian Regional Commission (ARC), a multi-state development agency founded during the Kennedy-Johnson Great Society era, also provides resources to improve the area's business climate surrounding Atlanta. The state-federal entity provides resources to communities considered economically distressed. Atlanta has few claims on funds from the ARC. Still, over the last seventy years, the regional agency has fostered numerous development activities that meet the approval of the ARC's fiscal regulations.

Despite the possibility of confusing overlap, the combination of available land, weak city governments, strong county governments, and even stronger state-level actors in the economic development and investment attraction space, the situation adds up to a relatively pro-business setting that makes it relatively easy to launch new development projects in the Atlanta region, including for new manufacturing investments.

The City of Atlanta

Atlanta is also the 2nd largest majority-black metro area in the country, with predominantly white and black, with blacks making up about 50% of the population, as already mentioned. As Figure 4.1 clearly shows, the Black and white populations tend not to live in the same areas of the city, with white people living in Midtown and points north, and the black population living Downtown and points south. Atlanta is the second most segregated city in the U.S. Sixty percent of the city's area consists of predominantly black neighborhoods. Northwest, Southwest, and Southeast Atlanta are 92% black, and the Buckhead and Northeast neighborhoods of Atlanta are on average 80% white. Sixty percent of the city's area consists of predominantly black neighborhoods: together, Northwest, Southwest, and Southeast Atlanta are 92% black. Some areas are primarily white, notably Buckhead and Northeast Atlanta, which are, on average, 80% white. Still, African Americans in the city have been moving to the suburbs over the last ten years, and the city's black population shrank from 61.4% in 2000 to 54% in 2010. Meanwhile, Atlanta has seen the fastest growth in the proportion of whites in the city than any other US city. The white population grew from 31% to 38% from 2000 to 2010.[35]

The Atlanta region has strong job growth, but gaps in the education and training system leave many Atlantans behind. More than half of the advertised jobs in the region require at least a bachelor's degree, while only 35% of residents over age 25 meet that requirement. At the same time, some residents do not have the skills needed to land a well-paying job. The academic achievement gap between Latino students and other groups starts early and widens as they enter high school. Latinos lag behind their peers in third-grade reading proficiency. Only 26

[34] https://www.georgia.org/online-resources

[35] https://worldpopulationreview.com/us-cities/atlanta-ga-population

percent of Hispanic students in Georgia are reading proficiently and above grade level by the third grade, compared to 39 percent for all students.[36]

Metro Atlanta is known as an affordable place to live, but housing costs are rising, threatening to erode this competitive advantage. An expanded regional transit network is critical to keeping metro Atlanta economically competitive. The region must collaborate to implement the new Atlanta-Region Transit Authority, or the ATL, to expand and better coordinate mobility options across the 13-county region. Still, according to an expert from the Federal Reserve Bank Atlanta, Atlanta is the most overvalued out of the top 100 markets in the U.S., at about 50% higher than where prices should be.[37] Housing is generally considered affordable if a family spends less than 30% of its income on rent or a mortgage and other housing costs. By that definition, most metro Atlanta neighborhoods are not affordable for families earning less than $50,000 annually.

Atlanta is home to one of the highest LGBT populations per capita, 19th among major US metropolitan areas. An estimated 4.2% of Atlanta's metro population is gay, lesbian, or bisexual.[38]

Longer-Term Change in Neighborhoods and Rising Displacement of Poorer Residents

In the aftermath of the financial crisis and COVID eras, the city examined how neighborhood populations and residential housing dynamics altered the numerical distribution of different income groups. The study examined Atlanta's population growth over the past decade and its accompanying demographic neighborhood change. Initially developed by the Institute on Metropolitan Opportunity at the University of Minnesota, the methodology used classifies neighborhood change along several dimensions. The study sought to quantify that change by "measuring the change in the ratio of low-income (LI) residents to non-low-income (NLI) residents in city neighborhoods from 2010 to 2018."[39] Based on this analysis, the research developed four categories to classify neighborhoods:

- Growth neighborhoods gained NLI and LI residents.
- Low-Income Displacement neighborhoods gained NLI residents but lost LI residents.
- Low-Income Concentration neighborhoods lost NLI residents and gained LI residents.
- Population Decline neighborhoods lost both NLI and LI residents.

Across Atlanta, neighborhood change impacted population sub-groups disparately. Rent-burdened, impoverished, and Black residents were increasingly found in Low-Income Concentration neighborhoods associated with economic decline. And residents with a bachelor's

[36] https://www.ajc.com/blog/get-schooled/limiting-the-dreams-latino-students-hurts-them-and-georgia/M597wvIAC49Rw4sRNMbE0J/#:~:text=Only%2026%20percent%20of%20Hispanic,student%20achievement%20and%20workforce%20readiness

[37] https://www.wabe.org/housing-affordability-improving-in-atlanta/#

[38] https://williamsinstitute.law.ucla.edu/wp-content/uploads/MSA-LGBT-Ranking-Mar-2021.pdf

[39] https://law.umn.edu/news/2019-04-25-institute-metropolitan-opportunity-releases-major-study-neighborhood-change

degree or higher and households with high median incomes were increasingly located in Growth and Low-Income Displacement neighborhoods. Of relevance, the current public policy practice appears to be exacerbating the inequities between these starkly different neighborhood types by investing in communities already experiencing growth and likely to experience displacement of lower-wealth residents while ignoring areas with concentrations of low-income residents.

Challenges for the City

Atlanta is the number one city for income inequality in the U.S. If a person is born into poverty in Atlanta, there is just a 4% chance of escaping poverty in their lifetime. Today, the median household income for Blacks is just one-third that of whites. The median household income for a white family is $83,722 compared to $28,105 for a Black family. 70% of Black families are liquid asset poor compared to 22% of white families. Sixty-six percent of all Latino families in Atlanta are asset poor. Latino families' median household income is about half that of whites.[40]

City economic development agencies, educational institutions, and training initiatives

Housing and community development focus on urban revitalization utilizing conventional tools in partnership with other city agencies. The tone of DCP's reports and documentation concerns residents, neighborhoods, and managing change. Their focus is on the community level, and their approach is decidedly local intent. Reviewing the record of other agencies with economic development as one of their responsibilities, the boosterism approach to economic development at the state and regional levels seems distant from the many challenges the local urban planning office addresses. DCP's Office of Housing & Community Development contributes to neighborhood revitalization by integrating targeted programs, outreach, and investment in neighborhood commercial areas.

Invest Atlanta is the City of Atlanta's economic development agency. The city is keen to develop the area south of Interstate 20, which cuts east-west across the city's historically Black neighborhoods south of downtown, a place that includes the Atlanta Technical College. Invest Atlanta has provided support such as tax credits and loans for redeveloping new mixed-use industrial spaces such as Lee and White Community. This former distribution facility has been developed for mixed uses that also houses a distillery, several breweries, restaurants, a co-working space for non-profits, a food manufacturer, JTEC, an energy-related manufacturing start-up[41], and a nano-technology materials start-up, one our interview subjects. The Lee and White project is located along the southern portion of the city's "Belt Line" string of urban trails and parks. The development of Lee and White is part of a push in the city to rehabilitate old manufacturing and warehouse facilities to help generate jobs and tax revenue.

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[40] https://www.atlantawealthbuilding.org/racial-wealth-gap

[41] In 2020 JTEC Energy was spun off from Johnson R&D, the Atlanta research laboratory founded by Dr. Lonnie Johnson. The JTEC is an innovative device that uses electrochemical transformations to convert a heat differential into usable electricity (see: https://www.linkedin.com/company/jtec-energy-inc).

The Atlanta Chamber of Commerce (COC) is a private non-profit organization that advocates for businesses in the city and surrounding region and supports economic development initiatives and workforce development. They also promote the region to the outside world. Chambers of Commerce are common in cities throughout the U.S.

- *According to an interview with the Atlanta COC the broad Atlanta region has complex jurisdictions. Georgia is a "home rule" state, meaning that decision-making is devolved from the state- to the country-level. Zoning is set at this level.*

The Georgia Institute of Technology is a public research university, established in 1885, part of the University System of Georgia. It is located adjacent to Midtown and provides a conduit for management and technology workers through its strong business and engineering programs. The university operates a technology business incubator, Advanced Technology Development Center (ATDC), primarily focused on IT start-ups. Kennesaw State University, which has two campuses in the Atlanta metropolitan area, one in the City of Kennesaw and the other in the City of Marietta (both north of Atlanta in Cobb County), is currently building a version of ATDC that will focus on incubating manufacturing start-ups.

- *An interview with ATDC personnel mentioned that Atlanta region covers a huge area that unlike the Mid-west or Northeast has lots of unincorporated areas controlled by county governments that can help with investment projects. At the same time, counties can collaborate regionally with other counties and state- and regional-level economic development actors. Unions in the area are only national, not local. In general this adds up to less government regulation, less union involvement, lots of support for economic development.*
- *There is good infrastructure in the region, including Interstate Highways and the Port of Savannah for ocean shipping (a four-hour drive), which is growing and has moved from the 3rd largest to the 2nd largest port in the U.S. Hartfield-Jackson is the busiest airport in the U.S., and there is a new nuclear power plant coming on line. Companies have access to a large population (and potential workforce), the weather is good (no snow and few hurricanes) and there are no earthquakes. Georgia Tech just received a $65 million grant to integrate AI with advanced manufacturing.*[42]
- *An interview subject from a nano-material manufacturing start-up gave three examples of how the City of Atlanta has supported them. First, the Local Initiatives Support Corporation (LISC), part of Invest Atlanta, provided an equipment financing loan. This is 'non-diluted' funding that allowed us to keep control of the company by limiting the role of outside investors. Second, WorkSource Atlanta, (WSA) is a City of Atlanta-connected non-profit that helps train and place manufacturing technicians. It has provided training for technicians. WSA is the City of Atlanta's former Workforce Development Agency (AWDA). It serves as the workforce system for the city of Atlanta. WSA provides job seekers with resources for sustainable employment*

[42] See: https://news.gatech.edu/news/2022/09/06/65m-grant-build-ai-manufacturing-georgia

and collaborates with local and regional employers to recruit and develop their labor needs. Third, the City's Mayor has announced the Summer Youth Employment Program to help young people 14-24 with internship and job placement opportunities to explore career interests and build work-related skills. Through the program, more than 3,000 young people were placed in paid employment and internship opportunities across metro Atlanta. This year, Atlanta youth will receive a variety of diverse experiences ranging from film and entertainment, financial literacy, de-escalation, STEM preparation, entrepreneurship, and retail among other areas.[43]

- *A respondent with an EV conversion start up that came out of ATCD said that ATDC does not provide funding, but helps with pitches. It helped then reduce a detailed technical slide deck to just five slides to communicate better with potential investors.*

8. Lessons from industry interviews

This section focuses on lessons from the research, including standard policy and business challenges urban manufacturing faces and a discussion of ten business models that might justify and sustain manufacturing in high-cost, congested urban settings. We illustrate these points with material collected during interviews with local companies and policy-oriented organizations. These challenges and workable business models used to structure the following sections appear to us to be common. We inserted comments from the interviews where appropriate when our interviews touched on these subjects. If there are no comments, it only means that the interviewees did not discuss these topics at particular length. We do not intend this to signal that such challenges are not present. Also, in many cases the material from the interviews outlines solutions to the identified challenges, not examples of the problems. Material from the interviews is in italics.

Common policy and business challenges for urban manufacturing

In our research across several U.S. cities, seven main challenges for urban manufacturing emerged. These challenges appear to be common. We inserted comments from the interviews where appropriate when our interviews touched on these subjects. If there are no comments, it only means that the interviewees did not discuss these topics at particular length. We do not intend this to signal that such challenges are not present.

1. Managing high costs (rent, taxes, wages, services, logistics)
    a. *According to a manufacturing start-up located in the West End, Atlanta's manufacturing ecosystem is growing, mainly because it is less costly than other major U.S. cities. This is happening on two levels: start-ups and scale-up.*
2. Finding and keeping suitable industrial space in zoning regulations and existing building stock. This was sometimes alleviated by zoning plans that purposefully carved out space for urban manufacturing. Still, these plans were under constant pressure from developers

[43] See: https://www.atlantaga.gov/Home/Components/News/News/14660/672?backlist=/

seeking the use of properties for higher-value uses such as residential and retail. Another solution has been to develop smaller, mixed-use properties closer to the urban core.

a. *A nano-technology material manufacturing start-up's founder was a professor in Indiana and had developed the technology there but moved into a 2,000-square-foot incubator space at ATDC because it had certified manufacturing space available that would allow them to sell their material to satellite manufacturers. This was crucial help because the manufacturing had specific certification requirements.*
b. *According to out interview with Georgia Power, most available industrial space in the region lies farther out from the city. The MSA is huge, with 29 counties. It runs almost to the Alabama border. Land closer to the city is more expensive. Developers owning the land want higher returns than they can get from manufacturing. Economic development agencies want buildings to go up quickly and start paying taxes. So manufacturing sites tend to be farther out where communities own land. They want to establish industrial parks and create jobs for their residents, and generate multiplier effects for local businesses. Manufacturing is a higher priority than warehousing because there is less traffic and higher pay.*

3. <u>Obtaining support from government and academia</u>.
   a. *According to our interview with Georgia Power incentives from the federal government provide the floor. Local economic development initiatives take over from there. Georgia has lower costs of doing business in terms of land, labor, and tax burden.*
4. <u>Finding suitable workers</u>.
   a. *For nano-technology manufacturing start-up located in the West End employs about 25 people and has had to hire production technicians to run their machines. They have vapor deposition chambers, laser cutting stations, and a pack-and-ship facility. There is also an "artisanal" process of applying a polymer that they hope to automate. The company aims to scale up production in service of clients from aerospace, data centers, and electric vehicles and the general shift to electrification (the product efficiently cools low and high-power electronics devices). Adding shifts would not increase production as much as developing a continuous flow process, which would not require many workers but would pose technical challenges for operations engineers. The respondent mentioned that manufacturing wages have risen, but the trick is to get interested, and commitment from young people, and the City has been very interested in this.*

   b. *One solution to finding the appropriate workforce has been to recruit from WorkSource Atlanta. Another is to recruit from Georgia Tech's engineering and business schools. For example, an executive from the nano-materials manufacturing start-up graduated from the school's Masters in Business program. The company works with Georgia Tech and Atlanta Technical College to develop training programs. Personnel have given talks there about or technology and manufacturing. The company is intentional about engaging the community. They plan to start an internal 'university' and 'lab' to include students in their manufacturing activities and provide a path toward engineering professions. They want to develop a software-based simulation that will predict how the materials they use will interact with other materials and will need software engineers. They want to help Georgia Tech and Atlanta Technical College develop curricula to feed the manufacturing ecosystem in Atlanta. Atlanta has many companies that are making manufacturing cool again. There are many 'deep tech' manufacturing start-ups in the City.*
   c. *According to our interview with ATDC, there is lots of engineering talent coming out of Georgia Tech. But skilled workers are also coming from international locations, making the city more diverse. There is a worker shortage at the moment, and companies are targeting rural communities to staff new warehouse fulfillment centers. At Georgia Tech, there are forklift simulators to help with job training.*

5. <u>Pollution and congestion</u>. There is a perception, often deserved, that manufacturing uses create noise, fumes, traffic, and other uses. The surging popularity of bike lanes has come with a constituency opposed to the curb cuts needed to service the loading docks familiar at industrial facilities.
6. <u>Environmental justice critiques</u>, where manufacturing's poor environmental record provides ammunition for project critics since urban spaces with available structures and land suitable for industrial zoning tend to be located in or near low-income communities and communities of color.
7. <u>Shortages of affordable housing for production workers</u>. Interviewees report many challenges in recruiting workers from close-in neighborhoods, given steeply rising housing and other costs associated with living in our near urban downtowns. Several respondents noted that manufacturing workers tended to travel from lower-cost outer suburbs and complained that public transportation did not run at hours suitable for workers traveling to and from work on early morning or night shifts.

Business model discussions

As we can see, manufacturing persists in the United States, even in high-cost urban environments. Our research asks, why is this the case? To get answers from the small sample investigated by our team (of four city regions with only six interviews in each), we have asked the question in the extreme: *Which business models appear to be viable and potentially sustainable in very high-cost and congested urban settings?* We found that urban manufacturing close in to the urban core is necessarily smaller in scale, more agile, and in some cases, more closely linked to innovation, and while it does provide employment opportunities for less educated workers and pathways for entrepreneurship, these opportunities are limited in scale. Nevertheless, urban manufacturing persists. This is true even when industrial space is hard to find, energy costs are high, logistics difficult, and housing unaffordable for production workers. Our research points to ten business models that motivated the interview subjects in the four city regions studied (and, presumably, elsewhere) to continue to engage in urban manufacturing:

1. The first relates to innovation, where production is co-located with R&D and new product development to support the iteration needed for prototyping and initial scale-up. We also note that dynamic innovation systems are usually linked to industries and scientific fields deeply rooted in an urban area. In Atlanta, there is less spill over from the historically large export-oriented manufacturing base, but we did fine evidence of this on a small scale speaking to a nano-material start-up. In this case, new manufacturing techniques were being invented as part of the innovation process.
2. The second relates to companies that need to be close to specialized or skilled labor.
3. The third is for products mainly produced in low-cost locations but need to be rapidly replenished during unexpected demand surges, such as air conditioners during a heat wave, snow shovels during a winter storm, or apparel and other fashion or seasonal items for which demand exceeds forecasts.
    a. *According to our interview with ATDC there is manufacturing space available near the Hartfield airport suitable for rapid replenishment manufacturing.*
4. The fourth is for low-volume items with standardized production processes but high unit prices that do not justify the challenges inherent in distant production, such as repairing and maintaining machinery and producing luxury goods.
5. The fifth is custom-made products, such as one-off prototypes or unique crafts or art objects.
6. The sixth is "non-tradable" goods and processing activities for which production and consumption are best co-located and localized. One example that has come up in our research is the development and processing of fresh and specialty food items, either for retail or institutional markets, such as local "farm-to-table" food supply chains. Of course, many other products -- aside from such donor-derived therapies and personal services -- do have the potential to be exported beyond their home region. An example might be recipes or food processing innovations developed in the context of local food systems that can be codified, scaled, and produced in volumes exceeding local demand for export beyond the region. So, a path for manufacturing growth can be from non-tradable to tradable products. This emphasizes the importance of business development, branding, scale-up, and distribution.
7. The seventh is for highly regulated products or products with regulatory requirements for domestic sourcing. This has historically been the case, especially for products for the military and other government purchases. However, in recent years domestic production requirements have been extended to a broader range of materials and products, such as those used for infrastructure projects. While there are many reasons to locate these new

investments outside of existing high-cost industrial regions, such as those listed above, there may be reasons to do so, such as those listed here. In addition, the availability of funds from the Federal Government to support domestic manufacturing can provide opportunities for local actors (states, counties, cities, universities, and industry groups) to gain access to new funding to support local industrial ecosystems, especially if there are viable industries or even the remnants of dying industries present in the region.

a. *According to our interview with ATDC, manufacturing is booming in Alpharetta, Georgia, located about 30 minutes northeast of Atlanta. There is a strong reshoring trend. Not all production will return, but companies will be assembling more products locally, even if they source parts globally. An example is Washega, a manufacturer of public address systems for industrial and institutional facilities, that sources speakers, displays, and electronic parts globally but builds and paints enclosures and does system integration locally in Alpharetta.*
b. *According to an interview with Georgia Power, it is a gift that the state is growing. The big boom at the moment is in electric vehicles (EVs). Two car makers invested last year, and we are receiving a lot of interest from battery manufacturers. 30,000 jobs have been created in EVs in the past 30 months. There has never been this level of interest before. It is based on federal policies such as the CHIPS Act, support for EVs and domestic EV battery production, subsidies for domestically produced solar panels, and support for improved supply chain resilience. Georgia is still the darling of the U.S. when it comes to foreign direct investment, and this has to do with local incentives and business culture, some of which exist broadly across the southern United States. About 30% of new investment is coming from international companies. Eighty percent of new investment is happening outside the metro area. Several 'mega-projects' of more than 1,000 acres are in the pipeline.*

8. The eighth is <u>legacy manufacturing plants</u> that have operated for many decades. The company often owns the real estate, processes are stable, and older machinery is fully amortized. Such activities can be characterized as "hanging on," however. Unless industrial zoning is explicitly protected, they are under constant pressure for redevelopment for higher-value land uses, such as housing or offices.
9. The ninth is for products where there is an imperative to shrink the geography of supply chains to <u>reduce their carbon footprint</u>.
   a. *Note: this reason was only mentioned in one of our Boston interviews.*
10. The tenth is for companies seeking to <u>avoid offshoring costs beyond unit prices</u>: tariffs, shipping delays, hidden management costs, and quality problems that increase scrap and rework costs can be expected when manufacturing is sourced internationally. Unexpected supply chain disruptions have been especially pronounced in recent years, leading buyers to look for manufacturers closer to end use (nearshoring and reshoring).

a. *According to our interview with ATDC, another reason Washega has chosen to do assembly locally is to build up parts inventory so they can manage inventory more effectively. That way they can respond more effectively to demand cycles and customize systems for clients more quickly. For example, they can build up inventory of unpainted and unfinished parts, and finish them as needed. Three-dimensional printing (3DP) is also redefining where low volume, high mix manufacturing can happen. Companies can build products to suit customers.*

Low volume, high mix, and shared production

The general (non-scientific) impression from across the four case studies conducted by our team is that the most viable form of manufacturing in high-cost urban areas tends to be low-volume, small-scale, and with modest employment benefits. The norm is lower productivity and less effective utilization of equipment. A possible exception uncovered in the research is medium-volume facilities which produce a high mix of items. Such facilities can support all of the roles outlined above except for legacy manufacturing, which is, by definition, non-replicable. In high-mix production environments, manufacturing output can be substantial, but production runs for any one product will tend to be relatively short. The challenge is to keep capacity utilization high in the face of varying requirements. This is more than just a matter of equipment utilization. For example, materials managers in high-mix environments must coordinate the flow of various inputs (materials, parts, and components), and machinery must have fast set-up times and flexible tooling. High variability means that high-mix manufacturing resists automation. While there is a range of newer technologies aimed at increasing the productivity of high-mix production, such as cobots, 3D printing, manufacturing resource planning, and other business process software aimed at streamlining high-mix production, they remain expensive and unproven, and adoption rates are low in smaller manufacturing companies (Waldman-Brown, 2020). Advanced manufacturing can also elevate the importance of a high-quality workforce, but with better-trained workers comes the additional challenges of availability and high costs. It is common for only a few business functions to be carried out within the urban area, such as final assembly and last-minute configuration, and those functions that benefit from proximity to R&D (e.g., prototyping).

The general impression from our research highlights two types of manufacturing that persist in high-cost urban environments that are both beneficial and sustainable: manufacturing related to innovation and production of non-tradable, particularly specialty foods. This is because these types of manufacturing are less cost-sensitive than higher-volume production and because there are social benefits beyond manufacturing employment to be garnered, such as supporting innovation and a diverse population of entrepreneurs. One promising avenue for scaling suitable products and entrepreneurship pathways is shared facilities, either in not-for-profit accelerators or for-profit contract manufacturers. These facilities can offer certifications, share the cost of plant and equipment, and offer various ancillary services, such as business consulting, design assistance, pooled purchasing, and help to find customers and marketing. When shared facilities work as they should, the next challenge comes when successful products need to scale past the high-mix setting to dedicated medium-volume facilities.

Again, a general (non-scientific) impression from the four case studies conducted by our team is that in high-cost-urban settings, industrial property and workforce shortages often force these firms to relocate outside the urban core. Nevertheless, reliance on R&D and start-ups can be sustainable if there is a steady flow of new products, new entrepreneurs, and small businesses focused on scaling the production of manufactured goods. However, fostering a robust pipeline of new companies and products requires specialized financial and educational resources focused on manufacturing entrepreneurship. If urban manufacturing is to be sustained and grow in a region, sustained policy support by city and state-level policy-makers is needed. This is often lacking as political regimes change and the demands of industries better suited to high-cost urban settings take precedence.

9. Concluding remarks

Historically, Atlanta is a manufacturing town of little consequence. Its role as a regional transportation, service, and administrative hub for the coastal southeast U.S. is still reflected in its mix of industries today. In this way, Atlanta has more similarities with Vienna than the three city regions our team examined.

The prospects for urban manufacturing in Atlanta must be viewed in the context of its racial past and present. Atlanta is one of the most segregated cities in the United States. During the 60s, 70s, and 80s, political leaders focused on bringing the white middle and upper classes back into the city, which pushed people with low incomes out. The evidence is astounding. Atlanta was predominantly African American in the middle of the 20th century. The build-up to the 1996 Olympics saw the city aspiring to become the "Queen of the South" once again. After building the city's infrastructure focusing on tourism and amenities, African Americans have slowly been pushed even further out of the city toward lower-cost suburbs to the city's south, areas with insufficient public services and a lack transportation access to the city where higher paying jobs and educational institutions are located. Today's population is the reverse of its mid-20th-century character, where Blacks occupied the inner city.

While the broader city region continues to attract manufacturing firms, including significant foreign direct investment, new manufacturing job numbers pale compared to job growth in services, healthcare, and retail. Yet, because of segregation and historical patterns of exclusion, many African Americans still struggle to find good-paying jobs, even with a college education. The transition the city has gone through is not only the result of white Atlanta wishing to reinhabit the city. Starting in the 1970s, with the early election of African American leaders, middle-class Black residents, too, are interested in seeing a turnaround and a transformation to a modern city with amenities, sports events, and other attractions meant for tourism.

However, there are bright spots. In 2020, The Atlanta-Journal Constitution reported that African Americans are about 25 percent of the city's tech sector, which compares favorably with Washington D.C. (15%) and Chicago, Ill. (8%), cities with large Black populations.[44] Indeed, our interviews found that initiatives and institutions to foster Black entrepreneurship, including in

[44] https://www.ajc.com/news/atlanta-fast-becoming-mecca-for-african-americans-tech/v8qANLKIEUMktizzi169RO

manufacturing, are well established and vibrant in Atlanta's non-profit and education and training landscape.[45]

To sum up, while progress is being made, the last several decades have seen the city of Atlanta become predominantly white. The population is well-educated, and the suburbs are transitioning as well. Indeed, the exclusion of African Americans from some more distant white suburbs to the north of the city suggests there are both enclaves within Atlanta and in its outskirts. One might question if Atlanta is as great a city as it was when it was more diverse.

The city's amenities have been built over the last three decades to serve people with high-middle-class incomes and above. Yet, the city still needs better infrastructure, particularly transportation infrastructure. Atlanta suffers from the 7th worst traffic congestion in the United States, with 74 hours lost per commuter annually (Bartiromo, 2023), and public transportation could be better.

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[45] For example, see: https://russellcenter.org/

Urban Manufacturing in Boston

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

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A note about geographic definitions. The report uses a flexible definition of the city region, depending on data availability and the analysis level.

- MSA: The broadest definition is the Metropolitan Statistical Area (MSA). An MSA is a multi-county geographic construct that attempts to encompass areas of urban concentration in terms of population and economic activity. The MSA definition is a statistical unit of analysis assigned by the U.S. Census Bureau and not a political unit. While MSAs generally include counties that form the region's industrial core, they may also include counties that are mainly residential, commercial, or governmental and, therefore, outside the main scope of analysis. However, because some economic data are readily available at the level of MSAs, the designation is used as a matter of convenience for some of the analysis.
- CORE CITY-REGION: A more focused geographic designation is the "core region." This consists of several counties surrounding the primary city containing the most industrial activity. Since more detailed sectoral statistics tend to be available at the county level, this customized collection of countries is used to reduce "noise" in the analysis.
- CITY: The most constrained geographic definition used in the study is the jurisdiction of the region's primary city, which is generally the most densely developed, most congested, has the highest operating costs, and has the highest level of contention over land uses. We mainly focus on industrial policies at this level.

We will use these designations throughout, although the MSA has been shortened after initial use, and Core City-Region has been shortened to Core Region. Our analytic strategy begins with the MSA to pick up regional trends, then focus on the Core Region to investigate industrial structure in detail, and finally to conduct interviews and investigate policies as close to the city level as possible to observe the position of urban manufacturing where it is likely to come under the most extreme pressure. The logic is that if manufacturing occurs in high-cost urban settings, there must be good reasons for it!

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1. Historical background

The geographic situation of Boston relative to the United States and the other regions included in this study is shown in Figure 1.1. Boston is one of the oldest cities in the United States. Its location on the northeast coast of the United States positioned the city as a hub for trans-Atlantic shipping in colonial times, as the city had access to shipping routes that connected it to other major ports on the East Coast and beyond. This allowed Boston to import raw materials worldwide and export finished goods to domestic and international markets. The seminal industry to emerge in Boston was shipbuilding. Boston's shipyards produced a variety of ships, from whaling vessels to clipper ships, and played a significant role in the maritime economy of the United States. The city's abundant timber resources and proximity to the sea made it an ideal location for constructing sailing vessels for various purposes, from trading and fishing to naval warfare, helping cement Boston's reputation as a major center of maritime activity.

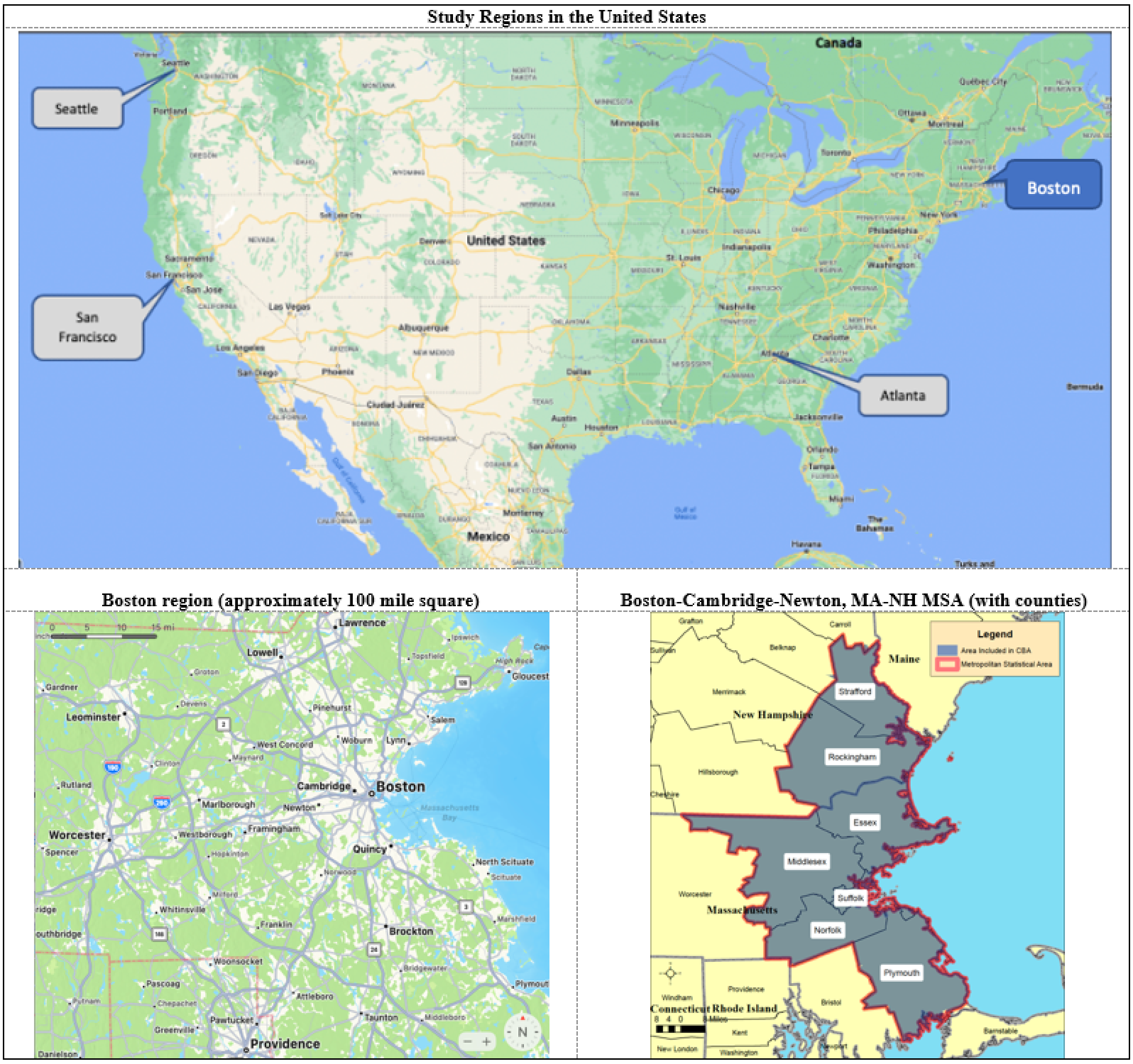
Still, the city and region also have long industrial histories, beginning with logging and fur trapping in the 16th and 17th Centuries. Several vital innovations in the area accelerated the industrial revolution in the mid-18th Century. Most well-known is the development of large-scale mechanized textile production, which migrated north of Boston in search of larger sources of water power in the Merrimack Valley (Brooks, 2016). The success of Boston's textile industry was due in part to the invention of the power loom by Francis Cabot Lowell. Lowell's loom revolutionized textile production by mechanizing weaving and increasing efficiency. This innovation helped make Boston a leading center for textile manufacturing in the United States. In the late 18th Century, the development of interchangeable rifle parts at the Springfield Armory (east of Boston) also helped shift manufacturing from a craft to mass production (Hounshell,1984; Ford, 2005).

By the late 19th century, Boston was home to various businesses, including breweries, shoe factories, and printing presses. The city's thriving economy also led to the growth of its transportation infrastructure, including the construction of railroads and the expansion of its port facilities.

In the early 19th Century, the first hospital in the city, Massachusetts General Hospital, was founded (in 1811). Cambridge, situated directly across the Charles River, is home to the oldest university in the New World (Harvard, founded in 1636). The combination of university research in Cambridge (where MIT was founded there in 1861) and teaching hospitals in Boston form the roots of innovations in medicine, medical equipment – and, most recently, biotechnology – that currently underpins the region's most vibrant industrial cluster: life sciences.

Despite its success, Boston's industrial economy faced challenges in the 20th century. The decline of traditional manufacturing industries and the rise of global competition led to job losses and economic stagnation. The City of Boston's population fell from 750,000 in 1920 to 560,000 in 1980, from .7% to .25% of the U.S. population (Glaeser, 2003). It was common for older, dense US cities to lose people to lower-density towns in the mid-20th Century, particularly those on the edge of traditional downtowns. The primary reason for this "urban sprawl" was the rise of the automobile. Early American cities such as Boston were built first around walking and then public transportation. Boston's oldest areas, such as Beacon Hill and the waterfront, are made at sufficiently high densities to accommodate walking. In contrast, newer city areas developed in the 19th Century, such as Back Bay and Roxbury, and nearby suburbs, such as Brookline, were built around the early forms of public transportation, such as omnibuses and streetcars.

Figure 1.1: Boston in geographic context



Sources: Google Maps, Apple Maps, U.S. Census Bureau: https://data.census.gov/profile

Automotive transportation required bigger roads, which could be built more easily outside the city. This also allowed people and goods to travel more considerable distances. As a result, manufacturing left cities for suburbs, which trucks could easily access. Eventually, large scale manufacturing left "rustbelt" cities in the Northeast and Midwest for "sunbelt" cities in the U.S. South and Southwest, which have mild winters and a much less pro-union environment (see Holmes, 1994, for the classic analysis showing that right-to-work laws, which allow workers to opt out of participation in a recognized union, have been associated with employment growth in the Southern U.S states where such statutes were adopted). Finally, in the post-World War II period, and especially after the 1970s, manufacturing began to locate outside the U.S. entirely to take advantage of low labor costs, falling ocean freight costs from the containerization of shipping, and eventually, in the 1990s, falling international communications costs from the digitization and de-regulation of telecommunications.

Deindustrialization hit Boston hard, like other older industrial cities. Indeed, an urban observer looking at Boston in 1980 would have every reason to believe it would go the way of other older U.S. industrial cities along a sad path toward urban irrelevance. However, that did not happen. During the past 20 years, the Boston MSA has gained population steadily, growing by 13.5 percent over the past two decades to 654,776 in 2021, an increase of about 100,000 (U.S. Census Bureau, see Table 3.2). While this is a significant absolute increase, the primary dynamic has been a halting and reversal of urban population decline as wealthier people have returned to the city, setting waves of "gentrification" that have triggered an explosion in housing values.

2. Major Industries and companies

Post-World War II industrial growth has mainly been due to two industries: information technology and life sciences. Both industries have their roots in university research funded by the U.S. federal government.

Information technology

MIT's Whirlwind Project, funded by the U.S. Navy, created a hotbed of computer science innovation at MIT's Lincoln Laboratory from the 1960s through the 1980s, resulting in the region's rapid growth of the "mini-computer" industry. Digital Equipment Corporation (DEC) was founded in 1957 by two engineers, Ken Olsen, and Harlan Anderson, working on computer systems where operators could change programming on the fly instead of laboriously feeding in a sequence of paper punch cards. This, along with the growing availability and falling costs of solid-state transistors, which could be used in place of expensive and less reliable vacuum tubes, created a market opportunity for computers that were smaller, less expensive, and easier to use than the more powerful mainframe computers sold by market leader IBM. DEC grew rapidly during the 1960s and 1970s and, at one point, was the second-largest computer manufacturer in the world.

With mini-computers, the computing market grew to include many smaller companies and organizations. In addition to DEC, local mini-computer companies included Data General, Wang Laboratories, and Prime Computer. Apollo Computer, founded in 1980 by former DEC employees and a founder of Prime, created a line of high-powered computer "workstations" to serve the growing needs of scientific and technical computing markets. Apollo also made innovations in early computer networking (Hewlett-Packard, based in the San Francisco Bay Area, acquired the company in 1989).

These companies, suppliers, and related firms grew along the "Route 128 Corridor" west of Boston from Middlesex Country north and east into Essex County. As documented by Saxenian (1996), both mini-computer and workstation companies in the Boston region failed to transition to the next wave of market expansion in the commercial computer industry driven by smaller size, lower cost, and ease of use: the personal computer (PC), a sector that came to be based on the driven by younger firms based in Sunbelt cities, such as Apple Computer in Cupertino, California; Dell Computer in Austin, Texas; and Microsoft in Seattle, Washington. Thanks to the advent of the microprocessor – which combined many transistors and other devices as a generic integrated circuit that could be programmed to run a wide variety of application software – the PC quickly gained in power after the introduction of the IBM PC in 1981. Personal computers soon completely displaced mini-computers and, a bit later, workstations. Nevertheless, as we shall see, computer and peripheral equipment manufacturing; semiconductor and other electronic component manufacturing; and related industries such as navigational, measuring, electromedical, and control instruments manufacturing continue as significant manufacturing employers along the Route 128 corridor north of Boston.

In the 1980s and 1990s, Boston became a hub for the emerging software industry. Leading companies such as Lotus Development Corporation made significant contributions to the development of personal computing. Lotus was founded in Cambridge in 1982, and its Lotus 1-2-3 spreadsheet software became one of the most popular applications for personal computers in the 1980s. More recently, Boston has become a center for developing cutting-edge artificial intelligence, machine learning, and cybersecurity technology. MIT spin-off companies include web search pioneer Akamai Technologies and cybersecurity companies such as Carbon Black, based in Waltham, the former home of DEC, and Rapid7, based in the City of Boston. This is a very partial list. There are hundreds of technology spin-offs from local universities, primarily MIT, including robot makers iRobot, Boston Dynamics, and Desktop Metal.

Life Sciences

The biomedical industry in the Boston City-Region has a storied history, with roots dating back to the 19th century. Over the years, the city has become a global hub for biomedical research and development, with a thriving ecosystem of academic institutions, startups, and established companies at the forefront of innovation. Massachusetts General Hospital (MGH) was crucial in advancing medical research in the 19th century and was instrumental in developing new surgical techniques and treatments, including anesthesia. Harvard Medical School, founded in 1782 and remaining one of the top medical schools in the world, has been a leader in medical research for over a century and has produced several Nobel Prize winners and other notable medical researchers. The industry's growth has been fueled significantly by talented faculty and students in a one-square-mile area of Cambridge encompassing Harvard and MIT. This includes many prominent MIT Professors who have contributed to the Human Genome Initiative at the National Institutes of Health, which ultimately led to the sequencing of the human genome.

As a result, Boston City-Region has been a hub for the emerging biotech industry, with companies such as Biogen and Genzyme leading the way in developing new medical treatments. For example, Biogen was founded in 1978 and has become a leader in neuroscience, focusing on developing treatments for diseases like multiple sclerosis (MS), spinal muscular atrophy (SMA), and Alzheimer's disease. Genzyme, founded in 1981, pioneered enzyme replacement therapy and was acquired by Sanofi, a French multinational, in 2011. The region has recently become a center for developing cutting-edge medical technologies, including gene therapy, immunotherapy, and precision medicine. Companies like Moderna, Vertex Pharmaceuticals, and Bluebird Bio are among the many locally-based companies working in these and other cutting-edge areas of biotechnology.

In the late 1980s, companies started building labs housing biological agent R&D. In subsequent years, the area around MIT has grown unabated. The research focus quickly evolved from small molecule pharmaceuticals to biologics and gene therapeutics. Over the subsequent 20 years, the area surrounding MIT, Harvard, and the Massachusetts Avenue corridor added 30 million square feet of new office and laboratory space housing the world's most significant life science companies (Interview, Lab Central). Most striking is the transformation of Kendall Square, adjacent to MIT, from a decaying warren of old low brick buildings originally part of the World War II armaments industry into a 20-story set of canyons consisting mainly of life sciences research labs.

As the industry took off, the State of Massachusetts became involved. In 1985, the Massachusetts legislature established MassBio (MassBio, 2023), an industry support group charged with advancing policy and promoting the education of scientists and engineers needed to fill the laboratories of large pharmaceutical companies. The organization, which currently has 1,600 member companies, aggregates supply purchasing (commodities, gasses, office furniture, etc.), tracks available real estate for new and expanding companies, holds conferences and lectures on cutting-edge topics, and sponsors mixers to bring diverse groups in the life science space. Mass Life Sciences Corporation (MLSC) is another state-funded organization that explicitly invests in the life sciences, biosciences, and pharmaceutical industries. Created by the state Legislature, MLSC provides project resources, including capital equipment, real estate, and technology infrastructure. It also supports educational institutions to train students and adults in life sciences skills by providing equipment, internships, professional development grants, and partnerships with other organizations to foster industry talent.

However, while the City of Cambridge seeks to promote infill development in East Cambridge, the Kendall Square Urban Renewal Plan of 1979-2023 includes strict requirements for the types of laboratories growing in the area and requires the inclusion of open space, street-level retail along with adequate transit and parking.[1]

3. Regional statistical profile

In November 2022, the civilian labor force (employment outside of government and military) in the Boston-Cambridge-Newton MSA (hereafter Boston MSA) numbered 2,536,200, with 2,465,000 employed. The result is a historically low unemployment rate of 2.8%, similar to the other city regions included in the research, except for San Francisco, which has a higher rate (see Table 3.1). The rate for the United States as a whole was 3.6%. Labor markets have been

[1] https://www.cambridgeredevelopment.org/kendall-square-1

tightening in the United States since the Global Financial Crisis in November 2009, when they reached 9.9%, with a brief spike to 14.7% at the onset of the COVID-19 pandemic in April 2020.

Table 3.1: Labor force statistics, Boston-Cambridge-Newton MSA compared with three other city-regions, November 2022, thousands of jobs

	Boston MSA	Atlanta MSA	Seattle MSA	San Francisco/ San Jose
Civilian Labor Force	**2,536.20**	3,208.70	2,788.20	3,291.80
Employment	**2,465.00**	3,122.20	2,714.30	3,189.60
Unemployed	**71.2**	86.5	73.9	102.20
Unemployment Rate	**2.8%**	2.7%	2.7%	5.8%

Table 3.2 provides a general statistical profile of the Boston MSA. This region occupies the coastal cities surrounding Boston and extends to southern New Hampshire, an adjacent state to the north (see Figure 1.1). According to the 2020 Census, the Boston MSA had a population of 4,941,632, making it the 11th largest in the United States.

The region is less diverse than many others of similar size. The racial and ethnic makeup is 2/3rds White, 12% Latinx, 8.6% Asian, and 7.4% Black, with the Black population, as in many large American cities, facing historical (and current) racial discrimination and segregation into lower-income neighborhoods with many fewer opportunities for economic or social advancement. The region's lack of diversity is offset somewhat by a relatively high level of immigration. Nearly a fifth of the population is foreign-born, and more than a quarter speak a language other than English at home.

Table 3.2: Boston-Cambridge-Newton MSA Basic Statistics (2020/2021)

Indicator	Value
Population	4.941,632
Employer establishments	131,172
Race and ethnicity	
White	3,378,922 (68.3%)
Latinx	580,852 (11.7%)
Asian	428,527 (8.6%)
Black	364,054 (7.4%)
Language other than English spoken at home	25.5% (U.S. = 21.6%)
Foreign-born	19.5% (U.S. = 13.6%)
Median household income	$100,750 (U.S. = $69,717)
Employment rate	64.5% (U.S. = 58.6%)
Poverty rate	9.3% (U.S. = 12.8%)
Bachelor's degree or higher	51.1% (U.S. = 35.0%)
Median gross rent	$1,718 (U.S. = $1,191)
Home ownership rate	62.3% (U.S. = 65.4%)
Without health insurance	2.6% (U.S. = 8.6%)
Without an internet subscription	6.7% (U.S. = 9.7%)

Source: U.S. Census Bureau: https://data.census.gov/profile

On average, Boston is a wealthy city, with a median household income of more than $100,000, compared to the national average of just under $70,000. The MSA's poverty rate is[2] low 9.3% in comparison to nearly 13% nationwide. For many, the region offers economic opportunity and a good quality of life. The employment rate is higher than the national average (64.5% vs. 58.6%). More than half of Boston residents hold a Bachelor's Degree or higher (51% compared with only 35% nationwide). Less than 2.6% are without health insurance, compared with 8.6% nationally. This is mainly due to a nationally-pioneering healthcare reform law passed in 2006, making insurance coverage mandatory in Massachusetts. Only 6.7% of households lack internet access, compared with 10% nationally.

However, economic success comes with challenges, especially with traffic congestion and high housing costs. Boston suffers from the second worst traffic congestion in the United States, with 134 hours lost per commuter annually (Bartiromo, 2023). Median gross rent is far above the national average ($1,718 per month vs. $1,191 nationally), and home ownership is slightly below the national average (62.3% versus 65.4% nationally).

4. Why manufacturing is important[3]

To provide a broader context for trends at the city-region level, this section asks why manufacturing is essential. The section is included in all four reports prepared by our team with the reasoning that the national situation with manufacturing in the United States will go a long way toward making sense of our finding in each of the city-regions we examined in our research. However, readers may skip this section. The main finding is that manufacturing employment has been declining in most OECD countries for many decades, driven in part by automation but, in the past 20 years and especially for the United States, by the rise of export manufacturing in China and other low-income countries.

The benefits of manufacturing for economic and social development are long-heralded as a mechanism for shifting resources from low- to higher-productivity activities (Kuznets, 1971).[4] The faster the growth of the manufacturing sector, the more the productivity is enhanced because resources – significantly labor – are shifted away from traditional sectors such as agriculture, where technology is applied to maintain (or increase) output. As labor shifts out of agriculture, manufacturing takes up the slack, creating solid middle-class employment in urban areas, especially for workers without high levels of education, along with large-scale workplaces suitable for union organizing.

Kaldor (1967) focused more on productivity and exports within manufacturing than labor. He argued that GDP growth is higher when manufacturing's share is rising because it has increasing returns to scale and because of manufacturing's disproportionate contribution to a

[2] According to the U.S. Census Bureau, a household is considered poor if its income is below a specific threshold set according to the Consumer Price Index. In 2021, this threshold was set at a total annual income of $36,500, or slightly more than $3,000 per month (see: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html).

[3] This sub-section is included in all reports to provide context.

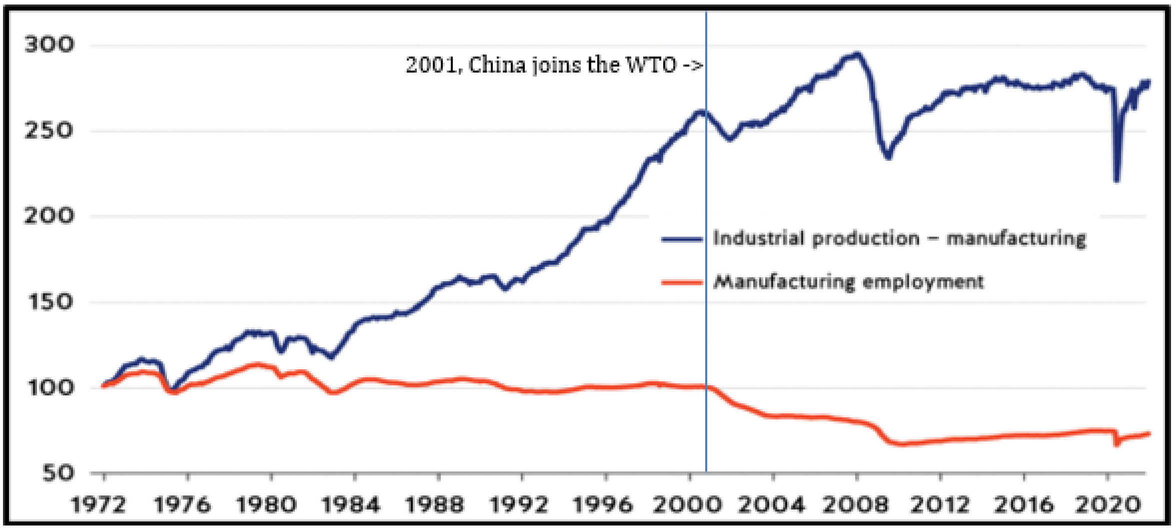
[4] For example, with the shift of labor and capital from agriculture to manufacturing through industrialization.

country's balance of payments through exports, which can be intra-regional or international. So, rising manufacturing output can generate regional and national wealth because of high value-added, steady productivity increases, and exports that create a positive revenue flow, even if manufacturing employment eventually grows more slowly or turns negative. This sectoral succession model assumes that once labor has been all but wrung out of agriculture through productivity increases, the same can happen with manufacturing as jobs in the services sector can take over as the engine of job creation, productivity increases, and export growth.

Manufacturing trends globally and in the United States

This process is ongoing in the United States and most other large OECD countries, where manufacturing output continues to grow, but employment is shrinking (Figure 4.1). At its peak in 1979, manufacturing employment in the United States reached 19.5 million, representing 22 percent of nonfarm employment. Forty years later, manufacturing employment stood at only 13 million, and its share fell to 9 percent. The dichotomy between output growth and employment decline is explained by productivity increases from automation, computerization, and better work organization and management practices, as predicted by models of sectoral succession. However, the trend was super-charged for the United States in the 2000s by migrating large-scale export-oriented production to lower-cost countries in the developing world, especially China. This shift simultaneously increased import competition for remaining manufacturing plants, lowered prices, and increased consumer product variety in the United States.

Figure 4.1: US industrial production and manufacturing employment index, 1972-2020 (indexed to 1972=100)

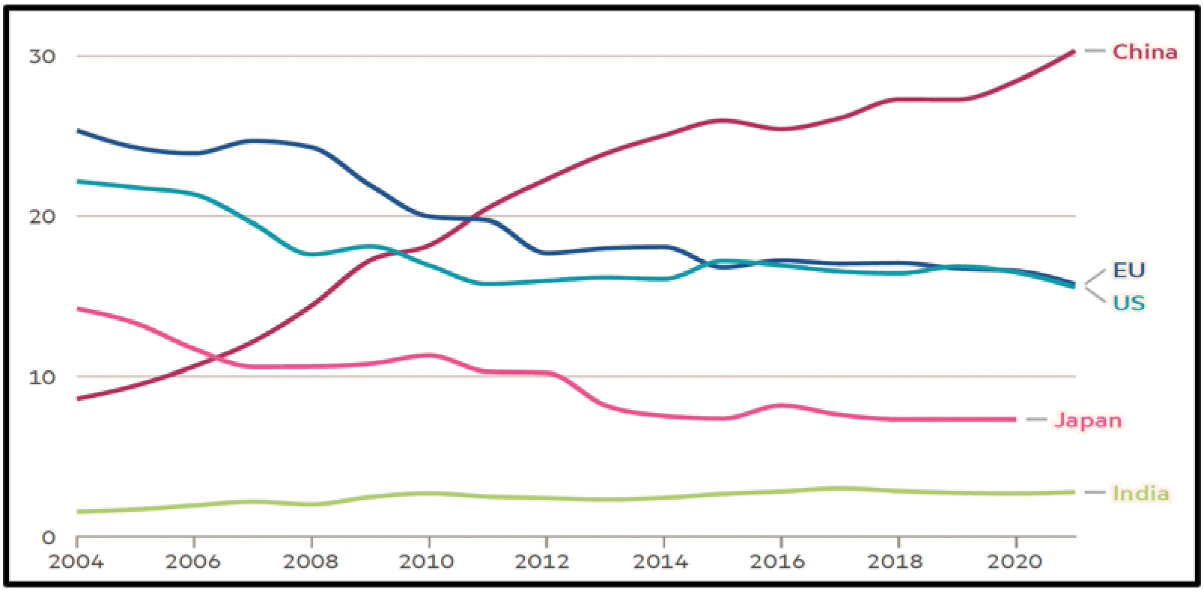


Source: Kirchner (2022) from Federal Reserve Bank of St Louis FRED database. Notes: Industrial Production: Manufacturing (NAICS), Index Jan 1972=100, Constant Prices, Monthly, Seasonally Adjusted; Employment: All Employees, Manufacturing, Index Jan 1972=100, Monthly, Seasonally Adjusted.

The China Shock

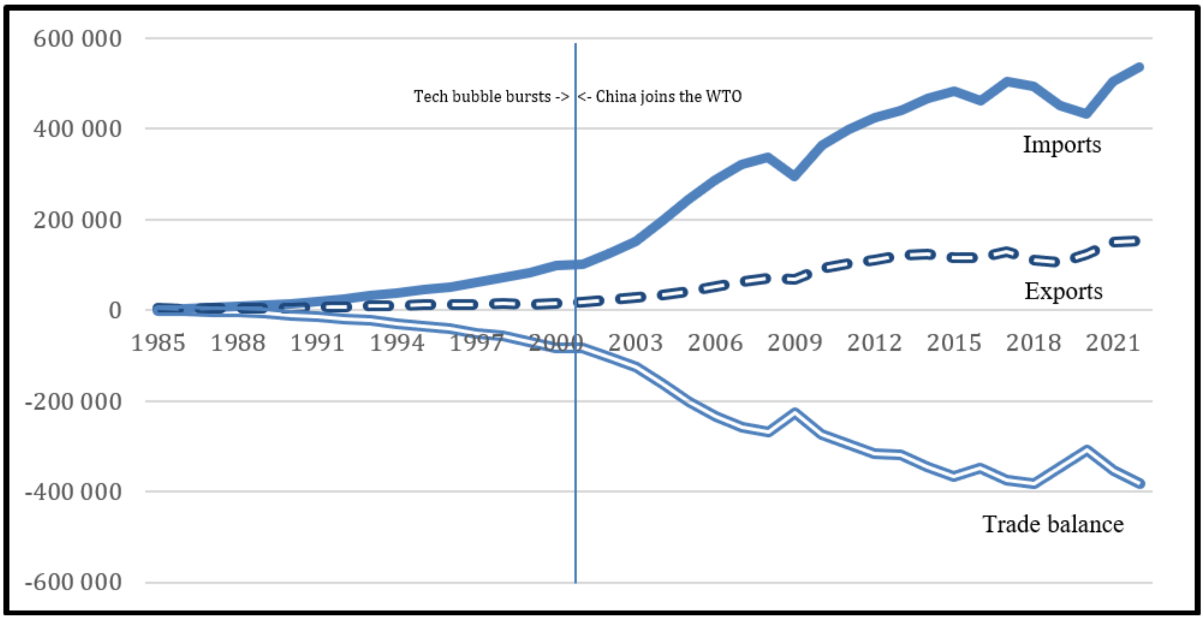
The net impact of offshoring manufacturing jobs on economic and social development is still being determined (Kirchner, 2022). Uneven effects are being felt in the manufacturing employment decline in the United States. Regions of historic manufacturing concentration are suffering greatly. Offshoring pushed China's share of global manufacturing value added to nearly 30% in 2021 from less than 10% in 2004 (Figure 4.2). This extraordinary rise created a massive trade deficit for the United States with China (see Figure 4.3).

Figure 4.2: Share of Global Manufacturing Value Added, 2004-2021 (percent)



Source: McGee (2023) for Financial Times based on World Bank data

Figure 4.3: US trade with China, 1985-2022



Source: U.S. Census Bureau: https://www.census.gov/foreign-trade/balance/c5700.html. Note: Figures are in U.S. million dollars on a nominal basis, not seasonally adjusted.

China's role as an export platform exploded after it acceded to the WTO in 2001. This led to huge trade imbalances with trading partners, especially the United States (see Figure 4.3). While the U.S. export balance in services (including technology licenses, an indicator of China's technological dependence on the United States) has remained positive, the trade balance with China in goods soared to negative US $382 billion in 2018 and leveled off since. Not coincidentally, this came on the heels of the bursting of the 'technology bubble' in the U.S. in 2001, which sent U.S. manufacturers scrambling to cut costs and access 'big emerging markets' in China, India, and Brazil – moves that often come with requirements to set up local production, conduct R&D, and (reluctantly and partially, at best) transfer technology to local joint venture partners.

In this way, the 'China shock' set the stage for the political upheavals of 2016 and beyond. Autor et al. (2016, abstract) frame it this way:

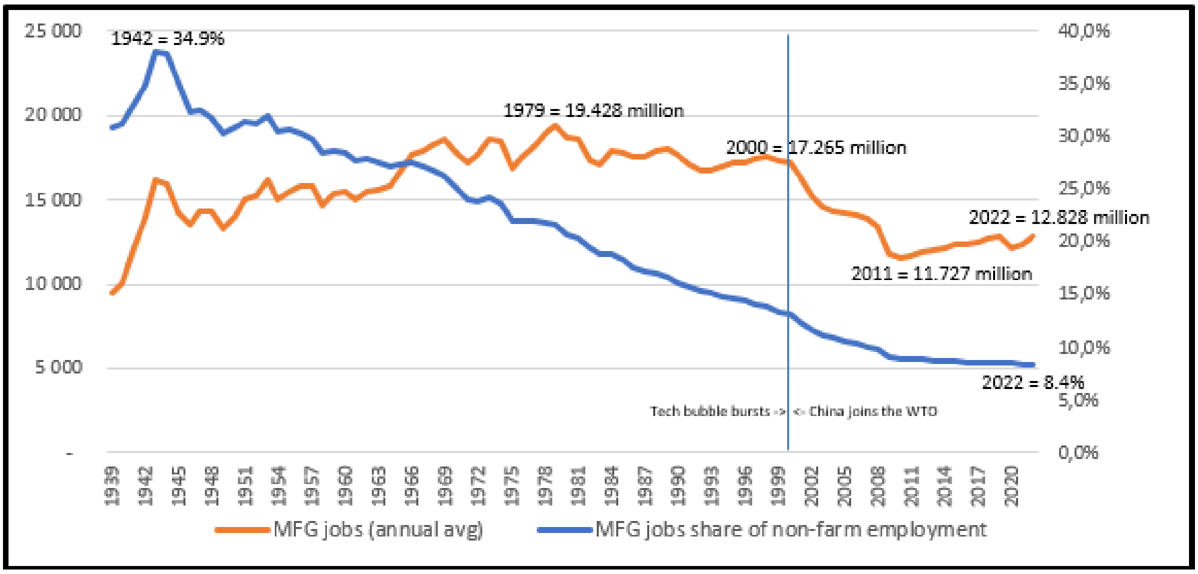
> *China's emergence as a great economic power has induced an epochal shift in world trade patterns. Simultaneously, it has challenged much empirical wisdom about how labor markets adjust to trade shocks. Alongside the heralded consumer benefits of expanded trade are substantial adjustment costs and distributional consequences. These impacts are most visible in the local labor markets where the industries exposed to foreign competition are concentrated. Adjustment in local labor markets is prolonged, with wages and labor-force participation rates remaining depressed and unemployment rates remaining elevated for at least an entire decade after the China trade shock commenced. Exposed workers experience more significant job churning and reduced lifetime income. At the national level, employment has fallen in U.S. industries*

more exposed to import competition, as expected, but offsetting employment gains in other industries have yet to materialize.

Manufacturing employment in the United States

Since its peak in 34% of total non-farm employment in 1942, during the height of World War Two, the share of manufacturing jobs in the United States workforce declined to its current low of 8.4% in 2022. However, this is mainly due to robust job growth in other sectors. The number of manufacturing jobs in the United States grew steadily after World War Two, peaking cyclically to a peak of 19.428 million in 1979, dropping gradually to 17.265 million in 2000, and then rapidly after China joined the WTO, to its modern low of 11.727 million in 2011. After that, manufacturing employment has been on a gradual rebound, to 12.828 in 2022 (see Figure 4.4).

Figure 4.4: US manufacturing jobs (thousands), and share of non-farm employment, 1939-2022



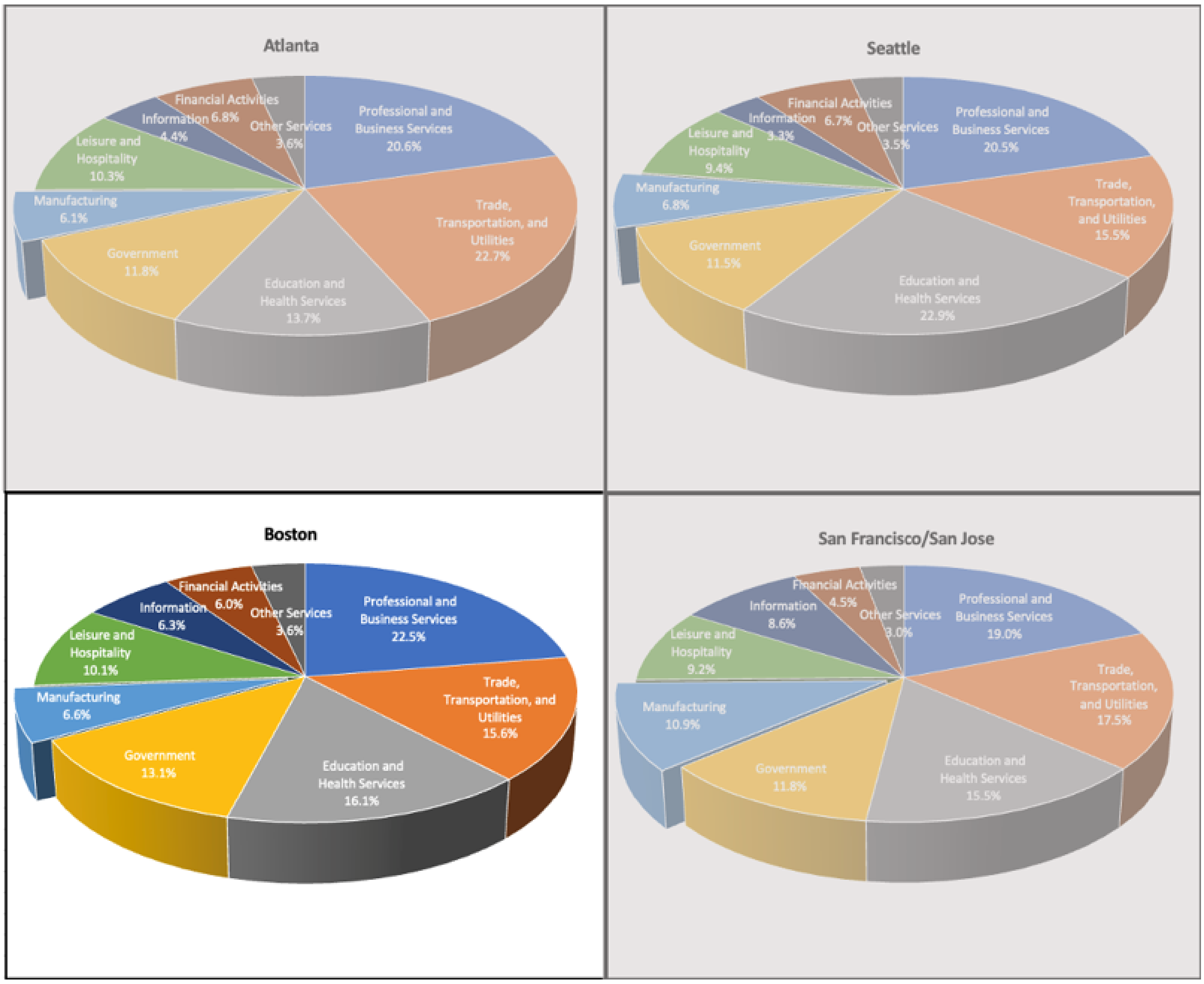
Source: Employment, Hours, and Earnings from the Current Employment Statistics Survey (National), U.S. Bureau of Labor Statistics

5. Manufacturing trends in Boston

This section discusses trends in manufacturing in the Boston metropolitan region (defined here by the Boston-Cambridge-Newton MSA) and discusses the importance of manufacturing relative to other regional sectors.

In December 2020, manufacturing employment in the U.S. stood at 13 million, 8.4% of non-farm employment. Figure 5.1 shows that manufacturing employment was 6.6% of non-farm employment in the Boston MSA, the second lowest of the four city regions included in the research after Atlanta.

Figure 5.1: Boston-Cambridge-Newton MSA jobs by major industry compared with three other city regions, November, 2022



Source: MSA data from U.S. Bureau of Labor Statistics Regional Dataset, https://www.bls.gov/regions/

However, the sectoral mix is similar across regions, reflecting their roles as core governmental, educational, transportation, financial, trade, and tourism hubs for their states and surrounding areas. In Boston, the largest private employer is health and education services, reflecting the city region's global role in these activities, and government, reflecting Boston's role as the capital of Commonwealth (State) of Massachusetts.

How is manufacturing faring in Boston?

In December 2022, the Boston MSA had about 186 thousand manufacturing jobs, down from 351 thousand in 1990, a decrease of 47%, as shown in Table 5.1 and the upper panel of Figure 5.2.

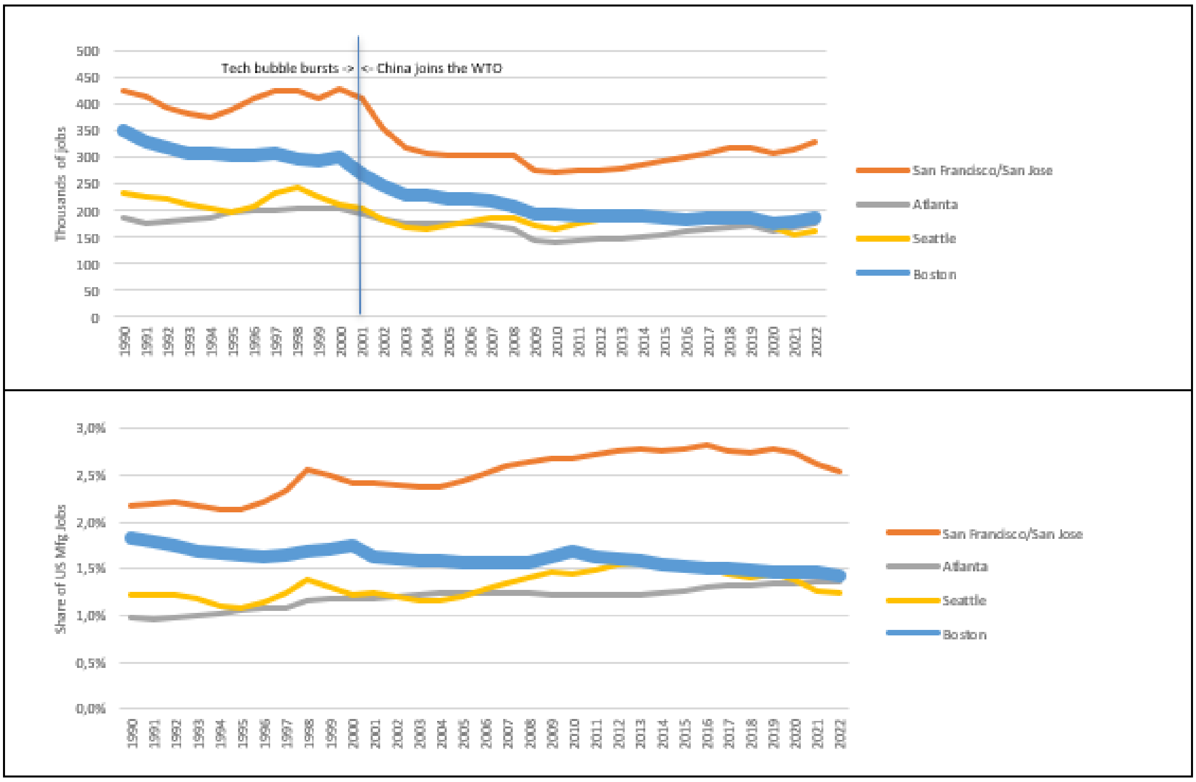
Table 5.1: Boston-Cambridge-Newton MSA manufacturing employment compared to three other U.S. city regions, total U.S. manufacturing employment, and total U.S. nonfarm employment, 1990-2022, thousands of jobs (only even years shown through 2010)

Year	Boston MSA	Atlanta MSA	Seattle MSA	San Francisco and San Jose MSAs	San Jose MSA	San Francisco MSA	US Mfg Emp	US Nonfarm Emp
1990	351.2	186	232	427	255	172	19,173	116,964
1992	317.5	179	222	393	230	163	18,149	115,968
1994	306.4	189	203	375	217	158	18,388	120,379
1996	302.9	200	209	413	241	171	18,527	125,461
1998	297.8	205	244	426	246	180	17,606	131,563
2000	301.0	204	213	431	252	179	17,288	137,228
2002	246.2	183	184	354	201	153	15,265	135,840
2004	228.1	176	165	310	168	142	14,302	136,851
2006	221.6	176	181	304	164	140	14,153	141,153
2008	208.8	166	187	304	168	136	13,412	141,576
2010	193.9	141	167	271	154	118	11,516	134,714
2011	190.2	144	175	276	158	118	11,729	136,258
2012	190.9	146	184	277	158	119	11,935	138,885
2013	190.0	147	188	278	158	120	12,023	141,103
2014	189.4	150	187	286	162	124	12,189	143,758
2015	187.0	156	188	295	165	130	12,332	146,634
2016	185.2	161	186	302	167	135	12,335	148,735
2017	187.2	165	179	308	167	141	12,440	150,654
2018	188.5	169	179	318	172	146	12,672	153,176
2019	188.4	172	184	319	172	147	12,806	155,324
2020	177.7	163	169	309	168	141	12,111	146,542
2021	181.5	168	155	316	169	147	12,331	150,740
2022	185.9	176	162	329	175	155	12,980	155,173
Emp. change 1990-2010	**(157.3)**	**(45.1)**	**(65.2)**	**(155.7)**	**(101.1)**	**(54.6)**	**(7,657.0)**	**17,750.0**
% change 1990-2010	**-45%**	**-24%**	**-28%**	**-36%**	**-40%**	**-32%**	**-40%**	**15%**
Emp. change 2010-2022	**(8.0)**	**35.3**	**(4.7)**	**58.0**	**21.0**	**37.0**	**1,464.0**	**20,459.0**
% change 2010-2022	**-4%**	**25%**	**-3%**	**21%**	**14%**	**31%**	**13%**	**15%**
Emp. change 1990-2022	**(165.3)**	**(9.8)**	**(69.9)**	**(97.7)**	**(80.1)**	**(17.6)**	**(6,193.0)**	**38,209.0**
% change 1990-2022	**-47%**	**-5%**	**-30%**	**-23%**	**-31%**	**-10%**	**-32%**	**33%**

Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

The MSA lost 165,000 manufacturing jobs in that period, the most significant number in our four city regions. The MSA did not participate in the national rebound after 2010 evident in the national figures in Figure 4.4 and the 8th column of Table 5.1 as well as for the Atlanta and San Francisco MSAs. Instead, the Boston MSA lost another eight thousand manufacturing jobs, for an additional decline of 4 percent from 2010. As seen in the lower panel of Figure 5.2, compared to the four study regions, Boston is the sole loser of manufacturing employment as a share of total national manufacturing employment (declining from 1.8% in 1990 to 1.4 % in 2022).

Figure 5.2: Boston-Cambridge-Newton MSA manufacturing employment and share of U.S. compared with three other U.S. city regions, 1990-2022



Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

Which manufacturing sectors are important in Boston?

This and the following sections narrow the focus from the Boston MSA to Boston's core region, which we define as mainly encompassing three counties: Suffolk County, which includes the city of Boston; Middlesex County, which includes the city of Cambridge (the home of Harvard, MIT, and Tufts Universities) along with cities to the east and north to Waltham and Lowell, both former textile mill towns in the upper Merrimack Valley; and Essex County, which follows the Route 128 Corridor north and east, including other former textile mill towns along the lower Merrimack Valley (Lawrence, Methuen, and Haverhill) and the coastal cities on Boston's North

Shore (including Lynn, Salem, and Gloucester). Areas to the immediate southeast and south of Boston's core region are excluded because they are generally more residential.[5]

Table 5.2 lists the NAICS-3-digit manufacturing sectors for the three counties in the Boston core region, ranked by June 2022 employment. The three counties account for 64% of the Boston MSA's manufacturing employment. Unsurprisingly, Suffolk County, which contains the city of Boston, has a low concentration of manufacturing firms. No manufacturing sector registers a location quotient (LQ) above 1.0 (wages and jobs). There were only 374 manufacturing establishments in Suffolk Country, employing 9,053, with a total wage bill of only $190 thousand. On average, these establishments are small, employing 24 workers. The highest is NAICS 312 beverage and tobacco product manufacturing (LQs of 0.6 and 0.7, respectively), possibly reflecting newly established micro-breweries and distilleries.

The situation changes markedly moving north and west from Boston. Middlesex County has double the number of manufacturing establishments as Suffolk County (1,674). These establishments also are larger (42 employees on average), with nearly eight times the number of employees (71 thousand) and a 2022 2nd quarter wage bill of $2.2 million. Essex County falls in between with 852 establishments and 38.5 thousand workers and a wage bill slightly less than $1 million. However, the average size of establishments is slightly larger than in Middlesex (45 employees on average).

It is in the more manufacturing-intensive counties where the regional manufacturing specializations of the Boston region emerge. In Middlesex County, NAICS 334, computer and electronic product manufacturing, has an employment LQ of 4.1, followed by NAICS 325, chemical manufacturing, which includes pharmaceuticals, with an employment LQ of 1.1, only slightly above the national average, reflecting the fact that most life sciences activity in the region is related to R&D, not production. All other manufacturing sectors in Middlesex County have employment LQs well below the national average. Essex County also specializes in NAICS 334, computer and electronic product manufacturing, with an employment LQ of 2.8, and NAICS 339 miscellaneous manufacturing (2.3), and NAICS 315 apparel manufacturing (2.4). These specializations all echo the region's history as a center of apparel and electronics manufacturing, underlining the importance of history in shaping regional specializations. Overall, the three-county core region had 2,900 manufacturing establishments with 188,491 employees and a wage bill of $3.3 billion in the second quarter of 2022.

[5] There are many industrial (and de-industrialized) cities to the east, south (including in the state of Rhode Island) and north of Boston (including in the southern portion of the state of New Hampshire) that can be considered part of the broader New England and Northeast regions, but we have placed these out of scope for the purposes of this study. Cities in southern New Hampshire along the Rt. 3 and I-93 corridors, for example Nashua and Manchester, have certainly received recent spillover investment from Boston's core region. By contrast, there are major cities in Massachusetts east of Boston such as Worchester and Springfield and cities to the south such as Brockton, Fall River, and New Bedford that remain largely deindustrialized. While these cities have the potential for revitalization, including the return of some manufacturing, they are mainly currently relics of the state's more vibrant industrial past.

Table 5.2: Employment and wages by the significant manufacturing industry, Boston core region, NIACS 3-digit industries, 2nd quarter 2022, ranked by June employment in each county (employment LQs above 2.0 in shaded rows).

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient
Suffolk County (includes Boston)						
NAICS 311 Food mfg.	118	3,236	27	37,436,819	892	0.4
NAICS 332 Fabricated metal product mfg.	24	1,615	67	58,893,886	2,784	0.2
NAICS 312 Beverage and tobacco product mfg.	20	989	49	23,901,234	1,909	0.6
NAICS 325 Chemical mfg.	18	912	51	25,318,522	2,139	0.2
NAICS 334 Computer and electronic product mfg.	28	556	20	12,050,702	1,664	0.1
NAICS 323 Printing and related support activities	50	358	7	7,911,882	1,698	0.2
NAICS 326 Plastics and rubber products mfg.	6	246	41	4,439,345	1,350	0.1
NAICS 339 Miscellaneous mfg.	40	201	5	3,571,421	1,351	0.1
NAICS 314 Textile product mills	10	183	18	2,805,179	1,186	0.4
NAICS 327 Nonmetallic mineral product mfg.	14	174	12	3,485,477	1,574	0.1
NAICS 315 Apparel mfg.	7	148	21	1,612,322	869	0.3
NAICS 321 Wood product mfg.	6	125	21	2,145,019	1,327	0.1
NAICS 335 Electrical equipment etc.	11	117	11	2,892,220	1,998	0.1
NAICS 337 Furniture and related product mfg.	13	106	8	1,683,712	1,185	0.1
NAICS 333 Machinery mfg.	9	87	10	2,257,741	2,162	0.0
Middlesex County (includes Cambridge)						
NAICS 334 Computer and electronic product mfg.	335	30,467	91	1,175,463,397	2,976	4.5
NAICS 325 Chemical mfg.	120	5,869	49	202,731,769	2,629	1.1
NAICS 333 Machinery mfg.	128	5,724	45	152,803,930	2,085	0.8
NAICS 332 Fabricated metal product mfg.	253	5,258	21	96,112,738	1,409	0.6
NAICS 339 Miscellaneous mfg.	161	5,004	31	116,033,550	1,804	1.3
NAICS 311 Food mfg.	170	4,811	28	77,379,230	1,251	0.5
NAICS 336 Transportation equipment mfg.	19	2,795	147	89,820,404	2,486	0.3
NAICS 323 Printing and related support activities	155	2,576	17	61,172,923	1,827	1.1
NAICS 326 Plastics and rubber products mfg.	37	2,039	55	46,153,370	1,748	0.4
NAICS 312 Beverage and tobacco product mfg.	34	1,488	44	22,760,015	1,224	0.7
NAICS 335 Electrical equipment etc.	54	1,311	24	34,790,444	2,074	0.5
NAICS 313 Textile mills	16	710	44	16,245,213	1,801	1.2
NAICS 322 Paper mfg.	19	657	35	16,277,592	1,916	0.3
NAICS 327 Nonmetallic mineral product mfg.	53	533	10	9,115,469	1,348	0.2
NAICS 331 Primary metal mfg.	17	440	26	10,353,580	1,822	0.2
NAICS 337 Furniture and related product mfg.	38	384	10	6,650,546	1,321	0.2
NAICS 321 Wood product mfg.	29	308	11	5,169,814	1,284	0.1
NAICS 314 Textile product mills	24	279	12	4,034,771	1,106	0.4
NAICS 315 Apparel mfg.	12	243	20	2,744,105	875	0.4
Essex County (includes Boston North Shore)						
NAICS 336 Transportation equipment mfg.	26	7,089	273	237,078,213	2,579	1.9
NAICS 334 Computer and electronic product mfg.	101	6,627	66	209,398,533	2,454	2.8
NAICS 311 Food mfg.	121	6,033	50	83,357,469	1,075	1.7
NAICS 332 Fabricated metal product mfg.	185	3,937	21	74,723,192	1,466	1.3
NAICS 333 Machinery mfg.	49	3,550	72	97,788,398	2,135	1.5
NAICS 339 Miscellaneous mfg.	75	3,115	42	93,749,958	2,316	2.3
NAICS 325 Chemical mfg.	46	2,402	52	57,152,780	1,829	1.2
NAICS 323 Printing and related support activities	49	1,326	27	22,591,941	1,307	1.6
NAICS 335 Electrical equipment etc.	19	1,145	60	28,678,760	1,917	1.3
NAICS 326 Plastics and rubber products mfg.	24	832	35	14,512,295	1,366	0.5
NAICS 315 Apparel mfg.	11	481	44	4,954,893	790	2.4

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient
NAICS 337 Furniture and related product mfg.	35	477	14	6,992,673	1,126	0.6
NAICS 312 Beverage and tobacco product mfg.	27	328	12	2,600,273	623	0.5
NAICS 322 Paper mfg.	6	296	49	4,100,350	1,074	0.4
NAICS 313 Textile mills	14	255	18	4,949,840	1,495	1.2
NAICS 327 Nonmetallic mineral product mfg.	21	217	10	4,055,407	1,431	0.2
NAICS 321 Wood product mfg.	21	216	10	3,666,491	1,324	0.2
NAICS 314 Textile product mills	15	132	9	1,609,835	970	0.6
NAICS 331 Primary metal mfg.	7	84	12	1,472,862	1,360	0.1
Core region total	**2,900**	**118,491**	.	**3,289,652,504**	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

Which manufacturing and non-manufacturing industries does Boston specialize in?

With manufacturing's decline, Boston's sectoral mix is changing. This is suggested by in Table 5.3, showing the employment and wages statistics for Boston's core region (again, defined as Suffolk, Middlesex, and Essex counties) for the 2nd quarter of 2022. The more detailed (4-digit) NAICS industries shown in Table 5.3 reveals the region's specialties beyond manufacturing relative to other locations in the United States. The Table ranks all industries with an employment LQ of 2.0 or higher. For Suffolk County, we see the expected urban specializations of a major U.S. city: finance, tourism, education, transportation, and retail. As also seen in Table 5.2 above, manufacturing is unimportant in the home county of the city of Boston. However, the industries that are important in the surrounding counties represent regional specializations in a variety of knowledge-intensive activities that feed into manufacturing and also a few manufacturing industries as well. For example, in Middlesex County, the industry with the highest employment LQ (12.9) is NAICS 5417, scientific R&D services, followed by NAICS 3345, navigational, measuring, medical, and control instruments manufacturing (shortened here as electronic instruments in the table), with an LQ of 6.9. In addition to its concentration in colleges and universities, the county specializes in knowledge-intensive jobs in software, web portals, and computer systems design (4.7, 4.2, and 2.1, respectively).

Again, the region's history as a center of textiles and electronics manufacturing is reflected in the concentration of electronics subsectors: electronic instruments (with an employment LQ of 6.5), computers and peripheral equipment (4.7), and semiconductors (2.8), along with what is the region's currently most dynamic sector, pharmaceutical, and medicine manufacturing (2.1). Amazingly, given the devastation of the industry in the U.S. Northeast, the manufacturing sector NAICS 3133 textile and fabric finishing mills has an LQ of 3.9 in Middlesex County.

In coastal Essex County, where the fishing and seafood processing industries are essential (fishing and seafood processing rank numbers 1 and 3), industrial machinery, aerospace, and a variety of electronics manufacturing subsectors are well represented (electronic instruments, communications equipment, and semiconductors), along with medical equipment and several more generic manufacturing activities: paint, bakeries, HVAC equipment, machine shops, and other food and chemical items.

Table 5.3: Employment and wages by detailed industry, Boston core region, NAICS 4-digit industries, 2nd quarter 2022, with employment LOQ >2.0, ranked (manufacturing shaded)

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient
Suffolk County (includes Boston)						
NAICS 5239 Other financial investment activities	825	24,106	29	1,615,579,433	5,250	9.3
NAICS 4872 Sightseeing transport, water	10	670	67	4,314,856	632	7.0
NAICS 4871 Sightseeing transport, land	10	340	34	3,302,728	794	6.4
NAICS 6113 Colleges and universities	52	32,619	627	747,374,519	1,646	6.2
NAICS 4811 Scheduled air transportation	37	9,355	253	208,175,393	1,712	4.4
NAICS 5231 Securities and commodity contracts	271	9,559	35	668,377,336	5,532	4.4
NAICS 3117 Seafood product preparation	7	649	93	10,394,196	1,244	3.9
NAICS 5417 Scientific research and development	481	14,819	31	665,157,125	3,483	3.6
NAICS 6221 General medical & surgical hospitals	18	77,910	4,328	1,807,777,338	1,801	3.6
NAICS 5132 Software publishers	481	10,008	21	428,204,043	3,336	3.4
NAICS 5161 Radio and television broadcasting	23	1,772	77	45,458,744	1,958	3.2
NAICS 7111 Performing arts companies	55	1,717	31	24,923,627	1,107	3.0
NAICS 5411 Legal services	925	15,441	17	769,382,848	3,934	2.8
NAICS 8133 Social advocacy organizations	304	3,163	10	59,715,554	1,474	2.8
NAICS 6242 Community and emergency services	93	2,520	27	45,295,148	1,387	2.7
NAICS 4491 Furniture & home furnishings retail	88	5,527	63	229,096,567	3,215	2.6
NAICS 7121 Museums, historical sites, etc.	36	2,015	56	27,804,628	1,081	2.6
NAICS 5241 Insurance carriers	126	14,141	112	596,734,112	3,269	2.5
NAICS 7112 Spectator sports	17	1,825	107	171,099,863	7,163	2.5
NAICS 7223 Special food services	202	6,912	34	77,710,952	865	2.4
NAICS 5416 Management, sci., & tech, consulting	1,175	19,935	17	1,037,592,136	4,046	2.4
NAICS 8129 Other personal services	217	4,132	19	39,241,563	751	2.3
NAICS 4852 Interurban and rural bus transport	10	147	15	1,687,758	860	2.3
NAICS 5412 Accounting & bookkeeping services	294	10,977	37	375,251,479	2,689	2.2
NAICS 5418 Advertising and related services	403	4,860	12	151,991,587	2,442	2.1
NAICS 6117 Educational support services	211	2,007	10	57,780,446	2,207	2.1
NAICS 7113 Event promotion	38	1,407	37	20,332,710	1,063	2.1
NAICS 5131 Publishing	108	2,960	27	149,108,474	3,865	2.1
NAICS 5415 Computer systems design	1,406	23,586	17	1,114,650,093	3,673	2.1
Middlesex County (includes Cambridge east to Waltham and north the Lowell)						
NAICS 5417 Scientific R&D services	1,799	70,722	39	3,453,964,067	3,790	12.9
NAICS 3345 Electronic instruments mfg.	187	17,059	91	577,209,990	2,614	6.5
NAICS 6113 Colleges and universities	68	36,197	532	1,037,622,525	2,075	5.2
NAICS 5132 Software publishers	793	19,780	25	961,451,313	3,781	5.0
NAICS 3341 Computer & peripheral mfg.	21	4,723	225	206,449,979	3,349	4.7
NAICS 5192 Web search portals etc.	235	4,732	20	293,581,908	4,826	4.2
NAICS 3133 Textile and fabric finishing mills	11	622	57	15,078,601	1,909	3.9
NAICS 4854 School and employee bus transport	23	3,280	143	29,928,443	696	3.2
NAICS 3332 Industrial machinery manufacturing	28	2,545	91	70,105,213	2,169	3.2
NAICS 4242 Drugs and druggists' wholesalers	122	4,477	37	323,854,354	5,687	2.9
NAICS 3344 Semiconductor manufacturing	92	6,588	72	285,498,934	3,371	2.8
NAICS 5178 All other telecommunications	55	700	13	36,347,994	4,054	2.6
NAICS 5415 Computer systems design services	2,782	37,360	13	1,877,782,739	3,860	2.5
NAICS 4853 Taxi and limousine service	87	846	10	9,091,823	818	2.4
NAICS 3333 Commercial machinery mfg.	30	1,198	40	37,818,951	2,456	2.1
NAICS 3254 Pharmaceutical and medicine mfg.	61	4,471	73	164,282,307	2,785	2.1
NAICS 5511 Management of companies	390	32,413	83	1,304,580,604	3,143	2.1
NAICS 6116 Other schools and instruction	602	5,774	10	43,971,611	569	2.0

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient
Essex County (includes lower Merrimack Valley and Boston North Shore)						
NAICS 1141 Fishing	82	194	2	3,152,679	1,535	13.6
NAICS 3332 Industrial machinery manufacturing	12	1,986	166	67,549,301	2,641	7.0
NAICS 3117 Seafood product preparation	7	542	77	11,477,516	1,648	7.0
NAICS 3364 Aerospace product and parts mfg.	8	6,933	867	234,720,854	2,611	6.4
NAICS 4852 Interurban and rural bus transport	10	175	18	2,400,291	1,049	5.8
NAICS 3345 Electronic instruments mfg.	48	3,763	78	123,987,134	2,549	4.1
NAICS 4592 Book retailers and news dealers	22	589	27	6,651,608	830	3.8
NAICS 8134 Civic and social organizations	118	2,727	23	15,441,185	466	3.8
NAICS 3255 Paint, coating, and adhesive mfg.	11	525	48	11,650,026	1,699	3.6
NAICS 3118 Bakeries and tortilla manufacturing	67	2,373	35	28,406,655	931	3.3
NAICS 4242 Drugs and druggists' wholesalers	39	1,785	46	44,128,786	1,923	3.3
NAICS 3391 Medical equipment & supplies mfg.	35	2,191	63	76,752,561	2,696	3.0
NAICS 4572 Fuel dealers	52	434	8	7,796,740	1,351	2.9
NAICS 3334 HVAC equipment manufacturing	9	819	91	15,150,853	1,434	2.7
NAICS 3342 Communications equipment mfg.	6	494	82	18,699,148	2,946	2.6
NAICS 3344 Semiconductor manufacturing	35	2,184	62	57,696,427	2,066	2.6
NAICS 3327 Machine shop mfg.	103	1,809	18	34,054,076	1,450	2.5
NAICS 4853 Taxi and limousine service	51	298	6	2,582,563	683	2.4
NAICS 6241 Individual and family services	8,204	14,009	2	106,722,267	595	2.3
NAICS 3119 Other food manufacturing	18	1,197	67	18,746,138	1,193	2.2
NAICS 6232 Mental health etc. facilities	188	2,841	15	42,014,178	1,137	2.2
NAICS 4452 Specialty food retailers	90	1,075	12	6,498,542	504	2.1
NAICS 3259 Other chemical product mfg.	6	360	60	7,553,754	1,614	2.0
NAICS 4859 Other transit & passenger transport	45	411	9	3,267,238	622	2.0
Core region total	**16,652**	**303,201**	.	**11,675,721,876**	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

6. Educational Resources

As we have seen, Boston's economy is based on three sectors: health, education, and finance. The 495 Interstate highway corridor, the second ring road outside the 128 Corridor, has significant health facilities, including the historically renowned Massachusetts General Hospital system. Within the Boston Metro area are more than 60 educational institutions, including a state university campus, the University of Massachusetts-Boston, and several community colleges. In addition, as previously mentioned, the region hosts preeminent private institutions, including Harvard, MIT, Northeastern, and Tufts universities. Combined, the city's annual population includes 250,000 students.

The state is affiliated with 15 community colleges and their respective campuses. Some have been losing students as cost rise and career opportunities narrow. The state utilizes federal passthrough dollars to support specific curricula such as nursing, public safety, and child development. The schools' quality is variable, and teachers' pay is tough to live on (https://masscc.org). Community college is an affordable first step into higher education for many lower-income students. Recent concerns about the colleges is their lack of alignment with the number one sector in the state: healthcare. Programs lack consistent standards. The field of health requires specific skills and education along with practicum training. Students attending many vocational programs, such as nursing, are ill-prepared to pass certification tests. Recommendations are for the schools to come under one governance structure and to design and implement curricula consistent across school locations (https://www.communitycollegereview.com/blog/massachusetts-community-college-system-slammed-twice-in-one-week).

7. Policy institutions and practices

The city of Boston's local government structure consists of a Mayor-City Council structure. There are 13 legislative members, four elected at large and nine district representatives. Electoral terms are two years with no term limits. The Council annually approves the budget, determines and oversees the structure of city agencies, decides upon land uses, and manages legislative formation and intent. The Council elects a president annually. The city council president serves as the acting mayor when the mayor is absent from the city.

District structure and representation reflect areas of approximately equal population size. Districts are decided and adjusted annually. City functions are divided into ten agency cabinets. Cabinet directors are appointed by the mayor and serve at the mayor's pleasure absent term limits. Eighty-nine departments carry out the business of the city. The Boston Planning and Development Agency (BPDA), formerly the Boston Redevelopment Authority (BRA), is responsible for land use decisions. The agency's actions cover all matters of land use and economic development. BPDA is charged with growing the city's tax base, encouraging job growth, and attracting new businesses. he agency also oversees establishing and applying standards regulating land use, including building dimensions, neighborhood form and function, land use density, building construction, and transit advocacy and maintains the city's distinctive character.

Over the last half-century, the city government leadership has been relatively stable. The previous two mayors governed the city for the last forty years. Many public, private, non-profit, religious, medical, and educational organizations and associations are within the city's boundaries, adding capacity, structure, and texture to the city's operations. At a regional scale, the state also provides institutional infrastructure, especially related to economic development activities. The city enjoys a highly articulated transit system, including light rail, buses, and commuter rail. At the regional scale, the city region boasts a significant airport, inter-city ferry service, and outer suburb transit options.

Boston city government operates training programs utilizing federal workforce training system funds. Local training programs focus on inner-city youth and low-wage workers. MassHire, a downtown Career Center is a state-funded training organization that offers a variety of programs, including English as a Second Language and Adult Basic Education. Most of the effort is in upgrading adult skills.[6] The City has implemented policies to promote workforce development and job creation in the industrial sector, establishing partnerships with local businesses and educational institutions to train and support workers in fields like advanced manufacturing, biotechnology, and clean energy. In addition, the city has launched programs to connect

[6] https://masshiredowntownboston.org/training-education/

workers with job opportunities in these growing industries, such as the Boston Career Link program. Labor unions continue apprenticeship programs, but only some positions are occupied competitively. Various other organizations, some philanthropic, some state-sponsored, and others private-non-profit, offer training to youth and adults.

The city has set ambitious goals for reducing greenhouse gas emissions and increasing renewable energy sources and has implemented several policies to promote sustainable practices in the industrial sector. For example, the city has established a green building code that requires new construction projects to meet high energy efficiency and sustainability standards and has launched programs to promote the use of electric vehicles and other clean transportation options.

Industrial land use planning

Boston's industrial zoning policies have played a critical role in shaping the city's industrial landscape. Zoning policies govern land use and development and can promote or inhibit the growth of the industrial sector. In Boston, zoning policies have supported industrial development and regulated industrial facilities' location and operation.

One crucial aspect of Boston's industrial zoning policies is the creation of industrial districts. These districts are designated areas of the city where industrial uses are encouraged and where certain types of development are prohibited. The goal is to create clusters of industrial activity that can benefit from economies of scale and shared infrastructure. A primary example is the Innovation District in the Seaport area, which is home to numerous startups and established companies in fields like biotechnology, clean energy, information technology, and robotics. Another example is the Newmarket Industrial District, located in the majority Black Roxbury neighborhood, which is home to a diverse range of businesses, including food processors, wholesalers, and construction firms.

Another critical aspect of Boston's industrial zoning policies is the regulation of industrial uses in non-industrial areas. Occasionally, industrial uses may be incompatible with residential or commercial development. Zoning policies can be used to restrict the location and operation of industrial facilities in these areas. For example, Boston has established buffer zones around specific industrial uses, such as waste transfer stations, to limit their impact on neighboring communities.

An older program from a previous City administration called Back Streets was meant to help light industrial and commercial companies grow throughout Boston's neighborhoods by assisting with permitting and licensing, real estate development (for example, by connecting companies to Boston Planning and Development Agency (BPDA). [7] In a report published in 2002, the program framed its mission in this way:

> *Boston's economy has successfully made the transition to a broad-based service economy with strong sectors in financial services, business and professional services, health care, education, and tourism; and these sectors are projected to grow most rapidly in*

[7] https://www.boston.gov/economic-opportunity-and-inclusion/back-streets

the coming decade. Boston's strengths in these areas, however, does not prevent it from maintaining its base of manufacturing and other industrial operations jobs, which are often well-paying sources of support to families in Boston's neighborhoods.

Boston is actively working to retain its industrial jobs and attract new ones through its planning and economic development activities. Recent Master Plans for East Boston, Roxbury, and South Boston preserve existing industrial space. At the Marine Industrial Park, the BRA/EDIC is able to provide space at reasonable costs to existing small manufacturing firms and start-ups that employ Boston residents. In addition, the city works with industrial firms which seek to expand their operations in Boston, move into the city, or redevelop "brownfields" to identify and take advantage of city and state incentives.

Blue collar industries will always have a place in Boston's balanced economy, and the preservation of Boston's industrial land, though a small part of the city's land base, is important to maintaining the presence of manufacturing and other industrial operations jobs in the city.

So far, however, the focus of Boston's new Mayoral administration (May Wu was elected in November 2022 is equity and inclusion, especially in housing and primary and secondary (kindergarten through 12th grade (K-12)) education, not promoting urban manufacturing, although this could change.

8. Lessons from field and desk research

This section focuses on lessons from the research, including standard policy and business challenges urban manufacturing faces and a discussion of ten business models that might justify and sustain manufacturing in high-cost, congested urban settings. We illustrate these points with material collected during interviews with local companies and policy-oriented organizations. These challenges and workable business models used to structure the following sections appear to us to be common. We inserted comments from the interviews where appropriate when our interviews touched on these subjects. If there are no comments, it only means that the interviewees did not discuss these topics at particular length. We <u>do not</u> intend this to signal that such challenges are not present. Also, in many cases the material from the interviews outlines solutions to the identified challenges, not examples of the problems. Material from the interviews is in italics.

Common policy and business challenges for urban manufacturing

In our research, seven main challenges for urban manufacturing emerged:

1. <u>High costs</u> (rent, taxes, wages, services, logistics)

a. *A respondent from a real estate development firm that develops industrial properties nationwide mentioned that manufacturing in Boston's Core Region is mainly a "booster" topic (something aspirational meant to enhance the region's image that is presently has little substance) in the urban core because the financial costs are too high. Small-scale production is taking place in Boston's Core Region, but in life sciences, a manufacturing facility costs two times what it costs to build a R&D facility. Property and equipment are expensive, and R&D is more profitable and so can afford these costs, while manufacturing is less profitable and cannot. So at the state level, there has been a pivot to outer "Gateway" cities, mostly beyond the Core Region. The Cities of Boston and Cambridge have been slow to accept this fact.*

b. *A respondent from Forge, a Boston-area non-profit that provides services to start-ups, mentioned that it could be difficult for local manufacturers to work with start-ups because many must be better managed and do not survive. Manufacturers work on very thin margins and cannot easily tolerate irregular or non-payment for services. Forge offers matchmaking and services to make the processes safer for both parties. They help to ensure that the start-ups' balance sheet is in order, that the bill-of-materials (BOM) documentation is complete, and that new products are designed with manufacturing in mind (DFM). At the same time, many small local manufacturers have experienced supply chain disruptions during the Covid-19 pandemic. They have been scrambling to fulfill orders from traditional customers, and hiring manufacturing workers has also been very difficult. Many shops have closed or consolidated with other manufacturing companies – the region's industrial base is continuing to shrink and be pushed farther from Boston's Core Region. All of these trends have made the job of Forge more difficult.*

2. <u>Lack of suitable industrial space</u> in both zoning regulation and existing building stock. This was sometimes alleviated by zoning plans that purposefully carved out space for urban manufacturing. Still, these plans were under constant pressure from developers seeking the use of properties for higher-value uses such as residential and retail.

   a. *A city official mentioned that industrial space is a significant limiting factor and that larger spaces are especially hard to find.*

   b. *According to a respondent from MassBio, finding suitable lab space for its member companies can be challenging. In recent years, fears of running out of lab space have led larger biotech companies like Moderna to acquire larger facilities along the 128 corridors for combined lab space and manufacturing. The Boston city region must also compete with other regions in the U.S. In Maryland, for example, the city of Gaithersburg has active programs to attract biotech companies and lower-cost housing than in Boston's core region.*

c. *Our respondent from a real estate development firm that develops industrial properties nationwide told us that the region has extraordinary outputs in R&D, especially in life sciences, but this has not spilled over into commercial manufacturing. So they are seeing the need for smaller and smaller manufacturing units, on the order of 20,000-50,000 square feet with a few dozen employees. The desire to promote urban manufacturing is there, but the math does not work out. With scale-up, manufacturing mainly shifts to places in States such as North Carolina, Indiana, and Arizona (the Seattle and San Francisco Bay regions are also too expensive). Companies are looking for a combination of low-cost real estate, services (power, water, and sewer), and specific kinds of workers, often coming from two-year colleges with sector-specific programs. Access to specific logistics infrastructure can also be important, such as cold storage or air freight terminals. North Carolina has probably done the best job at providing all this.*

3. Lack or suitable workers.
   a. *According to our respondent from MassBio, the fast-growing biotechnology industry in Boston's Core Region has made it difficult to find lower-level staff. The region is sorely lacking in career awareness and support at the high school level. Listed requirements are often higher than needed, and hiring managers must make adjustments. Labor intermediaries have been necessary, and we are considering working with them on setting realistic job requirements. Unfortunately, staffing requirements at biotech firms can be irregular since many drug programs fail.*
4. Lack of support from government agencies.
5. Pollution and congestion. There is a perception, often deserved, that manufacturing uses create noise, fumes, traffic, other uses. The surging popularity of bike lanes has come with a constituency opposed to the curb cuts needed to service the loading docks familiar at industrial facilities.
6. Environmental justice critiques, where manufacturing's poor environmental record provides ammunition for project critics since urban spaces with available structures and land suitable for industrial zoning tend to be located in or near low-income and communities of color.
7. The need for more affordable housing for production workers necessitates long commutes. Interviewees report many challenges in recruiting workers from close-in neighborhoods, given steeply rising housing and other costs associated with living in our near urban downtowns. Several respondents noted that manufacturing workers tended to travel from lower-cost outer suburbs and complained that public transportation did not run at hours suitable for workers traveling to and from work on early morning or night shifts.

Business model discussion

As we can see, manufacturing persists in the United States, even in high-cost urban environments. Our research asks, why is this the case? To get answers from the small sample investigated by our team (of four city regions with only six interviews in each), we have asked the question in the extreme: *Which business models appear to be viable and potentially* *sustainable in very high-cost and congested urban settings?* We found that urban manufacturing close in to the urban core is necessarily smaller in scale, more agile, and in some cases, more closely linked to innovation, and while it does provide employment opportunities for less educated workers and pathways for entrepreneurship, these opportunities are limited in scale. Nevertheless, urban manufacturing persists. This is true even when industrial space is hard to find, energy costs are high, logistics difficult, and housing unaffordable for production workers. Our research points to ten business models that motivated the interview subjects in the four city regions studied (and, presumably, elsewhere) to continue to engage in urban manufacturing:

1. The first relates to <u>innovation</u>, where production is co-located with R&D and new product development to support the iteration needed for prototyping and initial scale-up. We also note that dynamic innovation systems are usually linked to industries and scientific fields deeply rooted in an urban area. In Boston, it is bio-medicine, medical equipment, and electronics, while in San Francisco and Seattle, it is information technology. In such situations, long delays between product iterations necessitated by the tremendous geographical separation between innovation and production are impractical since manufacturing, and product design engineers often need close contact. In these cases, we heard that new manufacturing techniques and equipment were sometimes needed as part of the innovation process.
    a. *A respondent from Forge mentioned that only 20 % of the small, innovative companies they service require commercial-scale production. There are 7,000 manufacturers in the state of the manufacturer, and about 40% of these are dedicated to contract manufacturing or will provide contract manufacturing services. The role of Forge is to connect start-ups to this local manufacturing base. Our respondent from Forge mentioned that local manufacturing is vital during product development.*
    b. *A respondent from LabCentral, a shared lab non-profit with several facilities in Cambridge, discussed how gene therapy start-ups develop manufacturing processes alongside new products – product, and process development are linked. There are many established ways to do large-molecule drug manufacturing. Complex cell and tissue therapeutics have to develop the manufacturing process alongside the development of the product. Gene therapeutics has been around for a long time, but there are many variables, and the process needs to be optimized.*
    c. *According to a respondent from MassBio, Contract manufacturing organizations (CMOs) make great partners for biotech start-ups. They can help the research team understand how or if the production of a new biological agent will work. They can help solve problems such as drug delivery (getting the agent to the correct part of the body), dosage, temperatures for production and storage, drug tracking, safety, and longevity.*
2. The second relates to companies that need to be close to <u>specialized or skilled labor</u>.
    a. *A respondent from MassBio mentioned that small biotech companies, which form the core of MassBio's membership, want to locate manufacturing close to places with an educated workforce.*

   b. *In addition, some large pharmaceutical and biotechnology companies with laboratories in Cambridge and Boston's Seaport District have larger manufacturing facilities in Boston's Core Region, mainly along the 128 Corridor, including Moderna, Takeda, Bristol-Meyers, and EMD MillaporeSigma (part of Merck Pharma). According to MassBio, biotechnology manufacturing grew 4.5% in 2022, although several drug development failures have also led to recent layoffs. However, high skills are not needed for biotech manufacturing. According to our respondent from MassBio, four-year degrees are unnecessary, and short-term certification programs can be adequate. Biotech manufacturing can provide career paths for manufacturers. The skill set is not very different from food processing: following a recipe, monitoring processes, and tracking both inputs and finished products.*

3. The third is for products mainly produced in low-cost locations but need to be <u>rapidly replenished</u> during unexpected demand surges, such as air conditioners during a heat wave, snow shovels during a winter storm, or apparel and other fashion or seasonal items for which demand exceeds forecasts.
   a. *A respondent at the City of Boston's Office of Economic Opportunity and Inclusion mentioned that some manufacturers are in the city are there for reasons of resilience, responsiveness to customers, and ease of pivoting to new products, and benefit that became evident during the COVID-19 pandemic.*
4. The fourth is for low-volume items with standardized production processes but <u>very high unit</u> prices that do not justify the challenges inherent in distant production, such as machinery and luxury goods.
5. The fifth is <u>custom-made products</u>, such as one-off prototypes or unique crafts or art objects.
6. The sixth is "<u>non-tradable</u>" goods and processing activities for which production and consumption are best co-located and localized. One example that has come up in our research is the development and processing of fresh and specialty food items, either for retail or institutional markets, such as local "farm-to-table" food supply chains.
   a. *A Boston city official mentioned that most manufacturers within city limits were in the food and beverage sector, including makers of hard cider, beer brewers, and spirits distilleries. There are a few cannabis and vegetable growing facilities slated to open soon that want to be known as "urban cultivators" for branding reasons.*
   b. *A very different example from the research is the production of large molecule gene therapeutics, which are sometimes used in the advanced treatments of certain forms of cancer. A respondent from MassBio mentioned primarily in these cases, an essential input for manufacturing is "donor-derived" -- the patient's T-cells (critical cells in the immune system) are extracted, genetically modified to attack that patient's genetically-specific cancer cells, replicated, and re-introduced in the patient's body. In this case, manufacturing must be local so living T-cells are quickly reintroduced and patients closely monitored. Unless a method for creating generic T-cells is eventually developed, producing many gene therapeutics will remain expensive and close to treatment.*

Of course, many other products -- aside from such donor-derived therapies and personal services -- do have the potential to be exported beyond their home region. An example might be recipes or food processing innovations developed in the context of local food systems that can be codified, scaled, and produced in volumes exceeding local demand for export beyond the region. So, a path for manufacturing growth can be from non-tradable to tradable products. This emphasizes the importance of business development, branding, scale-up, and distribution.

7. The seventh is for highly regulated products or products with regulatory requirements for domestic sourcing. This has historically been the case, especially for products for the military and other government purchases. However, in recent years domestic production requirements have been extended to a broader range of materials and products, such as those used for infrastructure projects. While there are many reasons to locate these new investments outside of existing high-cost industrial regions, such as those listed above, there may be reasons, such as those listed here, to do so. In addition, the availability of funds from the Federal Government to support domestic manufacturing can provide opportunities for local actors (states, counties, cities, universities, and industry groups) to gain access to new funding to support local industrial ecosystems, especially if there are viable industries or even the remnants of dying industries present in the region.
8. The eighth is legacy manufacturing plants that have operated for many decades. The company often owns the real estate, processes are stable, and older machinery is fully amortized. Such activities can be characterized as "hanging on," however. Unless industrial zoning is explicitly protected, they are under constant pressure for redevelopment for higher-value land uses, such as housing or offices.
9. The ninth is for products where there is an imperative to shrink the geography of supply chains to reduce their carbon footprint.
    a. *A respondent from Forge noted that one reason to produce locally is to decrease carbon footprint.*
10. The tenth is for companies seeking to avoid offshoring costs beyond unit prices: tariffs, shipping delays, hidden management costs, and quality problems that increase scrap and rework costs can be expected when manufacturing is sourced internationally. Unexpected supply chain disruptions have been especially pronounced in recent years, leading buyers to look for manufacturers closer to end use (nearshoring and reshoring).
    a. *A respondent from Forge mentioned that many start-ups source manufacturing services internationally to lower costs. They show them savings regarding tariffs, overhead, shipping costs, and management problems. Supply chain disruptions have been very evident lately. Proximity has de-risking benefits.*

Low volume, high mix, and shared production

The general (non-scientific) impression from across the four case studies conducted by our team is that the most viable form of manufacturing in high-cost urban areas tends to be low-volume, small-scale, and with modest employment benefits. The norm is lower productivity and less effective utilization of equipment. A possible exception uncovered in the research is medium-volume facilities which produce a high mix of items. Such facilities can support all of the roles outlined above except for legacy manufacturing, which is, by definition, non-replicable. In high-mix production environments, manufacturing output can be substantial, but production runs for any one product will tend to be relatively short. The challenge is to keep capacity utilization high in the face of varying requirements. This is more than just a matter of equipment utilization. For example, materials managers in high-mix environments must coordinate the flow of various inputs (materials, parts, and components), and machinery must have fast set-up times and flexible tooling. High variability means that high-mix manufacturing resists automation. While there is a range of newer technologies aimed at increasing the productivity of high-mix production, such as cobots, 3D printing, manufacturing resource planning, and other business process software aimed at streamlining high-mix production, they remain expensive and unproven, and adoption rates are low in smaller manufacturing companies (Waldman-Brown, 2020). Advanced manufacturing can also elevate the importance of a high-quality workforce, but with better-trained workers comes the additional challenges of availability and high costs. It is common for only a few business functions to be carried out within the urban area, such as final assembly and last-minute configuration, and those functions that benefit from proximity to R&D (e.g., prototyping).

The general impression from our research highlights two types of manufacturing that persist in high-cost urban environments that are both beneficial and sustainable: manufacturing related to innovation and production of non-tradable, particularly specialty foods. This is because these types of manufacturing are less cost-sensitive than higher-volume production and because there are social benefits beyond manufacturing employment to be garnered, such as supporting innovation and a diverse population of entrepreneurs. One promising avenue for scaling suitable diverse products and pathways for entrepreneurship is shared facilities, either in not-for-profit accelerators or for-profit contract manufacturers. These facilities can offer certifications, share the cost of plant and equipment, and offer various ancillary services, such as business consulting, design assistance, pooled purchasing, and help to find customers and marketing.

- *An example from the City of Boston is Commonwealth Kitchen, a shared small-batch food producer, co-packing facility and small business incubator located in an old meat processing plant in Dorchester's low-income, historically Black neighborhood. The company has three business models. The first is to provide manufacturing and co-packing space for local food start-ups with clientele that want to scale beyond home production. Since, these companies rarely aspire to build national brands, Commonwealth Kitchen can help them overcome the challenges of obtaining certifications and purchasing and efficiently utilizing expensive equipment. However, it is difficult to find food processing equipment that is flexible and suited for low-volume, high mix production. An example is food items from diaspora communities appropriate for sale to local schools with high percentages on immigrant students. The second is to connect local food producers and institutional food service customers such as hospital, public school, and university cafeterias. The third is to help local farmers to develop private-label recipes for excess "bumper" yields. This can provide extra income to farmers from crops* *that would otherwise go to waste. Farmers can sell their farm branded products at their own farm stands and at farmer's markets.*

- *MassBio also provides pooled purchasing for its membership.*
- *LabCentral is a shared lab non-profit with multiple locations in and around Cambridge. The first facility was at 700 Main Street, which opened in 2013 and was meant to serve early-stage companies spinning off from university research. The duration for start-ups is two years, extendable to three years. Two additional facilities have been established in the Kendall area, near MIT. Each space is a bit different, for example, LabCentral 610 and LabCentral 238 are "graduation space's" meant for companies that have moved beyond initial start-up but are not yet ready for commercialization. All companies are in the pre-clinical trial stage of development. Companies engage in drug development, including manufacturing process development. They use instrumentation and equipment provided by LabCentral, some of which is donated by equipment manufacturers seeking to establish relationships early on with these high potential life sciences companies. The LabCentral 238 facility has a 'library' of process development equipment companies can use on loan. The idea is 'try before you buy.' They have gas hookups, furnishings, and lab benches to support easy adoption of this process development equipment which is often expensive and can have long lead-times, so this accessibility is a huge advantage to evolving startup needs.*
- *The 'graduation space', LabCentral 610 and 238 house larger companies, with 20-30 people, and more funding. These spaces offer less shared equipment as individual company throughput dictates that they bring in their own equipment. According to a respondent, LabCentral tries to foster community with a calendar of events such as science talks and education, book clubs, cultural impact events, art exhibits and have a mentorship program. They are partnering with an education services firm to offer a 'mini-MBA' to build founder management skills. Funding comes from sponsors such as Astellas Pharma, a Japanese multinational pharmaceutical company that committed $12.5 million to the LabCentral 238 facility.*
- *A respondent from MassBio told us that biotech start-ups often want to work with specialized contract manufacturing organizations (CMOs) located nearby. In addition, batches of cells need to be produced for clinical trials, which can be small, medium, or large-scale. Contract manufacturing organizations in or near Boston's Core Region include COGMEDIX (Worchester), STC Biologics (Newton), Symbiosis Pharmaceutical Services (Kendall Square), National Resilience (Allston), and Wuxi (near Worchester). Lonza, located in Southern New Hampshire, is a CMO supporting both large and small biotech companies. In drug development, small reactors of about five liters is enough, but the production scale rises to 200 liters for clinical trials.*

- *However, when drug production moves to a very large scale, it often progresses to another state, such as North Carolina or Puerto Rico. Large-scale production has been commoditized, and skill requirements are low. Still, MassBio believes that the State of Massachusetts has the potential to capture more of this work, especially in Gateway Cities (mostly located outside Boston's Core Region). The company has an office at the facility and is on the selection committee. Larger companies acquire many successful start-ups and move production to existing facilities located in Boston's core region and, most commonly, elsewhere.*

When shared facilities work as they should, the next challenge comes when successful products need to scale past the high-mix setting to dedicated medium-volume facilities.

Again, a general (non-scientific) impression from the four case studies conducted by our team is that in high-cost-urban settings, industrial property and workforce shortages often force these firms to relocate outside the urban core.

- *A respondent from MassBio told us that it is common for larger companies acquire successful start-ups and move production to existing facilities located in Boston's core region and, most commonly, elsewhere.*

Nevertheless, reliance on R&D and start-ups can be sustainable if there is a steady flow of new products, new entrepreneurs, and small businesses focused on scaling the production of manufactured goods. However, fostering a robust pipeline of new companies and products requires specialized financial and educational resources focused on manufacturing entrepreneurship. If manufacturing is to be captured in the region, it also requires a sustained focus on urban manufacturing by city and state-level policy-makers, which is often lacking as political regimes change and the demands of industries better suited to high-cost urban settings take precedence.

9. Concluding remarks

Boston's Core Region may not have much time to protect its industrial character. A recent report by the Metropolitan Area Planning Council of Eastern Massachusetts indicates the state is losing industrial land (MAPC, 2023. Land, Economy, Opportunity: Industrial Land Supply and Demand in Greater Boston). Land for industrial development declined by 3.5% in the last decade, while utilization of available industrial space went up from 89% to 95.6%. Surplus is almost used up, as measured by a vacancy rate of 4.4%. The state and the city of Boston are now facing the challenge of identifying existing under-utilized, underperforming, accessible, and easily convertible industrial space. [8]Most of this land is outside of Boston's core region in the so-called "Gateway Cities," former industrial cities encumbered by old mill buildings and early 20th-century moribund industrial parks. This type of real estate is costly to rehabilitate and sometimes far from the core region, beyond the 128 beltway and, increasingly, the 495 beltway. However, revitalization of manufacturing in these cities can solve several problems at once. It can

[8] https://www.msn.com/en-us/money/realestate/housing-pressures-squeezing-industrial-spaces-report-warns/ar-AA17PhTC0

provide jobs for local residents in places they can afford to live, decrease traffic congestion and commute times for workers that would otherwise need to travel closer to the urban core to work.

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Montreal – Promoting Urban Economic Development – with possible lessons for Vienna

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

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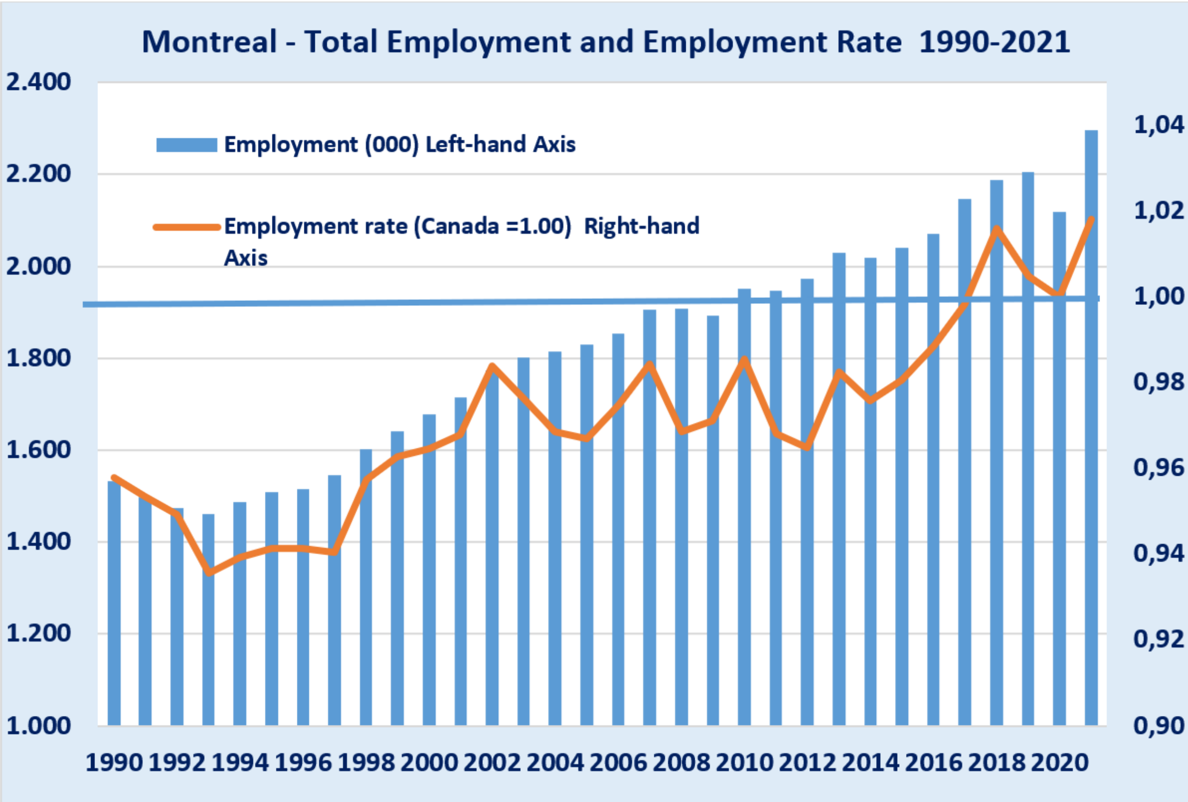
1. Preface

This paper is part of a broader study - *Potentials for new export-oriented production for large cities with a high quality of life: focus on North America* - coordinated by the Austrian Institute of Economic Research (WIFO) and funded by the City of Vienna. The object of the full study, which includes case studies for five other metropolitan areas in the US and Canada, is economic development, strategies that allowed the various cities (metro areas) to renew their economic base. What are the new successful export industries (in this case, in Montreal) and how are potential conflicts with quality of life managed? Can Vienna learn anything from Montreal?

In keeping with this research mandate, a large portion of the case study is given over to stories of particular "successful" export-oriented firms and to documenting the transformation of Montreal's economic base. The study area is the region; that is, the Montreal CMA (Census Metropolitan Area) as delimited by Statistics Canada, which essentially corresponds the region's commuting shed. The term "City", capitalized, is used when referring to the City of Montreal, the region's central municipality. Unless otherwise mentioned, all data presented is for the Montreal CMA. The study also draws on structured interviews with selected public and private sector actors.

Although primarily a research study, I have also attempted to tell a good story. Like other cities, the story of Montreal's economic resurgence cannot be divorced from its past. Specifically, as we shall see, Montreal's story cannot be divorced from its position as the center of a cultural island in North America.

Figure 1.1: Montreal - Total Employment and Employment Rate 1990-2021



2. Introduction

At the time of writing (September 2022), Montreal's unemployment rate was 4.9%, an all-time low. All vital signs point to a strong urban economy, despite an impending recession. Employment has grown consistently since the mid-1990s, the employment rate now above the Canadian average[1] (Figure 1.1).

It was not always so. Montreal in the 1970s and 1980s was a city in economic decline. Montreal lost its title as Canada's largest city as jobs moved to Toronto, today Canada's corporate and financial center. But, Montreal rebounded. It literally reinvented itself. To understand why Montreal declined and why it has since sprung back, we must begin with its unique position as the metropolis of a cultural island in North America[2].

Language and early growth

Montreal is the only major metropolitan area in North America where English is not the dominant language. Montreal is located in the Canadian Province of Quebec, which defines itself

[1] Note the sharp downturn in 2020, the beginning of the COVID19 pandemic, and subsequent upturn.

[2] Table A-1 (Appendix) presents selected statistics for Montreal compared to six North American metro areas.

as a nation, its legislative assembly appropriately called the National Assembly[3]. French is the province's official language, the language of over 80% of the population. Some 70% of Montrealers (CMA) have French as their home language, 17% English, with the remainder divided among various immigrant languages, Spanish and Arab the most prominent. Some 56% of the metro population speak both major languages, making it a *de facto* bilingual city.

Montreal owes its growth, which took off in the mid19th century, to its favorable location at the mouth of the St. Lawrence River, the farthest inland port on North America's East Coast, the natural break-bulk point for east-west trade. Montreal emerged as Canada's dominant manufacturing and financial center. Part of the British Empire (Canada was conquered by Britain in 1760), Montreal's corporate elite was overwhelmingly Anglo-Scottish, a situation that would endure well into the 1950s. Without wishing to oversimplify, Montreal's social structure was typically colonial, a "backward" Catholic French working class dominated by an Anglo-Protestant business class. Many French Canadians saw the Church, as much as English dominance, as the cause of their backwardness. Be that as it may, this unequal relationship could not last.

Political upheaval, economic decline, social transformation

What followed can only be described as a revolution, albeit a largely peaceful one, appropriately refereed to since as the "Quiet Revolution". The two decades of the Quiet Revolution (roughly 1960-1980) laid the foundations for Quebec's other distinguishing trait: its social-democratic (some would say socialist) politics, making Quebec an outlier in North America, closer in many respects to Western Europe[4]. Montreal today is arguably the least unequal metro area in North America, also the safest, and among the densest (Table A 1). This outcome is no accident, but the result of policy choices whose roots go back to the 1960s (see **Governance**).

The authors of the Quiet Revolution sought to correct two centuries of perceived injustice, bringing Francophones up the level of Anglophones, economically and socially. Education was seen as key. The new Liberal Government elected in 1960 took the school system out of the hands of the Church, raised the age of compulsory schooling, and modernized the educational system (see ***Human Capital***).

The second key to erasing the Fresh/English inequality was industry. The new government nationalized power companies, creating Hydro-Québec[5], subsequently launching a massive program of dam construction in the North, Hydro-Québec to become one of the largest hydropower companies in the world[6]. Hydro-Quebec, headquartered in Montreal, became a symbol of French Quebec's newfound sense of entrepreneurship and technical prowess, launching pad for spin-offs in engineering and related fields (see ***Economic Structure***). This period also saw the creation of the *Caisse de dépôt et placement du Québec* (simply, *Caisse*) to manage all public and parapublic pension plans, to become one the largest pension fund managers in

[3] *Assemblée nationale* in French.

[4] Quebec's after-tax Gini coefficient for 2019 was 0.282, which puts in the same class as Austria (0.274) and Sweden (0.280), well below the United States (0.395). Several factors account for Quebec's Gini coefficient: among which its progressive income tax structure and relative absence of incomes at the top. Sources: OECD (2022); Stat Can (2022).

[5] I shall make a frequent use of hyperlinks, notably when referring to institutions and firms.

[6] Reportedly the third largest https://www.nsenergybusiness.com/features/largest-hydropower-companies/.

North America, with a total current portfolio close to $400 billion. Like Hydro-Quebec, the Caisse acted as a role model and nursery for emerging firms, as well as a welcome source of capital.

However, this did not halt the rise of Quebec nationalism[7]. The culmination of this tumultuous period was the election in 1976 of the separatist *Parti Québécois (PQ)*, which promised a referendum on independence. The PQ introduced new language legislation making French schools compulsory for immigrants, French the language of public signs, and for firms above a given size. The reaction from the English-speaking population, not least the business community, was predictable. Hundreds of businesses left the city, generally moving to Toronto[8]. It is estimated that some 200,000 Anglophones fled Montreal between 1966 and 1986, many highly educated, a loss in human capital and talent the city could ill afford.

Starting in 1970s the Montreal economy went into a tailspin with unemployment in the double digits. The shock was further compounded by bad decisions, the construction in 1974 of a second (unnecessary) airport, Mirabel, since closed, causing Montreal to lose its hub function[9]. As if this was not made enough, de-industrialization ravaging all urban economies at the time, provoked further job losses[10]. It would take two decades before Montreal recovered. The transformation was as much social as economic, to which we now turn.

[7] The 1960 saw the emergence of the FLQ (*Front de Libération du Québec*) which would be called a terrorist organization today, fortunately short-lived, which disbanded in 1970 after the brutal assassination of a Quebec cabinet minister and intervention of the Canadian army.

[8] The *Conseil du Patronat* at the time recoded 263 head office relocations during the years 1977 and 1978, nearly all to Toronto.

[9] For Montreal's airport fiasco see Polèse (2020): p. 187. Turning misfortune into good fortune, the site has since been reinvented as Aerocity of Mirabel, a business park, now the home of numerous firms in the aerospace industry.

[10] Montreal lost some 100,000 manufacturing jobs between 1981 and 2011.

Table 2.1: Governance Structure [Greater Montreal]

ENTITY/ ORGANIZATION	COMPOSTION/ ATTRIBUTES	MANDATE	ADDITIONAL INFORMATION
City of Montreal	19 Boroughs. 12 were separate cities before amalgamation in 2002.	Police, transit, roads, water, waste, parks & recreation.	Elected mayor and council. 19 Borough councils & mayors. 2022 Budget: $CN 6.46 billion
Agglomeration Council	Montreal Island. City + 15 linked municipalities. (Created 2004).	Property tax assessment. Authorizes spending on shared services.	De facto controlled by the City, which accounts for 87% of Island population (and votes).
Montreal Metropolitan Community (MMC)	82 municipalities of the Greater Metro Area. (Created 2002).	Essentially a planning and coordination mandate.	Chaired by the mayor of Montreal. Council of 28 elected municipal officials
Montreal International	Regional economic promotion agency (Created 1996).	Attracting FDI, entrepreneurs, students. Prospecting, marketing.	Co-financed by private sector and three levels of government.
Chamber of Commerce of Metropolitan Montreal	Business advocacy organization (first founded 1821).	Networking, mentoring, training. SME promotion	All major business belong. Active regional player.
Autorité régionale de transport métropolitain (ARTM)	Regional transport Authority (Created 2017).	Oversees financing and organization of local transit services.	A provincial entity with a majority non-elected board. Still not totally functional.
Aéroports de Montréal (ADM)	Local airport authority (Created 1992)	Manages Trudeau International Airport and Mirabel Aerocity	Federally chartered corporation, independent board of directors, self-financing
Port of Montreal	Local port authority (Created 1998)	Owns and manages port installations.	Autonomous federal agency, self-financing.

3. Governance Structure

Montreal's metropolitan governance structure (Table 2. 1) as well as the demographic weight of the City (Table A 1) set it apart from other metro regions in North America. However, the City has only limited economic powers; it cannot directly subsidize firms. The Province (i.e. Quebec) is the dominant actor, administering a broad range of programs (i.e. tax credits, direct equity participation, etc...) about which more will be said later. The Montreal CMA accounts for over half of Quebec's GDP. The Province's programs are, as such, *de facto* also metropolitan programs, often implemented via regional structures such as the MMC (Table 2.1).

Montreal is also distinctive in the non-partisan nature of politics, municipal political parties separate from national and provincial parties, facilitating dialogue between different tiers of government. Montreal's three tier governance model (City/Agglomeration/MMC) has evolved over time, a reflection of the Province's power (and willingness) to change structures. Under the Canadian constitution, local authorities (cities, municipalities…) are creatures of the provinces with no separate constitutional existence. City boundaries and powers are defined by the provincial legislature, which can create and abolish "cities" at will. This three-tier model is the outcome of political compromise, a tug-of-war between the City's wish to expand its borders, the understandable resistance of smaller municipalities to amalgamation, and the need for shared financing mechanisms for a constantly expanding city-region, the Province the final arbitrator.

To understand how Montreal's model evolved, we must return to the Quiet Revolution's interventionist and social democratic legacy. All governments since have sought to ensure a minimal level of territorial equity. As the urbanized area expanded, the Province has stepped in on several occasions to minimize inter-municipal fiscal competition and impose shared financing of public services. Ensuring the fiscal health of the City of Montreal is a parallel consideration. In the end, the Province is the City's *de facto* fiscal underwriter.

The Montreal Urban Community (MUC) was created in 1969, grouping the 28 municipalities of the Island of Montreal, public transit and policing the chief items of shared financing. Predictably, the urban area continued to expand. By the year 2000, Montreal Island accounted for only half of the regional population. Also, Montreal's economic woes (see above) created strong pressures for reform. Metropolitan structures were seen as a necessary step for ensuring Montreal's competitiveness. At the federal level, the port and airport were transformed into autonomous corporations. The Province created Montreal International, a public-private partnership, in 1996 and the new Metropolitan Chamber of Commerce was launched in 2001.

The MUC was disbanded in 2001 to be replaced in 2004 by the three-tier model currently in place. This governance model, imposed by Quebec, was the object of hot political debate at the time. Island mayors who would lose their municipalities strongly opposed proposed amalgamation with Montreal, which was nonetheless implemented. But, in a subsequent referendum 15 mainly small municipalities voted to de-amalgamate. In the end, 12 Island municipalities were amalgamated into the new City of Montreal, doubling its population and land area. The 15 de-amalgamated municipalities (13% of the Island population) were, however, fiscally linked to the new City creating the Agglomeration Council, which for all practical purposes is an extension of the City, creating an integrated space for Island-wide public services (see map, Figure A 1).

At the wider regional level, the Montreal Metropolitan Community (MMC), created in 2002, was initially viewed as a toothless talking shop, a view that has since proven to be overly simplistic. The 82 municipalities of the MMC adopted a *regional spatial development plan* in 2012, defining growth corridors and common density, transit, and environmental goals and, more recently, a *metropolitan economic development plan*[11] (see **City-Regional Strategies**).

Montreal's governance model is far from perfect. Inter-municipal tensions persist. The integrated management of public transit remains a challenge. The three-tier model means overlapping bureaucracies and often cumbersome decision-making[12]. That said, Montreal's governance model has helped maintain of a more "equal" city-region. Public service quality does not vary significantly across municipalities, avoiding the center-city/suburban social divides that plague many U.S. metro regions[13]. This has undoubtedly contributed to what I call a regional culture of dialogue (to which I shall return), without which it is doubtful that Montreal would have rebounded as fast as it did.

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[11] CMM (2022). Not yet on-line, since only recently adopted. PDF available from the author on request.

[12] Indeed, the portrait I have painted is overly simple. Other overlapping structures exist, notably Regional County Municipalities (MRC in French), groupings of municipalities, imposed again by Quebec, that share certain services.

[13] Note also, unlike the US where education is generally dependent on local tax revenues, primary and secondary education is provincially funded out of general tax revenues. Thus, the quality of schools does not in principle vary across municipalities and neighborhoods, further contributing to spatial equality.

The fiscal health of the City of Montreal has also allowed it to ensure the continued quality of urban services. In the absence of safe, lively, central neighborhoods, it is doubtful that Montreal would have been able to nurture the IT start-up scene at the heart of its recovery. Some years ago, the author asked the founder of a successful IT firm why he had chosen to locate in a central neighborhood. The answer: "Mario, the kids I hire want to able to go out any time of the day or night to have a coffee or beer". But, here I am jumping ahead of our story.

Table 3.1: Human Capital and Research: Comparative Indicators, 7 metropolitan areas

Metro Area	% Population 25-34 with B.A. 2016	% recent immigrants with B.A 2016	Patent Applications 2015-2019	Journal Publications 2015-2019	Springer Nature Index Science Cities 2017		Univ Student per 10K 2018	Rank of Top University (mean of 4 rankings, Table A 1)
					World Rank	Articles		
Montreal	39.8%	50.1%	2,043	36,766	39	673	468	41
Vancouver	44.6%	51.1%	1,444	24,474	76	465	421	44
Boston	**58.0%**	50.0%	**15,633**	**131,117**	**3**	**3.917**	**648**	**2**
San Francisco	**56.2%**	58.4%	**39,999**	**92,284**	**4**	**3,639**	**645**	**3**
Seattle	46.6%	**60.9%**	11,339	33, 767	29	908	321	40
Atlanta	38.8%	50.0%	1,681	36,767	28	853	315	76
Pittsburgh	48.0%	**74.2%**	1,601	29,598	47	658	413	66

Table 3.2: Montreal: Research Infrastructure. University-level Institutions

Institution	Founded	Students	Foreign	Research $ / Faculty	$ / Graduate Student	Students/ Staff	Publications
McGill Unversity	1821	40,036	32%	$321.20	$60.40	8.1	168,765
Unversité de Montréal (U. de M.)	1878	45,360	23%	$278.00	$35.90	9.1	106,394
Concordia University	1974	43,752	33%	$67.60	$8.30	44.1	31,951
Unversité du Québec à Montré (UQAM)	1969	39,316	13%	$64.30	$9.00	32.1	27, 293
École de technologie supérieure (ÉTS)	1974	8,000		$163.90	$16.60	42.1	7,785
École polytechnique de Montréal	1873	7,00					18,057
Hautes études commerciales (HEC)	1907	13,046					6, 242

Table 3.3: Top Corporate Montreal-based R & D Spenders 2018-2019 ($100 Million+)

Corporation	R & D Spending ($Million)	Ownership	Industry
Bombardier	$1 472	Quebec	Aerospace
Pratt & Whitney	$552	US	Aerospace
BCE (Bell Canada Enterprises)	$537	Canada	Telecom Services
Bausch Health	$535	Quebec	Pharmaceutical
IBM	$512	US	IT Services
Ericsson	$368	Sweden	Telecom Equipment
CGI	$288	Quebec	IT Services
CAE	$183	Quebec	Aerospace
Hydro-Quebec	$144	Quebec	Power Generation & Distribution

4. Human Capital and Research Environment

Table 3.1 confirms that Boston and San Francisco are in a class of their own in North America, whether measured in terms of scientific publications, degree holders, university rankings, patents, or other metrics of human capital. Those exceptions aside, Montreal compares favourably, on the whole, with other metro areas in terms of research and human capital.

Montreal has four universities (Table 3.2), two French, two English, each with some 40,000 full-time enrolled students. The two older universities, Mc Gill and the University of Montreal, have a full range of graduate programs. Both rank well on various university rankings (Table A 2). McGill often ranks in the top ten outside the U.S. and remains prestigious in the lands of the British Commonwealth from which it draws many students. The University of Montreal, by the same token, attracts a growing number of students from the French-speaking world,

Montreal also counts three specialized university institutions, HÉC, Polythechnique, and ÉTS, plus my own[14]. In addition, Montreal has over twenty colleges, private and public, the latter called Cégeps (*Collèges d'enseignement général et professionnel*) specific to Quebec, emphasising technical, and workplace skills. Montreal has one of the largest student populations per capita in North America, most living in central neighborhoods, contributing to the city's flavour.

Montreal is home to Technoparc Montreal, a science park, ceded to the City in 2008. The idea of creating a science park on the model of Stanford Unversity or Cambridge Science Park was first launched in the late 1980s by a consortium of community leaders, including university rectors, CEOs, and the then president of the Chamber of Commerce. Technoparc Montreal started to formally operate in 1994, welcoming its first company, a pharmaceutical research laboratory, on land expropriated by the then independent municipality of Saint-Laurent, since amalgamated with the City of Montreal. It has expanded since, now encompassing two million m^2 of serviced space, home to some 125 companies and 7000 employees. Companies must have a minimum of 25% of their employees engaged in research. Aerospace is the principal sector, accounting for about 40% of jobs, followed by IT (30%), with the remainder in life sciences (15%) and miscellaneous technologies.

Technoparc Montreal's success can in large part be attributed to its judicious location adjacent to Trudeau International Airport, near the crossroads of the Island's main East-West and North-South highways, and a twenty-minute drive from downtown. Technoparc was thus located in what was already the core of Montreal's emerging technology economy in the centre-west of the Island, anchored by the airport and highways and rail lines leading west: see Figure A 2 in the Appendix. Technoparc's management structure has changed over the years. It was administered from 2008 to 2019 by a non-profit corporation, receiving an annual operating subsidy from the city (about $2million US). Management came under attack in later years for not being sufficiently aggressive, Technoparc's profitability further hampered by the

[14] INRS (Institut national de la recherche scientifique), part of the University of Quebec system, with three research centers in Greater Montreal.

absence of a direct link with public transit. Management was transferred to the City in 2019, giving elected officials direct oversight[15].

Along the same lines, much research is carried out in-house, although not necessarily only by firms located in science parks, aerospace again a notable example (Table 3.3). Bombardier, the matriarch of Montreal's aerospace industry[16], whose main plant predates Technoparc Montreal, is however located nearby. Pratt & Whitney, on the other hand, is located on the South Shore (easily identifiable on Figure A 2[17]). Aerospace is also an example of post-secondary education and research programs developed in conjunction with industry. Cégep Édouard-Montpetit is home to the *École nationale d'aérotechnique*, reportedly the largest college-level institution for aviation technology in North America, with some 1300 students.

Montreal's research culture, both in industry and in academia, does not differ markedly from the rest of North America. If my own experience is any guide, Montreal's universities offer a generally supportive environment for research, although teaching loads vary, which in part explains the lower funding ratios for the two younger universities (Table 3.2). The culture of Montreal's universities is by and large informal and open to outsiders. Canada, like the U.S, has a system of research granting councils[18]; Quebec also has its own granting council[19].

However, two distinctive features warrant mention. First, language. The dominance of French is both an advantage and a disadvantage. It is a disadvantage, specifically in North America, for recruiting top talent, to which one may add cold weather and high-income taxes. On the positive side, Montreal's linguistic distinctiveness makes it attractive to Francophones and Francophiles, domestic and foreign, which however is a comparatively limited recruitment pool. Also on the positive side, public investments in education are less likely to be lost, students (at least in the French sector) less likely to leave for greener pastures, a point to which I shall return.

Second, Quebec's approach to education is arguably the most democratic in North America. University tuition for residents is the lowest on the continent and *Cégeps* are free. The school system was totally reformed after the Quiet Revolution, abandoning the old classical curriculum, to which we may add subsidized childcare and pre-school learning. The evidence suggests that Quebec's education reforms paid off. Results on international PISA evaluations for 15-year-olds for reading, math, and science puts Quebec in the top classes with East Asian and Scandinavian students, above, for example, the United States and Austria[20].

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[15] Montreal has other techno parks, notably Technopole Angus, a mixed-use residential business park, built on the grounds of an abandoned rail rolling stock manufacturing plant. The University of Montreal has also recently completed a science campus, built on land left vacant by an abandoned rail yard.

[16] More correctly, the matriarch is Canadair, a crown corporation founded in 1944, whose facilities were bought by Bombardier in 1986.

[17] Note that the right-hand table gives 6,625 aerospace jobs for Longueil, the location of Pratt & Whitney, both its production and research facilities.

[18] The three federal granting councils are: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Canadian Institute for Health Research (CIHR). https://cihr-irsc.gc.ca/e/193.html

[19] Fonds de recherche du Québec, with separate sections for the natural sciences, health, and the social sciences.

[20] Source: CMEC (2019). I found no comparable source for U.S. states.

To conclude, there is little doubt in my mind that Quebec's educational reforms were a necessary precondition for Montreal's resurgence[21]. This was no less than a cultural revolution, a change in mindsets, transforming a society which historically eschewed business into a one that prizes entrepreneurship. Many firms at the heart of Montreal's economic recovery, we shall see, did not exist two generations ago[22].

Table 4.1: Montreal: Employment structure 2019

*Compared to Canada

NAICS		**Employment**	%	**LQ***
11,21	Agriculture, forestry, fishing, mining	9.900	0.4%	0.14
22	Utilities	13.000	0.6%	0.80
23	Construction	112.800	5.1%	0.66
31-33	Manufacturing	237.800	10.8%	**1.18**
41	Wholesale and retail trade	348.200	15.8%	1.06
48,49	Transportation and warehousing	134.300	6.1%	1.11
51,52	Finance, insurance, real estate, rental and leasing	150.100	6.8%	1.07
54	Professional, scientific and technical services	225.100	10.2%	**1.26**
55, 56	Business, building and other support services	103.700	4.7%	1.16
61	Educational services	158.500	7.2%	1.00
62	Health care and social assistance	296.600	13.5%	1.02
71	Information, culture and recreation	109.800	5.0%	**1.24**
72	Accommodation and food services	122.500	5.6%	0.87
81	Other services (except public administration)	85.900	3.9%	0.91
91	Public administration	96.800	4.4%	0.83
	Total	2,205.000	100.0%	.

5. Economic Structure and Change[23]

Montreal's recovery entailed a major restructuring of its economy. Table 4.1 shows the distribution of employment in 2019 by major sector[24]. Manufacturing and tradable information-rich services exhibit the highest location quotients[25], the two pillars of its export base, whose relative weight is now reversed (Figure 4.1). Like other metro areas, Montreal saw major job losses in manufacturing, but which were largely compensated by growth in tradable information-rich services as well as services dependent personal contact (health, education, hospitality). Figures 4.2 and 4.3 show job changes (largest absolute losses and gains) by industry between 1991 and 2016.

[21] Note that UQAM and ÉTS (Table 3.2), plus INRS, were founded during the years of the Quiet Revolution.

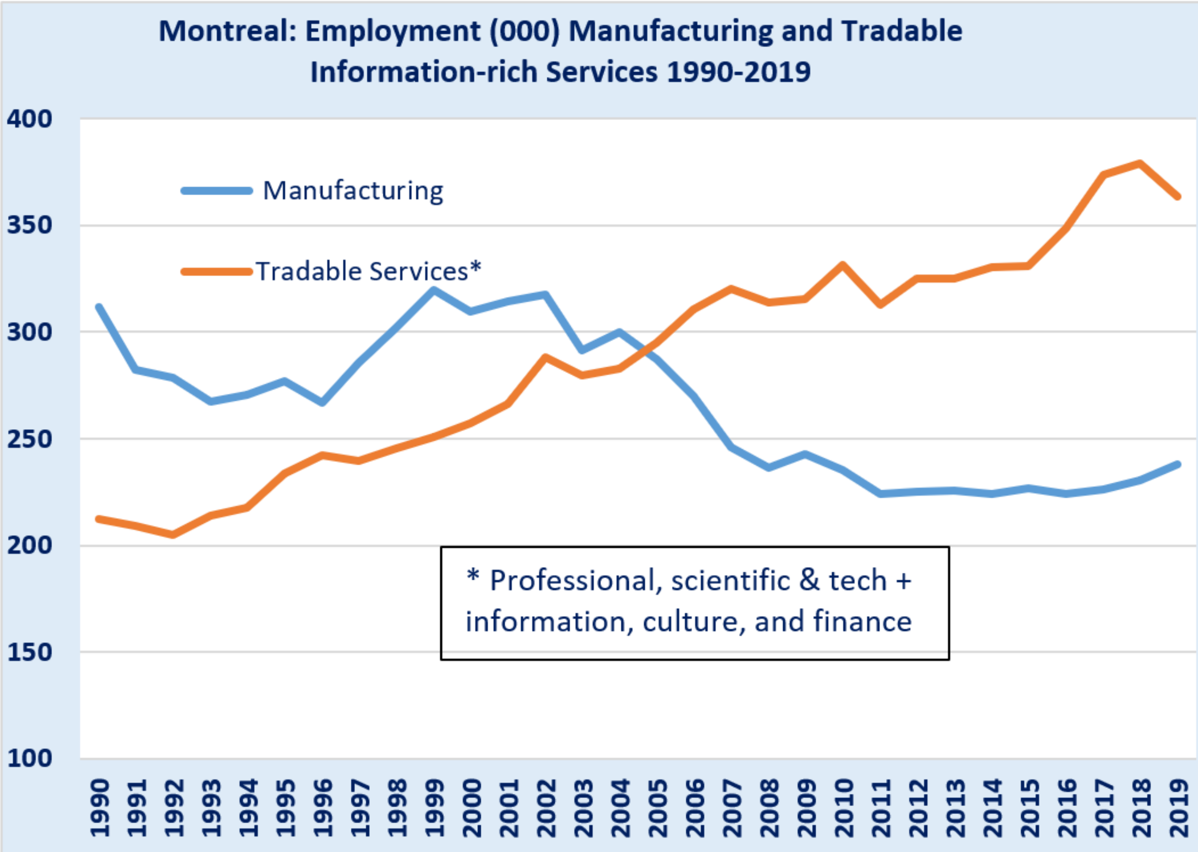
[22] The current Premier of Quebec, François Legault, proudly vaunts his business background, co-founder of Transat, a tourist airline. For more on Quebec's entrepreneurial revolution, see Polèse (2019)

[23] "Montreal" in all tables and figures refers to the Montreal CMA (Census Metropolitan Area). "Employment" refers to all employed persons at the time of the survey (Table 4.1 and Figure 41.1) or of the census for all subsequent figures.

[24] I have stopped at the year 2019, to exclude the sectoral impacts of the COVID 19 pandemic, which notably affected the accommodation, food services, and recreation industries.

[25] The reference point for calculating Locations Quotients (LQ) is Canada for Table 4. 1 and urban Canada for Figures 4.4 and 4.5, because taken from different data sources, Statistics Canada Labour Survey in the first case and the Census in the second case. The second provides, in principle, a sounder base from which to deduce export orientation.

Figure 5.1: Montreal: Employment (000) Manufacturing and Tradable Information-rich Services 1990-2019



Continued strong manufacturing base

Although declining in relative terms, manufacturing employment has remained strong, hovering between 200,000 and 250,000 in recent years (Figure 4.1).

Figures 4.4 and 4.5 illustrate Montreal's export base expressed in terms of employment in 1991 and 2016. These are admittedly rough estimations; but nonetheless provide a fair picture of Montreal's changing economic base[26]. A short explanatory note on the concept of export base is thus in order. A region's economic (or export) base, in the vocabulary of urban economics, is any activity that brings money into the region, thus supporting local jobs. Thus, government is Washington D.C.'s primary economic base and tourism most probably for Las Vegas. Whether the "export" earnings come from domestic or foreign sources is not relevant in terms of their impact on the local economy. One hundred widgets sold by Montreal firms to

[26] See Appendix for the derivation of Figures 4.4 and 4.5 and discussion of data issues; i.e., comparability of industry classes over time; industry export orientation.

customers in Vancouver are no different from one hundred widgets sold to customers in New York. It is in this light that Figures 4.4 and 4.5 should be read.

Manufacturing's declining weight in Montreal's economic base is largely due to the almost total collapse of the clothing and textile industries, once the mainstays of the economy. As elsewhere, these industries dependant on cheap labour (both immigrant and domestic) fell victim to the competition of developing economies as world trade opened up[27]. The industry was forced to reinvent itself, shedding most of the standardized fabricating stages (including notably almost all textile manufacturing), increasingly focusing on the design end and on niche markets (i.e., winter clothing). Montreal's manufacturing base has shifted progressively towards more knowledge-intensive industries, notably aerospace and pharmaceuticals, plus an eclectic mix of industries, including speciality dairy products and medical instruments.

Montreal's continued strength in manufacturing rests on several factors: (*a*) a major container port; (*b*) low relative wages compared notably to the US; (*c*) low energy costs[28]; (d) location. Montreal is a few hours' drive by truck from major US markets. An exporter of designer clothing once remarked to the author: "I can put my shipment on a truck at midnight and it will be at Macy's (downtown New York) at 6AM. No Asian competitor can match that".

[27] The multi-fibre agreement governing trade in textiles and apparel was gradually phased out in the late 1990s and eventually totally abandoned in 2005.

[28] Average electricity prices in Kw hours for major industrial consumers in 2021 were about half those in Toronto and a third those in New York. This remains one of the Province's (not just Montreal's) chief comparative advantages, specifically for high electricity consumption industries (i.e. aluminum). Thanks to its vast North and numerous rivers, Quebec has a hydroelectric potential, exploited and managed by Hydro-Quebec which we met earlier, with few equivalents in North America. Quebec is a major exporter of electricity to New York State and New England.

Figure 5.2: Montreal: largest employment losses. Principal industries 1991-2016

Figure 5.3: Montreal: largest employment gains. Principal industries 1991-2016

Figure 5.4: Montreal: Structure of Basic (export-oriented) Employment 1991
Green = Service Sector; Brown = Manufacturing

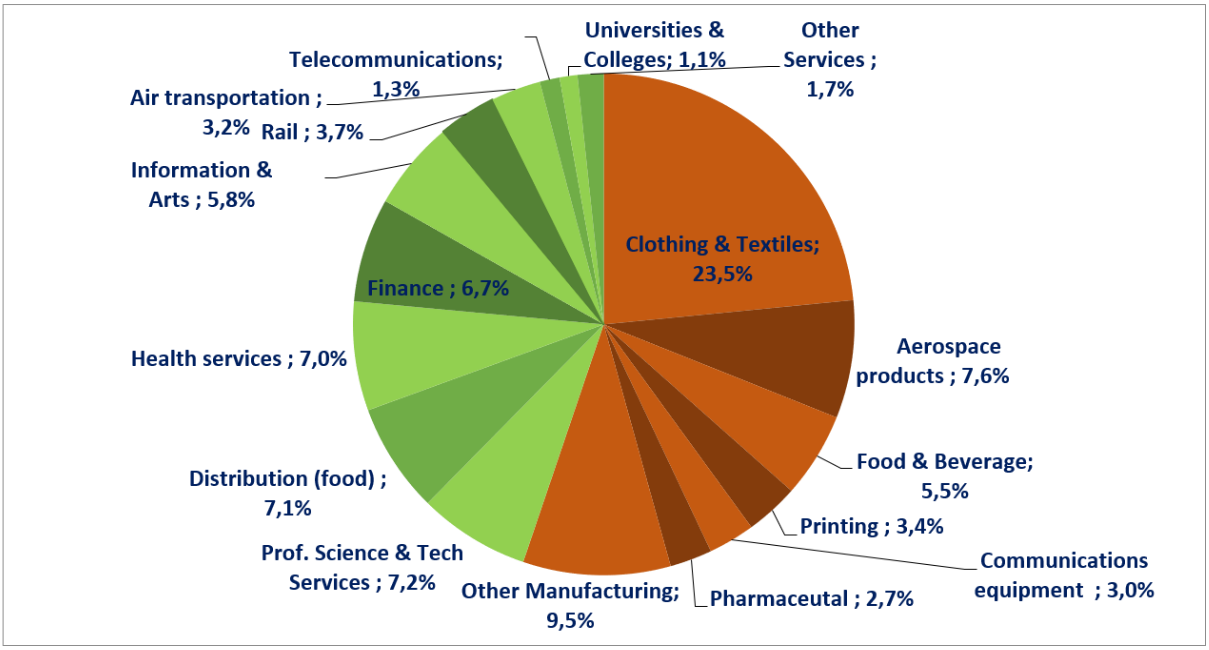
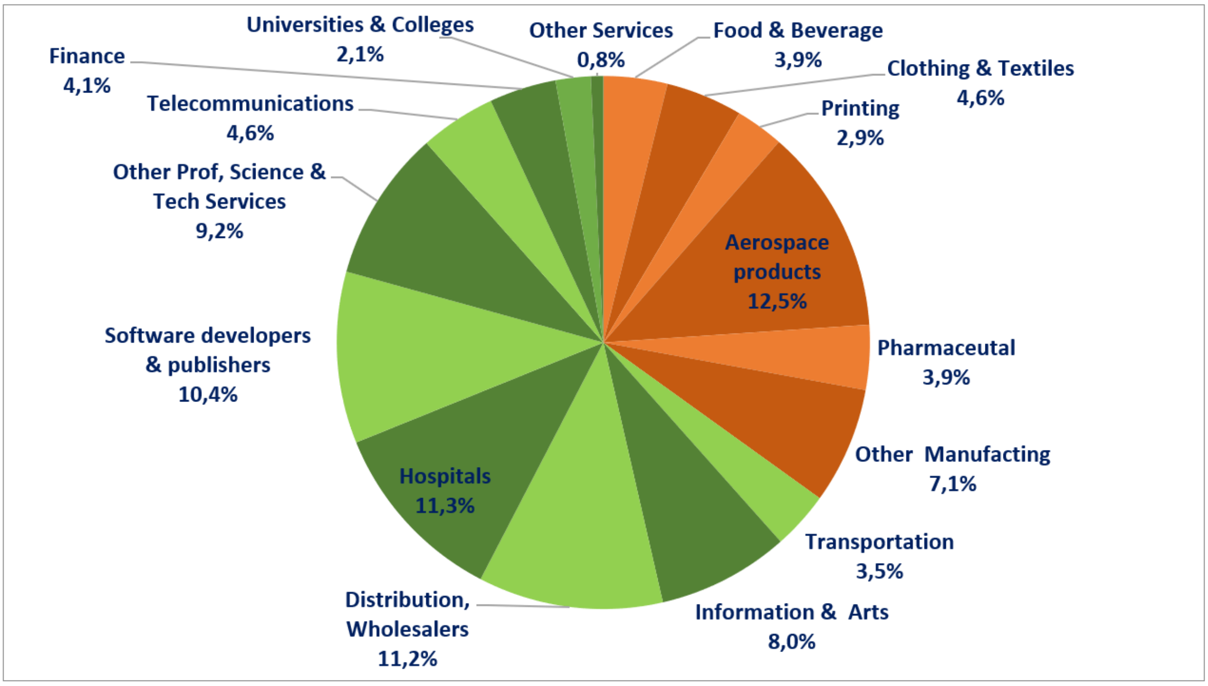


Figure 5.5: Montreal: Structure of Basic (export-oriented) Employment 2016
Green = Service Sector; Brown = Manufacturing



Aerospace: a combination of talent, geography, and chance

Montreal's cost advantage is only half the story. Montreal aerospace industry, the flagship of its manufacturing base, has its roots in the city's engineering legacy, the outcome of geography and political events. As Canada's major port and rail hub until the mid-20th century, Montreal emerged as the manufacturing and repair center for rolling stock with large locomotive works, many now abandoned. The rise, subsequently, of the aerospace industry owes much to World War II. Britain needed airplanes, to be built ideally out of reach of the Luftwaffe. Montreal was the closest city across the Atlantic with the necessary engineering and industrial base.

Many firms active today have their roots in that period. Héroux Devtek, a producer of landing gear, was founded in 1942 by a local engineer.

Montreal's aerospace cluster accounts for some 35,000 jobs today in over a hundred firms, including home-grown giants like Bombardier (business jets[29]) and CAE (flight simulators), plus foreign-owned affiliates such as Airbus, Pratt &Whitney (turbine engines), and Bell Textron (helicopters). Airbus bought Bombardier's jetliner division in 2018, following the latter's failed attempt to enter the wide body market. The new division, Airbus Canada Limited, is a public-private partnership with the Quebec government holding 25% of shares.

The basis of Montreal's aerospace cluster, like all clusters, is critical mass: a talent pool built up over several decades. Government support and public-private partnerships are also part of the story. Aéro Montreal, which dubs itself a strategic think tank, sponsors, training programs, networking events, mentoring, incubators, etc.… In an industry like aerospace dominated by large firms, start-ups will often be (emerging) subcontractors, shortening supply chains. Montreal's aerospace industry prides itself on being able to provide a complete ecosystem for the manufacture, along all stages, of large commercial aircraft.

Aerospace is, in short, an example of the consolidation of a historically strong industry with large established firms. The story of Montreal's software industry, the other flagship of its export base, is somewhat different, and to which we now turn.

Rise of Knowledge-Rich Service Exports

Here again, we need to begin by looking at the historical antecedents.

Engineering and IT Consultancies

Montreal is home to some of the world's largest engineering consulting firms, most home-grown, SNC-Lavalin and WSP Global Inc. prime examples. Both have grown to become multinationals with annual revenues in the order of $10 billion (US) according to the most recent figures and some 50,000 employees each, the majority outside Canada. In each case, foreign markets are the chief source of revenue, in the order 80% for WSP and 75% for SNC-Lavalin (last annual reports), principally outside North America.

[29] Bombardier was also active in light rail, its division since sold to Alstom, a French firm, as part of its recent restructuring.

Like Aerospace, Montreal's engineering consulting sector has its roots in geography and politics. Engineering firms (both consulting and construction) emerged in response to Canada's vast infrastructure needs (roads, rail…). However, the industry truly took off in the 1960s, following the creation of *Hydro-Québec* and ambitious program of dam and hydropower plant construction, among the largest of its kind at the time. Montreal firms became world leaders in the design, construction, and management of dams, power plants, and transmission lines. Language and cultural affinity facilitated the entry of Montreal firms into French-speaking and Latin American markets, North American know-how with a Latin touch, so to speak.

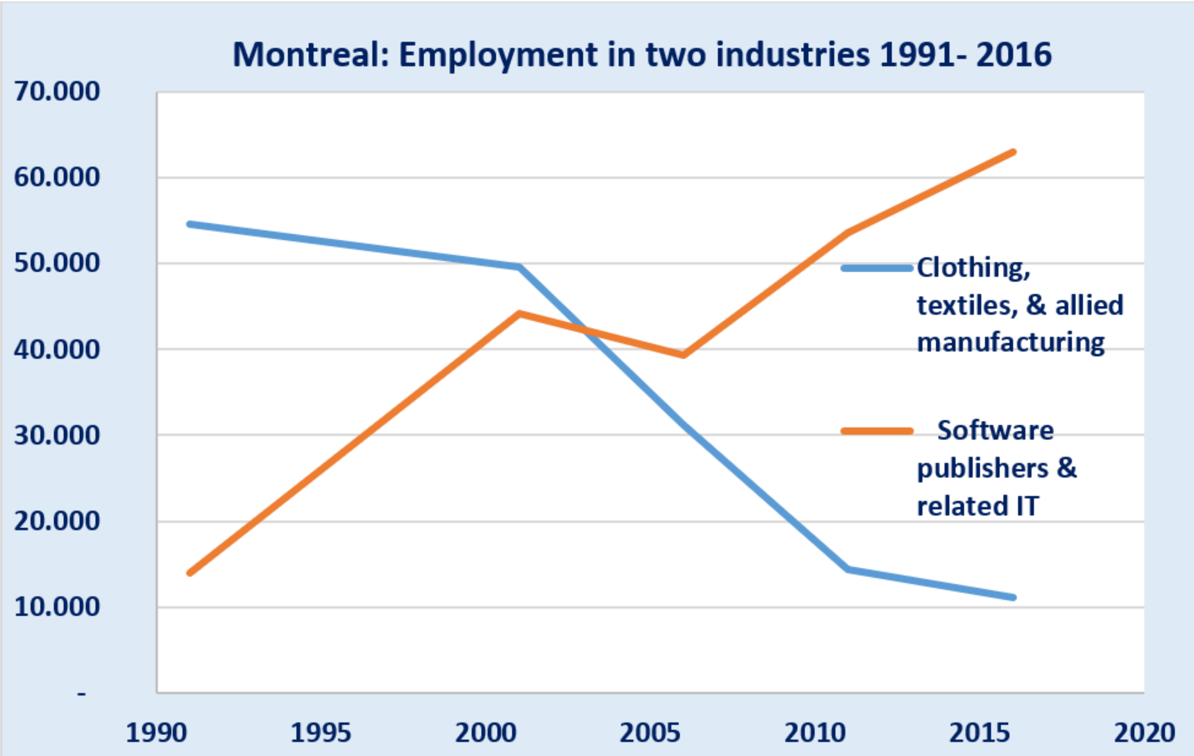
Thus, when the IT revolution took off in the 1990s, Montreal had a waiting talent pool, providing the conditions for the emergence of IT consultancies, CGI a notable example of a home-grown success story[30] with today some 77,000 employees and 400 offices around the world, 85% of its revenues derived from clients outside Canada.

CGI is also an example of a firm whose founders initially started outside Montreal. Here we come to a key attribute underpinning Montreal's resurgence: its position as the cultural capital of French-Canada, its central place in the vocabulary of economic geography. A French Canadian start-up with export ambitions, wherever its founder may live, will eventually set up shop in Montreal, if only for marketing purposes, once it grows beyond a given size. Montreal, in a word, has a captive entrepreneurial pool, different from other North American cities.

The other dimension of Montreal's position as French Canada's central place is a strong arts community, plus a tradition (again, very un-American) of state support for the arts. Montreal is the home of Radio Canada, the largest French-language public broadcaster outside France, as well as private TV, sound, and music studios. Montreal has a thriving movie, advertising, and publishing industry. In short: any French-speaking *artiste* with ambitions will eventually end up moving to Montreal.

[30] CGI originally stood for "Conseillers en gestion et informatique", *subsequently rebaptized "Consultants to Government and Industry"*.

Figure 5.6: Montreal: Employment in two industries 1991-2016



Software publishers, computer gaming - marriage of technology and the arts

When, with the Internet, software publishing took off as an export industry, it should come as no surprise that Montreal found its niche in computer graphics and animation, specifically in the production of video games[31]. The pioneer of Montreal's computer graphics industry is often thought to be Daniel Langlois, a filmmaker, who left the Montreal-based Nation Film Board of Canada in 1986 to found Softimage, which would go on to become a leader in 3D animation, producing special effects for Hollywood blockbuster such Jurassic Park and Titanic, thus establishing Montreal's reputation. The company has since disappeared, its technology acquired by Microsoft, but in turn generated several spin-offs, among which Autodesk and Discreet. Another early example is Strategy First, founded in 1988, since bought by a Florida-based firm, a path typical of this industry with a constant crunching of births, deaths and take-overs.

The crucial turning-point was 1996. Building on Montreal's emerging reputation in arts-based software, the Government of Quebec, in the hope of attracting major international players, introduced a Refundable tax credit for the production of multimedia titles, allowing employers to recuperate up to 37.5% of eligible wage expenditures. The most important catch, cultural

[31] The MMC's Economic Development Plan (to which we shall return below) includes a table with location quotients for Montreal using all of North America as reference point. Montreal's highest quotient (3.63) is for software publishers, NAICS 5112, suggesting a true competitive advantage. CMM (2022), Table Annexe 1.

affinity certainly a factor, was Paris-based Ubisoft, one of the world's top video game publishers. Ubisoft opened a studio in Montreal the same year (initially, 500 employees), since grown to 4,000 employees to become its flagship studio. Ubisoft Montreal transformed the industry landscape, becoming a magnet. Gaming today accounts for some 20,000 jobs and 200 firms, with a constant churning of start-ups and deaths. The wider software industry accounts for over 70,000 jobs, totally compensating losses in the clothing and textile industries.

I have counterpoised (Figure 4.6) the apparel and software industries for a reason[32]. The new IT jobs not only replaced the old clothing and textile sectors numerically, but also physically. Which brings us to the lifestyle and urbanistic foundations of Montreal's software industry. The vast majority of new firms, foreign and home-grown, located in central neighborhoods, often converting abandoned warehouses or textile mills. Ubisoft took over an old textile mill, located in what is has since become one of the city's trendiest neighborhoods, *the* place to be for the Montreal's artistic and intellectual elites, Recalling my earlier quote, the talent on which this "creative" segment of the software industry depends is drawn to a particular urban environment[33], which Montreal was able to provide[34].

Tax credits and urban lifestyle are not the whole story. Other cities can boast similar lifestyles[35]. Other North American cities offer similar financial inducements. What is Montreal's *distinctive* advance? The answer often received from industry actors (including those interviewed for this study) turns on two points: a talent pool with a distinctive creative outlook, but also "loyalty" for lack of a better term. In-house talent, often formed at considerable cost, is less likely to depart for greener pastures. It's not simply a matter of language, but also of shared values, of belonging to a society unique in North America. On the other hand, the need to attract and hold talent from outside the French-speaking world is no less real. English is the de facto *lingua franca* of the IT world. Whether Montreal's linguistic (and social) distinctiveness is on balance an advantage or a handicap for attracting talent remains an open question and a subject of debate.

Specialized university and cégep programs in computer graphics, the visual arts, and specifically video gaming, have multiplied in recent years, consolidating the region's human capital advantage. The Province has also continued to underwrite the industry's cost advantage[36]. The recent evolution of the gaming industry suggests that the bond with the arts will only grow

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[32] The Software Publishing and Related Industries sector includes NAICS 5112 (Software Publishers), 512 (Information and Data Processing), and 5415 (Computer Systems Design). This grouping allows us to produce a consistent sector over time. The same grouping also applies to Figures 4.3, 4.4, and 4.5.

[33] For an econometric analysis, see; Duvivier, Polèse, and Apparicio (2018) and Polèse and Duvivier (2018). Five variables stand out as the best predictors of the growth of software jobs: public transit; proximity to city center; bars and restaurants; student populations; jobs in the arts.

[34] A glance at Figure A. **4** (map) confirms the concentration of related employment in the center and along the south-north axis of the metro line. Note the difference with aerospace (Figure A. **3**) with the highest concentration around the airport, two knowledge-intensive industries, but with very different geographies.

[35] London's and New York's IT clusters are concentrated in similar central, formally industrial, now trendy neighborhoods, predictably dubbed, respectively, Silicon Roundabout and Silicon Alley.

[36] The tax credits have been renewed. Also, economic theory suggests that (francophone) labor immobility should exert a downward pressure on wages.

as new products seek to provide so-called metaverse experiences, virtual reality appealing to all the senses of the human mind and body.

Montreal will never match the IT talent pools of The Bay or Boston areas. Montreal's human capital advantage lies elsewhere. Nothing better illustrates Montreal's distinctive creative culture than two companies that have since become emblematic, Just for Laughs (its video capsules exported around the world) and Cirque du Soleil (with shows presented in more than 300 cities) the first producing comedy sketches without words, the second a circus without words[37].

AI (artificial intelligence): a story of academic entrepreneurship and immigration.

The cultural and lifestyle predilections of human capital bring us to immigration, a non-negligible factor in Montreal's economic resurgence[38]. Montreal naturally attracts talent from the French-speaking world, often from places with an entrepreneurial legacy[39]. Among the most powerful examples is the emergence of Montreal as an Artificial Intelligence (AI) hub. Here the star is a single individual, who chose Montreal as his home[40], an example of what is sometimes referred to as serendipity in the urban economics literature: what if Henry Ford had not been born in Detroit or Bill Gates in Seattle?

AI has been heralded as the new frontier of IT. It is not an easy industry to define, an assembly of applications (algorithms …) used across industries. Montreal's rise as AI hub has been the object of study in the academic literature[41]. In a nutshell, the godfather of Montreal's AI industry is Yoshua Bengio of the University of Montreal, arch example of a successful academic entrepreneur. Bengio was born in Paris of Jewish Moroccan parents who moved to Montreal. Bengio, together with Geoffrey Hinton of the U. of Toronto and Yann LeCun at NYU, are generally considered the fathers of deep learning, the basis for AI. In 1993, Bengio founded the Montreal Institute for Learning Algorithms (MILA), affiliated with U. of Montreal and McGill, since grown to become, reputably, the largest AI research consortium of its kind with some 600 researchers. Major players of the digital universe (Google, Microsoft, Facebook…) have since opened AI research labs in Montreal, often located not far from MILA.

Montreal's rise as AI hub is noteworthy not only because of the pivotal role of a key individual, a leading scientist in this case, but because it points to a different industry growth path from video gaming. Here, the impetus came from the university community. The typical model here is a university-affiliated research institute, IVADO (Institute for Data Valorisation) another example, which partners with private firms to develop proprietary applications. Bengio and his disciples have been superbly successful in harnessing research funds, accumulating prizes and awards. The Montreal AI research community has reportedly garnered over a billion dollars in

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[37] For *Cirque du Soleil*, see also Leslie and Rantisi (2009) and Leslie and Rantisi (2006) for the fashion industry.

[38] Immigrants are on average better educated than natives, a result in part of Canada's immigrant selection process.

[39] At the risk of cultural oversimplification, I think, for example, of Mid-Eastern (Egypt, Lebanon, Syria…) Christion and Jewish minority populations who historically gravitated to French culture, although that legacy is slowly dying.

[40] At an entirely different level, Saputo, today one the largest dairy product companies in world, was founded in 1954 by an Italian immigrant. Note that French-owned Danone has a major production facility in Montreal. I don't know what Montreal's specific advantage is for dairy products, but it visibly has one.

[41] See Doloreux and Turkina (2021) and Gherhes *et al*. (2022).

public money from both provincial and federal sources since 2016. Note that both research institutes are located in the same trendy area as earlier-mentioned IT players, proof, if need be, of the role of proximity, creating an ecosystem to use a much hackneyed term.

AI is interesting also in that it invites us to rethink industry classifications and what is meant by "exports". Clearly, the Google, Microsoft, and other foreign-financed labs correspond to the notion of export base, defined earlier, as do the various servicing relationship between home-grown AI labs and foreign customers that bring money into the Montreal economy. Such money flows (and corresponding jobs) can take various paths, including licensing agreements and other payments for proprietary know-how, not easy to measure and largely invisible. In the end, as with much trade in what are called "services" (are AI applications services?), we are compelled to fall back on indirect measures of a region's export base.

Finally, the rapid rise of AI in Montreal also holds a cautionary tale. Element AI, a private company (Bengio one of the founders) was launched with great pomp in October 2016, positioning itself as a global leader in AI, going on to acquire a US-based open source machine learning database. Let me skip the details and jump to the end of the story. The company was acquired in January 2021 by a California-bases software company, becoming a subsidiary, most of its original staff laid off. As I understand it, the company tried to move to usable applications too soon, underestimating the distance between fundamental research (not necessarily easy to understand) and a saleable product. Not all start-ups have the (patient) financial backing needed to move from basic research to marketable products. Element AI visibly did not.

Mistakes, relative advantages and disadvantages

The Element AI story provides a useful introduction to Montreal's failures, cases where investors and decisions-makers got it wrong, and also a warning of the risks of promoting currently fashionable industries. Montreal lost over 6,000 jobs in the telecommunications equipment industry between 1991 and 2016 (Figure 4.2). This was largely due to the collapse of Nortel, once the flagship of Canada's high-tech manufacturing sector. Nortel filed for bankruptcy in 2009 and no longer exists. An earlier example, is the automobile industry, star industry in its heyday. Montreal succeeded in attracting a General Motors plant (some 3,600 employees) in 1966. The plant no longer exists, demolished in 2002. The reasons are not difficult to find. Montreal lies outside the heartland of North America's auto industry. The centre of Canada's auto industry lies predictably across from Detroit. And unlike aerospace, Montreal had no distinctive inherited know-how advantage for auto making.

Among more recent examples of bad policy are the Cité du Multimédia and *E-Commerce Place*, inaugurated by the Quebec government, respectively, in 1998 and 2000. Buoyed by the success of if its targeted tax-credits in launching the video gaming industry, the then minister industry decided to create cluster – a building complex- for multimedia IT firms and, in the case of the second, to take advantage of the growing e-commerce industry. In both cases, firms would receive tax credits if located in the designated office blocks. Both initiatives have since been abandoned[42]. Both techno centres were located outside the existing IT cluster that had

[42] The Cité du Multimédia still exists, but no longer entails any special government aid.

grown organically, Both were seen as disloyal competition by existing firms, simply moving around existing jobs, and a wasteful investment in (flashy) buildings rather than in human capital. For E-Commerce Place, the problem ran deeper. Unlike gaming, where the arts input is a competitiveness factor, Montreal had no evident talent advantage for e-commerce.

Montreal is rarely the first choice for Canadian or North American headquarters of foreign-owned multinationals, natural consequence of the dominance of French and, *relative* to Toronto, smaller business service sector. Toronto's emergence as Canada's financial center was inevitable, and needs no further comment[43]. All of Canada's big five banks are today headquartered in Toronto[44]. Montreal has several large home-grown institutions, notably the National Bank of Canada and Desjardins, not forgetting the *Caisse*[45]. Montreal also has a growing network of venture capital funds. However, in *relative* terms, Montreal cannot compete with the deep capital markets of San Francisco and Boston (Table A 1), the reason all too many start-ups turn to outside investors or, if successful, end up being bought out by outsiders,

Conversely, Montreal's French-speaking labour pool can make it attractive for US firms as entry-point to French-speaking markets, but these remain small compared to global, notably Asian, markets. In the opposite direction, French firms may find Montreal attractive as entry-point to North America. BNP, France's largest bank, has its North American headquarters in Montreal, in part to accompany French firms, evidence yet gain of the role of cultural ties for FDI[46].

6. City-regional strategies

We need here to return to ***Governance*** to remind the reader that local authorities (i.e. City of Montreal) have limited economic powers and to separate "staff" and "line" functions. The MMC (Table 2.1) is primarily a "staff' organization, in keeping with its mandate as a regional planning body. The range of "line" programs administered by various actors (be it in the form of financial assistance, counselling, training, networking or other programs) is almost limitless and falls beyond the ambitions of this case study.

I shall focus on four actors - the City, the MMC, the Chamber of Commerce, and Montreal International - and on shared priorities. *Human capital* its various dimensions - education, entrepreneurship, immigration – is visibly number one. The underlying diagnosis (implicit or explicit) is simple: if the region can nurture, attract, and hold the necessary talent, the rest will follow. Concern with *quality of life*, very much a City responsibility, is the natural corollary. *Connectivity* – an integrated, accessible, economic space - is a central regional priority, principal object of public investments in physical capital (transit, highways…), generally underwritten by the

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[43] Note on Figure 4.2 that Montreal lost some 10,000 jobs in the insurance industry between 1991 and 2016. See Polèse and Shearmur (2004) for the role of cultural codes in the location of financial and business services.

[44] The Royal Bank of Canada and The Bank of Montreal, both founded in Montreal, still maintain symbolic headquarters in the city, but their true headquarters are in Toronto

[45] The Global Financial Centres Index (2022), ranks Montreal 29th internationally, which is quite respectable. The comparative rankings for New York, San Francisco, Boston, Toronto, and Vienna are, respectively 1, 7, 14, 22, and 46.

[46] There are sound economic reasons why FDI is sensitive distance and culture. Managers must communicate and travel.

Province, also where environmental objectives, the transition to a *greener economy*, most noticeably come into play.[47]

Focus on know-how and talent and stimulating entrepreneurship are the first two guiding objectives set forth in the City of Montreal's *Economic Development Strategy* . Cultural and creative industries top the list of high potential sectors followed by the digital industry[48]. Urban transportation (intra-urban mobility) and clean technologies are equally identified as key sectors. Mayor Valérie Plante, recently re-elected, and her municipal party (*Projet Montréal*) have their roots in community organizations, ecological and social concerns increasingly at the top of the agenda.

Dedicated bicycle lanes and a public bicycle sharing program, a technology since also exported to New York, are among the signature projects. The City continues to invest in the livability and animation of central districts: pedestrian streets; squares; sponsored festivals and cultural events… all this with the stated objective of consolidating Montreal's reputation as an arts-friendly, tolerant, fun city, a place where creative types of all stripes are welcome. The City's upgrading of Montreal's Gay Village is a visible example. Such initiatives are generally managed by non-profit community organizations financed by the City and/or the Province.

City and Province sponsored community organizations also play a major role in the integration of immigrants, including job counselling and placement. Landed immigrants have access to paid (by the Province) francisation and citizenship courses. "Inclusion", an admittedly hackneyed term, is a repeatedly stated policy objective. Many elected officials are immigrants[49]. It is impossible to exaggerate the importance of immigration for Montreal. Full consideration of the subject would require a separate report. That said; the evidence suggests that the Province's and City's strategies have on the whole been successful in integrating immigrants into the labour market[50], which of course does not mean that problems do not remain.

Moving to physical capital, the most ambitious current infrastructure project is the *Réseau express métropolitain* (REM), a 67km light rail system with 26 stations, piloted by the *Caisse de Dépôt* at the cost some 7 billion dollars (CAD)[51]. Although piloted by a provincial agency[52], the project mirrors what one might call a regional consensus: that is, on the need to reduce car use, increase densities, and connect employment poles. REM will link the airport, downtown, *Technoparc Montreal, and* the city's two senior university campuses. An extended REM is currently under discussion between the Province, the City, and reginal actors.

[47] Political differences exist. The current centre-right Quebec government is less environmentalist than the City government, but can nonetheless not escape the growing green imperatives driving political discourse,

[48] I have skipped over life sciences, also mentioned, less export-oriented. The US pharmaceutical firm Moderna recently announced its decision to locate a production facility in Montreal, chiefly, I understand, to serve the domestic market.

[49] To take an example close to home, my borough mayor is of Congolese origin, female, member of the mayor's party.

[50] Immigrants accounted for 30.7% of Montreal's labour market (2021). Immigrants (Quebec) registered an unemployment rate of 5.3% and an employment rate of 81.9%, not very different from natives. Source: Diallo *et al* (2022).

[51] REM is in principle self-financing, the *Caisse* recuperating costs (plus hopefully a healthy profit) via fees levied on real estate values within 1 km of the planned rail line.

[52] This has given to some controversy, the ARTM (Regional Transport Authority) left out the of the planning process

REM can be seen as the most recent step in a provincial strategy of strengthening the centre, starting with the Métro (subway) in 1967, the location downtown of UQAM and ÉTS campuses respectively in 1969 and 19714 , the convention centre in1983 (enlarged since), and more recently (2021) a new university research hospital, located a stone's throw from UQAM, directly linked to the Métro's main transfer station[53].

The *Montreal Metropolitan Community's Metropolitan Economic Development Plan 2022-203* (CMM 2022) provides a comprehensive overview of the region's weaknesses, strengths, and priorities. Like all such documents, it is essentially indicative in nature; but which does not take away from its use as a consensus-building tool, ratified by the MMC's 82 municipalities.

Let us recall that the mayor of Montreal is the statutory head (*présidente*) of the MMC. It is thus not surprising that environmental and human capital concerns again dominate. Four "strategic axes" are identified, respectively[54]: (1) transition to a more energy-efficient economy; (2) intelligent, eco-responsible territorial organisation; (3) reinforce the region's innovation ecosystem; (4) build skills and know-how for the Greater Montreal of tomorrow. The document puts particular emphasis in the need to improve the region's human capital, where it is also the most critical, not only with respect to education and training, but also the need to attract and hold talent, the integration of immigrants a recurrent theme.

The focus on green objectives is very much in tune with the Zeitgeist (which does not make it any less laudable), not very different from what would expect to find in similar documents elsewhere. However, Montreal stands out, certainly in North America, in that green strategies are mediated via a regional body with the mandate of arbitrating conflicts in land–use and industry location. The MMC administers, to take an example, a provincially-financed program compensating rural communities for foregone industrial development opportunities with the objective of protecting agricultural land. Municipalities must apply and, if they meet the necessary criteria, are directly compensated.

Cluster organizations, Aéro Montréal among the oldest, are key players, we have seen, in furthering specify industries. Models vary across industries with a high degree of organizational flexibility. Some are public-private partnerships, the most common model, while other rely wholly on membership funding. The gaming industry has its organization, La Guilde, participation is voluntary, financed entirely by member. Propulsion Québec is among the newest clusters, part of the green bandwagon, hoping to build on Quebec's expertise in power generation, stocking, and transmission. Hydro-Québec is a partner[55]. It advertises itself as a future world-class cluster for the production and management of electric and smart transportation modes.

Montreal International (M.I.), financed via the MMC, is the region's business promotion arm. Other cities have similar agencies focused on FDI. M.I.'s distinguishing feature is the level of

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[53] Note: no parking was planned for the UQAM campus, an environment-friendly policy before it became fashionable,
[54] The author's translation from the French.
[55] Hydro-Québec maintains a major research centre, IREQ, in suburban Montreal.

private sector involvement and (quoting a source) its "results-driven" philosophy[56]. Though 80% publically-funded. M.I.'s board of directors has a private sector majority. Line-officers are given defined FDI $ targets. This strategy has visibly produced results[57]. A main reason (to quote another source) is perseverance and consistency, transmitted institutional competence and a focus on targeted areas. The probability of success is greater in industries where Montreal has an established reputation and in markets where local firms are already active[58].

This has not stopped M.I. from joining the green bandwagon, green technologies (greentech) identified as a promising new area. But again, this green thrust is likeably to be most successful where Montreal has a recognised talent tool, in aerospace for example, applying new technologies to the production of greener, energy-efficient, commercial aircraft.

The Chamber of Commerce of Metropolitan Montreal is the region's private business promotion actor. CCMM, in its current form, was born in 1992 out of the merger of two language-based chambers (going back to the 19th century), a key moment in the consensus-building institutional reforms underpinning Montreal's resurgence[59]. The CCMM sees itself as having a regional development mandate, more than simply a business lobby. Participation is voluntary and includes firms and institutions (universities, research institutes...) across the size spectrum.

The CCMM has often performed a valuable regional leadership function, bringing together public and private players. Relaunch Montreal and I Love working downtown are two recent initiatives, in part Covid-propelled. The CCMM administers a range programs, often in partnership with the provincial and federal governments, several specifically aimed at immigrant integration, linking employers with immigrants and aiding firms with immigration procedures (note that M.I. is also instrumental here). Among other examples, Export assistance programs, help small firms to enter new markets. For all such programs, the CCMM often works in tandem with industry cluster organizations. But in the end (to quote several sources), even if somewhat of a cliché, it all comes back to developing, attracting, and holding talent.

7. Summary: Possible Lessons for Vienna

Does Montreal hold useful, transferable, lessons for Vienna? No two cities are truly comparable. Public policies are rarely transferable out of context. Industry location advantages are by definition unique to place. With these cautionary warnings in mind, I shall nonetheless procced.

Vienna shares two attributes with Montreal: both display a high quality of life and both have sprung back from a difficult past. Montreal, like Vienna, is a generally safe, liveable, city with a robust social safety net. And like Vienna, Montreal went through a bad period (although far

[56] *Montreal International* was initially created to attract international organizations. Its mandate has since widened to attracting FDI, foreign entrepreneurs, and foreign students. M.I.'s current budget is $16 million (CAD).

[57] According to M.I.'s 2021 Activity Report, the agency attracted $3.8 billion in FDI, creating 11,550 jobs with an average annual salary of $82,088. Institutional claims of this type should, however, always be read with caution.

[58] The US and France accounted for respectively 49% and 31% of FDI in 2021 with half going to IT-related industries.

[59] The Federal Government also played a key role by transforming the Port and Airport into autonomous bodies under local control with strong private sector participation.

less dramatic) losing a good part of its human capital and its position as central place for a wider economic hinterland.

Therein lies a first lesson. Cities can renew themselves and often faster than one thinks. Montreal reinvented its economic base in the space of a generation.

That said, let us return to the questions asked by the City of Vienna; specifically, the identification of successful new export sectors and mediation of possible conflicts with quality of life. I fear that the answers for Montreal may fall short of what the City of Vienna expected. In a nutshell: *a*) new successful export sectors almost always have roots in Montreal's past; *b*) their relevance for Vienna is not self-evident; *c*) the conflict with quality of life is not a major issue. However, the very difference with expectations can hold useful lessons. All this of course demands more explanation, to which we now turn.

"New" export sectors. When asked to identify Montreal's promising new export sectors, interviewees generally fell back on broad, predictable, categories (i.e., aerospace, IT…), not terribly helpful. More helpful were the comments that often followed, and which almost lead in the same direction. To quote (roughly) one highly knowledge actor, directly involved in Montreal economic development for over forty years: "new industries cannot be divorced from the city's past". Stated differently, business promotion (whether attracting FDI or nurturing promising start-ups) succeeded best where the city-region had a well-established reputation and recognized talent pool. This is an admittedly a fairly self-evident conclusion (at least, for those in the field), but which was nonetheless repeated to me on almost every accession.

Montreal's growling techno industries (aerospace, gaming, artificial intelligence, ….) but also less techno-based sectors like dairy products and fashion all had their roots in pre-existing talent pools, often old industries that reinvented themselves. Similarly, established firms often acted as anchors and incubators for start-ups in "new" but related industries.

Montreal's experience is a useful reminder, as such, of the cost of information, in the jargon of economists. Credibility and reputation remain powerful determinants of investment decisions and business success. As one industry actor put it, angel investors in gaming come to Montreal, simply, because of its international reputation as place with a quality talent pool, just like customers are willing to pay more for German-built cars because of their reputation for quality.

For Vienna, the lesson is simple, although perhaps not what the City expected. Local actors, not outsiders (Montrealers included), are best equipped to identify promising export sectors, areas where Vienna has a recognized reputation and talent pool. As such, Montreal's successful industries are not necessarily useful guides for Vienna. There is no reason *a priori* why Vienna should copy Montreal in video-gaming or the manufacture of corporate jets. In both of these industries, new export products are emerging (i.e., metaverse gaming, electric aircraft…); but, again, it is difficult to see how this is relevant for Vienna.

Marrying the arts and technology. Montreal's marriage of the visual arts and IT is, arguably, a notable exception to the conclusion above, transferable perhaps to Vienna. Vienna's reputation as cultural beacon needs no introduction. Music naturally comes to mind. One would *a* *priori* expect Vienna to excel, if not already so[60], in the application of technology to music, be it the production of musical instruments or of software for the (electronic) production, stockade, and export of music.

Broad-based definition of exports. Interviewees in Montreal showed little interest in the distinction between the export of manufactured goods and so-called service exports, and for good reason. As we have seen, gaming and other IT products, in principle classified as services, account for a growing proportion Montreal's export base. As such, Montreal demonstrates the growing obsolesce of the manufacturing/service dichotomy as a guide for economic policy[61]; which in principle should hold not less true for Vienna.

A short conceptual note is in order at this point[62]. Electronically traded "services" are independently transportable like manufactured products and should not be confused with traditional tradeable services where the producer (i.e., consultant) or the consumer (i.e. tourist) must travel to consume or deliver the service. There is no fundamental conceptual difference between exporting corporate jets and video games, both probably 100% exported in the case of Montreal. However, electronically traded products do have a non-negligible green advantage; their transport does not require the consumption of fossil fuels.

Talent, human capital. Whatever term one wishes to use, *talent* was the recurrent theme to which almost all interviewees returned again and again. Access to talent, constantly repeated, remains the first priority for technologically advanced firms, followed by costs[63]. With an aging labour force, recruiting and holding qualified immigrants has become the principal concern of most firms. Montreal has been generally successful (certainly compared to many other places) in integrating immigrants into the workplace. However, I'm not sure how transferable Montreal's model is to Vienna; the nature of immigration is different. Public initiatives and public discourse visibly matter, but all this remains highly context specific[64].

Human capital in its three dimensions - *education, entrepreneurship, immigration*, - played a pivotal role, we saw, in Montreal's resurgence. Successive governments have consistently sought to upgrade the education system and to foster an entrepreneurial culture.

For entrepreneurship, Montreal's array of programs and incubators to assist start-ups is not necessarily novel. It's impossible, in the end, to know how useful specific programs were (or are) in

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[60] A quick trip on Google for example revealed the following link for music-based start-ups: https://beststartup.eu/47-top-music-startups-and-companies-in-austria-2021/

[61] The division of the economy into three sectors – primary, secondary, tertiary – was first introduced by the UK statistical office in the 1930s, paternity generally attributed to the New Zealand economist Allen Fisher.

[62] Note that the author was a member of the Statistics Canada consultative committee on services for some fifteen years, whose mandate, among other things, was to review NAICS codes for service industries and the measurement of trade in services.

[63] I have refrained from talking about costs, although clearly a factor in Montreal's performance, because largely a structural legacy (see Table A 1). Also, I do not know what leeway Vienna has to offer financial incentives (i.e. tax credits…).

[64] All the institutions cited in the previous section (MMC, an exception, a staff organization) are active at various levels in immigration integration.

promoting business[65]. It's as much a matter of general business climate and attitudes as policy. What makes Montreal's story different was the need to replace human capital lost (education, the principal tool) and the cultural challenge of creating (and holding) a new entrepreneurial class. In this, Montreal was visibly largely successful.

Mixed "creative" *neighbourhoods and suburban techno closures*. Central "creative" neighbourhoods played a major role, we saw, in Montreal's rise as an IT and video gaming hub. The choice to locate in particular neighbourhoods was, as noted earlier this study, a conscious choice, confirmed by more than one actor in the industry. The City played a pivotal role in allowing such neighborhoods to emerge, not only by ensuring the quality of urban services (transit, policing, parks, streets…), but also in openly promoting social and commercial mixity and flexible housing and real estate markets.

How transferable is Montreal's model? I have insufficient knowledge of Vienna's urban planning regime to know whether such "creative" districts (with converted factories, warehouses…) can easily emerge in Vienna or perhaps already have. Montreal's experience suggests that such "*creative*" districts should as far as possible be allowed to emerge organically, the state following the creative crowd, not directing it[66].

The same lesson holds for techno clusters centred on manufacturing and other space extensive activities (i.e., laboratories, logistics…), which tend to favour suburban and semi-suburban locations, the strongest cluster evolving near and around Trudeau international airport (Map, Figure A 2). Science parks need of course to be planned. However, the success of Technoparc Montreal can in large part be attributed to its location in the heart of what was already Montreal's rising suburban techno cluster,

Absence of conflict with quality of life. Most actors, when asked, saw Montreal's quality of life as a contributing factor in Montreal's economic development, not in opposition. Conflicts have arisen for specific (noisy, polluting…) projects close to residential neighborhoods, but these are the exception, industrial and residential uses separately zoned, and not perceived as a general problem. As noted earlier in the study, part of the reason may be the relative absence of space constraints, but also Montreal's transformed industry structure. Montreal's green challenge is not industry, but the internal combustions engine. Manufacturing is no longer the main source of greenhouse gases[67]. Only one petrochemical plant remains[68]. The main source of atmospheric pollution is transportation, trucking[69] and above all private automobiles. Thus, the focus

[65] I doubt that public business assistance programs in Montreal differ substantially from those elsewhere, with the same observed limits: i.e., bureaucratic, take time, small amounts, conditional....

[66] Recall Montreal's two ill-fated attempts to create state-designated IT districts.

[67] According to CCM (2022: 64), industrial processes accounted for 8% of total CO_2 emissions in the region in 2019, other business activities (except transportation) 25%, and transportation 50%.

[68] Indeed, one of the main challenges for the City is the decontamination of vast industrial zones left behind by Montreal's shirking petrochemical industry, cost the principal obstacle.

[69] Here also the principal culprit is no longer industry, but e-commerce, warehousing, and the Amazon's of this world. By the same token, he principal consumer of industrial zoned space is increasingly logistics.

in the City and regional strategies on electrification and promoting public transit, on which Vienna has little to learn from Montreal.

Regional institutions. Among Montreal's greatest achievements, I would argue, is a regional culture of dialogue. Various factors made this possible[70]. However, much of the credit must go to the institutional reforms introduced over the years by the provincial government and federal governments (see Table 2.1).

It is doubtful whether the MMC model is transferable to Vienna. An analogous regional planning body would span three Länder (Vienna, Lower Austria, Burgenland), very different from Montreal where the entire city-region falls under the authority of a single provincial (Land) government. However, could the mandate of The Vienna Business Agency, which resembles Montreal International, be extended to the City Region?

As a closing word, let me return to the first half of the question asked by the City of Vienna: identifying successful export industries. If the Montreal story teaches us anything it is that the identity of industries matter less – they are constantly changing – then the underlying conditions that allow a city to constantly renew its exports base. Those underlying conditions, we saw, are as much social as strictly economic. In the end, we keep coming back to human capital, The challenge, as true for Vienna as for Montreal, is providing an environment that allows the city to attract and hold talent.

[70] The non-partisan nature of local politics, separate from provincial politics, undeniably helps.

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(institutional hyperlinks in text)

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Appendix

Sources and methods

Supplementary tables and figures (maps)

Sources and Methods: Tables and Figures

- Figures 1.1 and 4. 1 and Table 4.1: *Labor Force Survey (LFS)*, Statistics Canada, published monthly, but only available at the two-digit NAICS level for CMAs. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410009601
- Figures 4.2 to 4.7- *Censuses (every five years),* Statistics Canada. The source for all five figures is a database housed at INRS, built from special Statistics Canada tabulations, updated every census year since 1971. The data matrix contains employment figures for 135 Canadian urban areas (Census Agglomerations + CMAs) and 127 industry classes. Geographies and class definitions are continually adjusted and standardized to ensure compatibility over time. See next point.
- Figures 4.2 and 4.3. Employment losses and gains 1991-2016 by industry. As with all historical series, the principal challenge is ensuring compatibility over time. For industry classes, the challenge was twofold. First, for data prior to the 2001 census, former SIC codes needed to be made compatible with NAICS, introduced in 1997 as part of NAFTA (North America Free Trade Agreement). Second, NAICS codes are continually updated to account for the industry changes, notably the emergence of new industries. Thus, NAICS code 5112, software publishers, was subsumed in earlier census series under the general heading of "computer and related services", which is why, for example, the Software and Allied IT class (Figure 4.3) includes more than software publishers.
- Figures 4.4 and 4.5. Export-base estimates (pie charts) for 1991 and 2016. Export-oriented employment estimates are based on the assumption that jobs above a location quotient (LQ) of unity (1.0) serve to produce goods and services that are exported beyond the Montreal CMA. LQ is calculated compared to all Canadian urban areas (Census Agglomerations) with populations above 10,000. Thus:
- Cij= [Eij-Ej(Ei/En)]
- Where Cij = export employment in industry i in region j (Montreal CMA)
- Eij= Employment in industry I in region j (Montreal)
- Ej= Employment in region j (Montreal)
- Ei = Employment in industry i for all of urban Canada (n)
- En= Employment for all of urban Canada (n).
- This is a fairly classic method for calculating a region's economic base, but with evident limits. The use of urban Canada as reference point undoubtedly understates the true weight of the most export-intensive industries as other Canadian urban areas may equally have employment clusters in the same industries. Obvious examples for Montreal are aerospace products and videogames, almost totally exported outside the region and outside Canada.
- For 2016, data published by the MMC provide a useful point of comparison with our estimates. CCM (2020: Table Annexe-!, p. 162) gives LQs for Montreal at the 4 digit NAICS level, with all of North America as reference point. The results largely reproduce

our estimates with the highest manufacturing LQs, for example, in aerospace and other transportation equipment, followed by clothing and dairy products.

- Table 2.1 – Governance Structure. Hyperlinks to instructions in table.
- Table 3.1- Two sources: *Observatoire Grand Montréal. Comparaisons nord-américaines (henceforth, OGM)*: https://observatoire.cmm.qc.ca/comparaisons-nord-americaines/. Nature Index, Top 200 science cities: https://www.natureindex.com/supplements/nature-index-2018-science-cities/tables/overall
- Table 3.2 – *Canada's Top 50 Research Universities 2019*: https://researchinfosource.com/top-50-research-universities/2019/list ; List of 100 best universities in Canada: https://edurank.org/geo/ca
- Table 3.3 – *Canada's Top 100 Corporate R&D Spenders 2020*: Research Infosource Inc.: Top 100 List

Figures and Tables in Appendix

- Figure A 1 (Map): Montreal Metropolitan Community (MMC). Source: MMC.
- Figures A 2 and A 3 (Maps). Distribution of jobs in two industries 2016. Source: City of Montreal : Ville de Montréal - Montréal en statistiques - Atlas de l'emploi (montreal.qc.ca)
- Table A 1: Comparative data for seven urban areas. Primarily two sources: OGM and the Economic Development Division of the MMC. The principal exception is median household income, sources: https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1 ; List of cities in Canada by median household income - Wikipedia ; see also note below.
- At OGM (*Observatoire Grand Montréal*), my heartfelt thanks to Philippe Rivet, head, and Maxime Trottier, senior analyst, who kindly gave me access to the original databases.
- That said: caution must be exercised when comparing data across cities, especially between different nations. Comparing Canada and the US, income and GDP data are for example sensitive to exchange rate fluctuations. Income per capita and (nominal) wages have historically been lower in Canada than in the US by about 10 to 15%. That difference tends to disappear when adjusted for cost of living (PPP). However, for firms competing on international markets it is nominal wages that principally matter, the basis of Montreal's wage advantage.
- Table A 2: University Rankings. Hyperlinks listed at bottom of table.

Table A 1: Comparative Data, 7 Metropolitan Areas

(a) Population - Metro and Central City

Metropolitan Area	Metro Population	Growth	Median Age	Foreign-born (%)	Central City Population	Growth
	2021	% Δ 2010-2021	*2016*	*2016*	*2021*	% Δ 2010-2021
Montreal	4,291,732	12.2%	40.2	24.6%	**1,762,949**	6.9%
Vancouver	2,642,825	14.2%	**40.9**	**40.8%**	631,486	4.6%
San Francisco	4,623,264	6.6%	38.8	**39.0%**	**884,108**	9.8%
Boston	**4,899,932**	7.6%	38.8	18.8%	695,500	12.6%
Atlanta	**6,144,050**	**16.2%**	36.2	13.7%	504,700	**20.2%**
Seattle	4,011,553	**16.6%**	37.1	18.2%	787,995	**29.5%**
Pittsburgh	2,353,538	-0.1%	43.1	3.8%	299,434	-2.1%

(b) Urban Structure & Social Conditions

Metropolitan Area	Central City: % of Metro Pop.	Density Pop/ km²	Public Transit (%)	EIU Livability Rank	Homicides per 100,000	Income equality*
	2021	2016	2016	2019	2018	2015
Montreal	**41.1%**	**1031**	**23.5%**	**20**	**1.1%**	**4.9**
Vancouver	**23.9%**	**884**	**20.4%**	**6**	**1.7%**	**7.9**
San Francisco	19.1%	720	18.4%	46	4.1%	18.9
Boston	14.2%	531	13.8%	45	1.9%	18.3
Atlanta	8.2%	258	3.3%	33	5.7%	14.9
Seattle	19.6%	250	10.1%	36	3.3%	13.6
Pittsburgh	12.7%	171	6.3%	34	5.5%	15.5

*Ratio of highest to lowest income quintile.

(c) Selected Economic Indicators

Metropolitan Area	Median Household Income*	Air Traffic Passengers (000)	Venture Capital Investment (M $US)	Manufacturing**	Professional, scientific & tech services**	Information & Culture**
	2015	2019	2015-2017	2020	2020	2020
Montreal	$ 50,668	20,305	$ 1,771	**10.8%**	11.0%	2.9%
Vancouver	$ 59,583	26,401	$ 1,256	6.8%	11.5%	3.3%
San Francisco	**$ 88,518**	**70,796**	**$ 81,808**	6.2%	**13.6%**	**5.9%**
Boston	**$ 78,800**	42,587	**$ 24,567**	6.6%	**12.3%**	3.2%
Atlanta	$ 60,219	**110,531**	$ 3,036	6.3%	8.1%	3.5%
Seattle	$ 75,331	51,829	$ 5,710	**8.7%**	8.1%	**6.9%**
Pittsburgh	$ 58,358	9,779	$ 896	7.8%	7.4%	1.5%

* **Top 2 in bold**. * $US. Exchange rate: 1 $CAN = 0.82 $US. ** Employment shares

Table A 2: University Rankings, 8 cities, 2022 (2 top universities in city)

	Ranking Source				
	(a) CWU	(b) QS	(c) Shanghai	(d) Times	**Mean**
Montreal					
McGill University	28	25	67	44	**41**
U of Montreal	117	111	101	88	**104**
Vancouver					
U.B.C	49	46	42	37	**44**
Simon Fraser	354	298	.	201	**213**
Boston					
Harvard	1	5	1	2	**2**
M.I.T.	2	1	4	5	**3**
San Francisco					
UC Berkeley	12	32	5	8	**14**
Stanford	3	3	2	4	**3**
Seattle					
U of Washington	25	85	19	29	**40**
Seattle U	n/a	801	201	n/a	**501**
Atlanta					
Emory	129	160	101	82	**118**
Georgia Inst of Tech	68	88	101	45	**76**
Pittsburgh					
Carnegie-Mellon	86	53	97	28	**66**
U of Pittsburgh	75	163	101	140	**120**
Vienna					
U of Vienna	212	151	151	137	**163**
Vienna Medical U *	295	180	301	201	**244**

* Vienna Tech U for QS. a) https://cwur.org/2022-23.php. b) https://www.topuniversities.com/university-rankings/world-university-rankings/2022. c) https://www.shanghairanking.com/. d) https://www.timeshighereducation.com/world-university-rankings

Figure A 1: Montreal Metropolitan Community (MMC).

The MMC covers 82 municipalities shaded above in various colors. The geographic area covered is conterminous, with minor exceptions, with the Montreal CMA (Census Metropolitan Area).

Color codes: Green = City of Montreal; Light Green = 15 Linked Cities. The two form the Agglomeration, the Island of Montreal. The remaining 66 municipalities are colored thus: Rose = Laval; Blue = North Shore; two shades of Orange = South Shore.

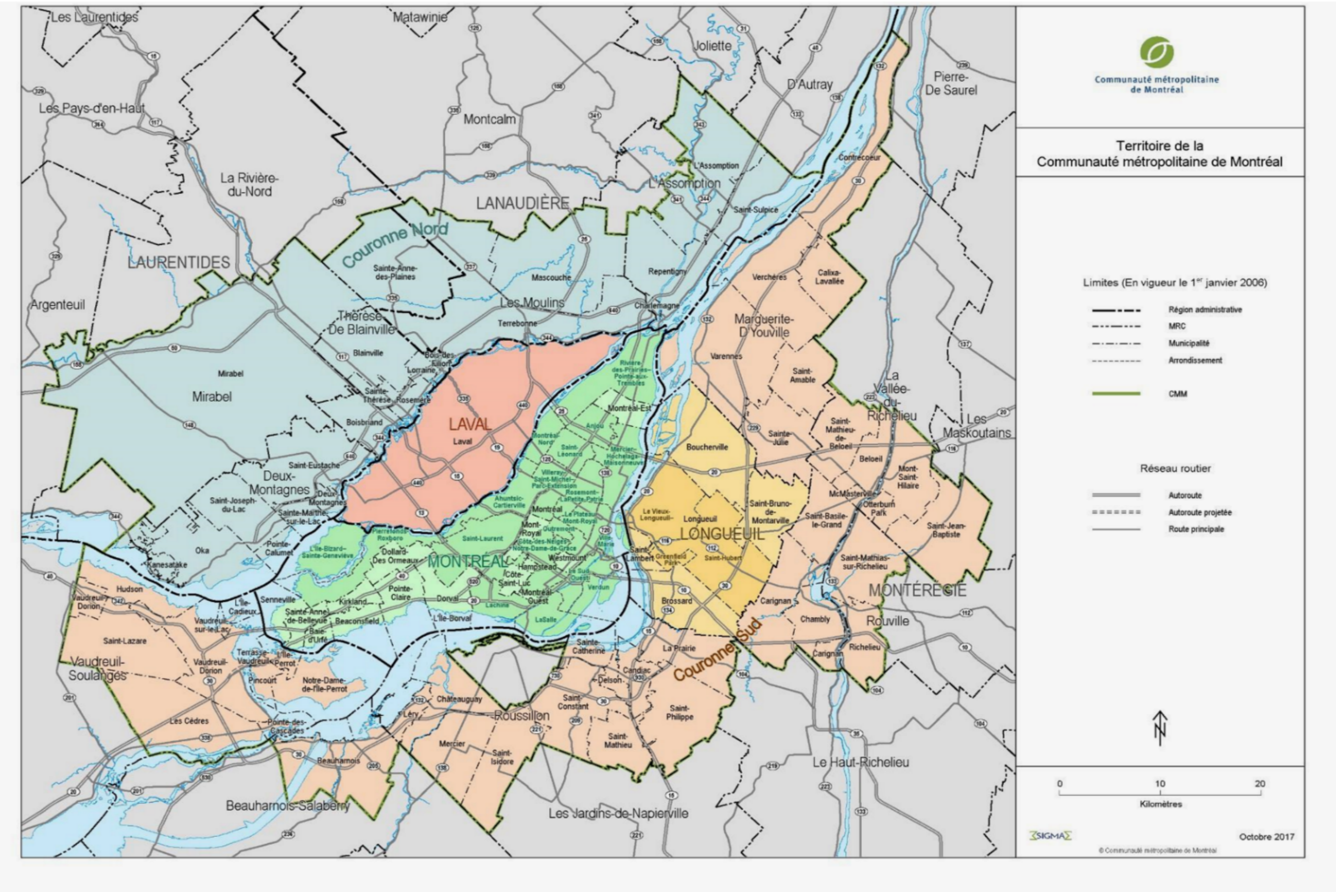
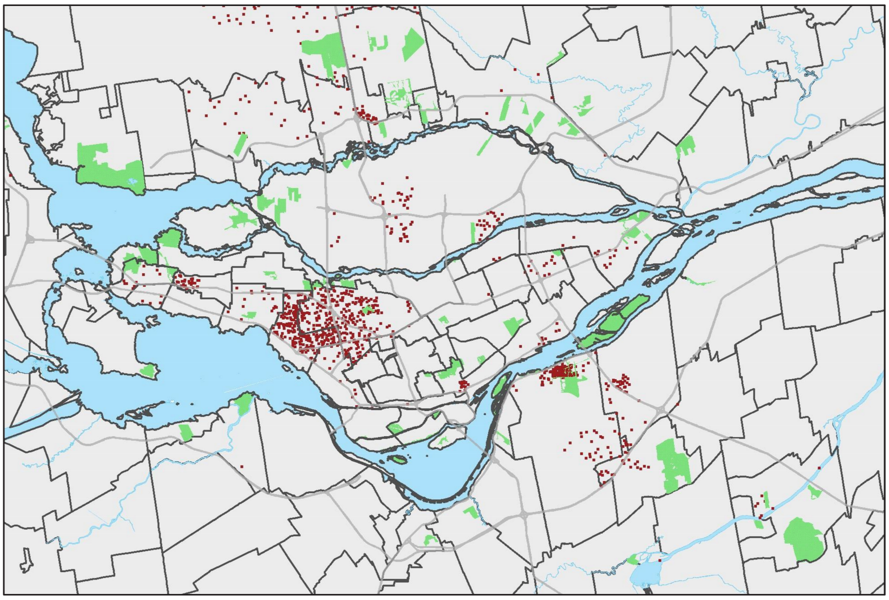


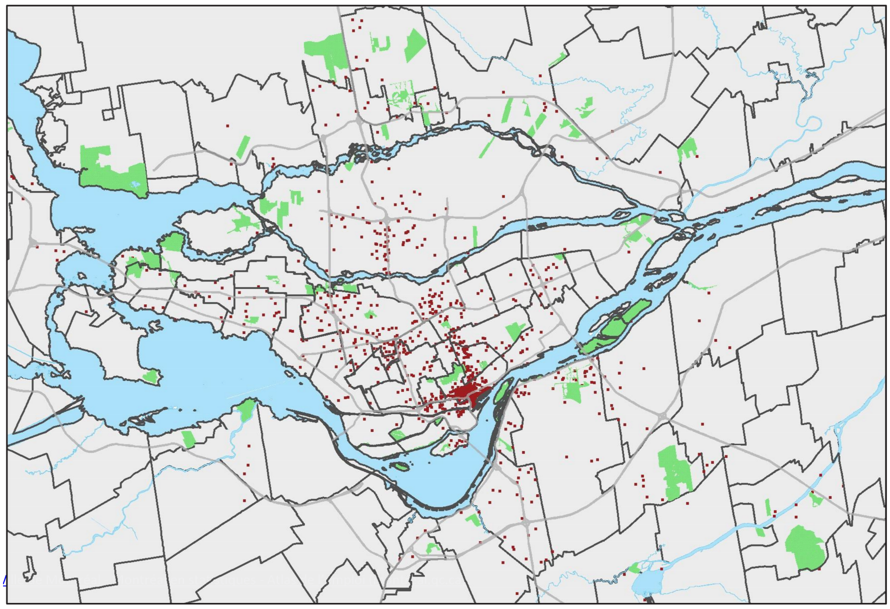
Figure A 2: Aerospace and other Transportation Equipment (each dot =100 jobs) 2016



	Employment	CMA share (%)
Montreal CMA	**33 905**	**100,0**
Agglomération de Montréal (Island)	17 085	50,4
Ville de Montréal (City)	9 320	27,5
Ahuntsic-Cartierville	40	0,1
Anjou	320	0,9
Côte-des-Neiges–Notre-Dame-de-Grâce	90	0,3
Lachine	405	1,2
LaSalle	45	0,1
Le Plateau-Mont-Royal	40	0,1
Le Sud-Ouest	85	0,3
L'Île-Bizard–Sainte-Geneviève	0	0,0
Mercier–Hochelaga-Maisonneuve	275	0,8
Montréal-Nord	155	0,5
Outremont	0	0,0
Pierrefonds-Roxboro	35	0,1
Rivière-des-Prairies–Pointe-aux-Trembles	495	1,5
Rosemont–La Petite-Patrie	50	0,1
Saint-Laurent	6 660	19,6
Saint-Léonard	90	0,3
Verdun	10	0,0
Ville-Marie	445	1,3
Villeray–Saint-Michel–Parc-Extension	80	0,2
Villes liées (linked cities)	7 765	22,9
North Shore	7 185	21,2
South Shore (exc. Longueuil)	1 120	3,3
Laval	1 890	5,6
Longueuil	6 625	19,5

Source: Ville de Montréal- Montréal en statistiques- Atlas de l'emploi

Figure A 3: Professional, Scientific & Technical Services (each dot =20 jobs) 2016



	Employment	CMA share (%)
Montreal CMA	**173 130**	**100,0**
Agglomération de Montréal (Island)	124 400	71,9
Ville de Montréal (City)	110 600	63,9
Ahuntsic-Cartierville	5 260	3,0
Anjou	2 025	1,2
Côte-des-Neiges–Notre-Dame-de-Grâce	6 450	3,7
Lachine	1 355	0,8
LaSalle	1 095	0,6
Le Plateau-Mont-Royal	8 465	4,9
Le Sud-Ouest	5 225	3,0
L'Île-Bizard–Sainte-Geneviève	285	0,2
Mercier–Hochelaga-Maisonneuve	2 575	1,5
Montréal-Nord	585	0,3
Outremont	1 100	0,6
Pierrefonds-Roxboro	935	0,5
Rivière-des-Prairies–Pointe-aux-Trembles	1 025	0,6
Rosemont–La Petite-Patrie	4 680	2,7
Saint-Laurent	8 655	5,0
Saint-Léonard	1 240	0,7
Verdun	2 025	1,2
Ville-Marie	53 405	30,8
Villeray–Saint-Michel–Parc-Extension	4 215	2,4
Villes liées (linked cities)	13 800	8,0
North Shore)	12 585	7,3
South Shore (exc. Longueuil)	10 910	6,3
Laval	11 990	6,9
Longueuil	13 245	7,7

Source : Ville de Montréal –Montréal en statistiques - Atlas de l'emploi

Pittsburgh – Promoting Urban Economic Development – with possible lessons for Vienna

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

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1. Foreword

This report is a part of a broader study focused on identifying for the city of Vienna potential lessons learned from economic development paths and experiences in a set of cities that have shown the ability to adapt and transition successfully from older to new economic structures. Consistent with the research mandate, the content of the report is based most heavily upon interviews with key local and regional economic development actors with special insight into the Pittsburgh economy.

To set the stage for the lessons learned from the interviews, we first present a brief overview of the region and its economic industrial structure, then turn to a description of the region's institutional environment, identifying critical elements most frequently mentioned by interviewees. We follow this with sections on interview insights and key take-aways from the interviews that respondents and we believe might be most useful for the broader research team.

2. The Pittsburgh Region

For many decades, Pittsburgh was known as "steel city" and was an international leader in steel production. For several reasons, most major steel producing regions experienced a sharp and rapid employment decline starting in the 1970s. In the United States, steel employment from 1975 to 2000 declined by about two thirds. In the ten years from 1975 to 1985 alone employment fell by 50 percent and left cities like Pittsburgh devastated. In Pittsburgh steel worker employment was cut in less than half from around 90,000 to 44,000 in the five-year period from 1980 to 1984.[1]

During the days of the steel industry's dominance large firms such as US Steel and Bethlehem Steel were dominant players. The eventual recovery of Pittsburgh, however, relied on the state and local governments and a tradition of regional cooperation dating back to the 1940s. Large private enterprises played no major role in this turnaround. Although there are many technology-oriented companies present in Pittsburgh, none of them has played a leading role in regional economic development efforts. While private companies are important contributors to the economic health and vitality of the region,[2] the story of Pittsburgh's transformation following the steel industry's decline and the region's continued development is much more strongly tied to decisions and actions taken by non-government organizations, frequently in collaboration with a governmental system that has sometimes championed development strategies but more frequently only coordinates and facilitates development efforts. The relatively limited governmental role in regional economic development efforts is due to an extremely high degree of fragmentation of local governments in the Pittsburgh region. This fragmentation hindered regional approaches to addressing the severe steel-related economic decline and many of these non-governmental organizations, whether planned or accidental, helped make regional cooperation and coordination possible. We will highlight the most important non-

[1] Pittsburgh: History - Early History, French And British Vie For Strategic Location (city-data.com)

[2] For a list of significant private technology related companies present in the Pittsburgh region, see https://builtin.com/pittsburgh/companies-in-pittsburgh/. Accessed November 14, 2022.

government organizations that helped create the environment and opportunities for this recovery in a separate section to stress their importance.

Today, Pittsburgh once again has a vibrant economy. While steel production and other traditional manufacturing are still in the mix, the drivers of the recovery were health care, driven primarily by the University of Pittsburgh Medical Center (UPMC), and artificial intelligence, driven by Carnegie Mellon University (CMU)[3]. Together with the University of Pittsburgh (Pitt), these three institutions are the core drivers of the new technology. The proximity of these institutions, all located in the Oakland neighborhood, has resulted in the designation of this neighborhood as an innovation district (Pittsburgh Innovation District (pittsburgh-id.com)).[4]

Philanthropic foundations also played an important role in the region's revival. In recent history, Pittsburgh's foundations have focused their activities and sought to make "transformative grants." An example is the Richard King Mellon Foundation which has financially supported CMU's work in advanced technologies and funded Hazelwood Green, an innovation hub, with $100 million. Thanks to strategic decisions like UPMC's early focus on building expertise in organ transplants[5] or CMU's investment in computer science and robotics, Pittsburgh today ranks among the most important innovation hubs in the world[6]. This is also apparent in the status of CMU, which is ranked as the top university in the world in artificial intelligence research and education[7]. However, this leadership is based on a fairly narrow range of research and the challenge will be to maintain and build on this status. To remain competitive among a select group of cities with similar innovative capacities, Pittsburgh is seeking to improve its position in the life sciences, particularly where they intersect with technology, to provide a stronger basis for future innovation. The University of Pittsburgh, ranked 8th in the world for medicine[8] and 26th in bioinformatics and computational biology[9], is a strong anchor in such an effort.

While universities in other innovative places create new firms that are spin-offs from their research, Pittsburgh's specialized expertise in artificial intelligence and computer science by contrast has attracted established companies, including Google, to locate in the city. Another economic development factor in the region's success is an "ecosystem" of organizations and institutions that assists startup tech companies with business, marketing, talent identification and retention, design, manufacturing, financing, and technical expertise. The Pittsburgh region has also benefitted from efforts of civic and higher education leaders who looked to learn from success stories elsewhere.

While the Pittsburgh economy has recovered from the massive decline in its historically dominant industry, development barrier legacies from its past remain, including a relatively older and less diverse population than comparable U.S. metropolitan areas. In addition, although

[3] CMU's Robotics Institute, the largest of its kind, was founded in 1979 and the School of Computer Science in 1988.

[4] https://www.pittsburgh-id.com/. Accessed October 17, 2022.

[5] UPMC established its Organ Transplant Surgery Center in 1981. It is today one of the largest such centers in the world.

[6] Capturing the next economy: Pittsburgh's rise as a global innovation city (brookings.edu)

[7] World's best Artificial Intelligence (AI) universities [Rankings] (edurank.org)

[8] 100+ Best Medical Schools in the World [2022 Rankings] (edurank.org)

[9] World's best Bioinformatics and Computational biology universities [Rankings] (edurank.org)

housing in Pittsburgh is relatively affordable, much of the housing stock, particularly within the central city's boundaries, is old and offers fewer amenities than is customary today. In addition, the decline of manufacturing jobs that offer higher than average pay has also created discontent among less technology-oriented workers and new industries have not expanded as quickly as hoped or are not offering similarly high wages[10]. These issues and their challenges are a reminder that economic development is an ongoing effort with no pre-defined endpoint.

3. Economic Structure

The Pittsburgh, PA Metropolitan Statistical Area includes Pittsburgh's urban core county, Allegheny, and six adjacent Pennsylvania counties (Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland). The region occupies 13,680 km^2 (5,282 square-miles) and has a population of 2,324,447. The MSA population has declined by 1.4% since 2010, and the decline includes a 2.2% reduction in working-age population (19-64). Allegheny County, with a population of just over 1.2 million, is the second largest in Pennsylvania. Among the 25+ population, 94% have at least a high school education, 16% have some college, 10% have an associate degree, 22% have a bachelor's degree, and 14% of the population has a graduate or professional degree.

Employment

The employed share of the regional labor force during the 2014-2018 period averaged 95.74% as unemployment nation-wide was at historically low levels. The *Food Services and Drinking Places* industry was the region's largest employer in 2018, followed by *Hospitals* and *All Other Retail*. These three industries account for a combined 18.71% of the Pittsburgh regional economy.

Figure 3.1 below summarizes the change in employment structure by industry from 2001 to 2019. Corresponding employment levels for each year appear in Appendix A. The total number of jobs in the most recent pre-COVID year was 1,494,261, up from 1,386,079 in 2001. 91% of the region's jobs are in private non-farm employment, which is dominated by the *Health Care and Social Assistance* industry at 14.9%, followed by *Retail Trade* (9.5%), *Government and Government Enterprises* (8.2%), and *Professional, Scientific, and Technical Services* (7.9%). *Accommodation and Food Services* follow at 8.2% and *Manufacturing* makes up 6.1% of the region's employment.

Table 3.1 lists 2001 and 2019 jobs, absolute and percent change, and the location quotient for the five fastest growing industrial sectors during the 2001 to 2019 period, ranked by percentage change. The location quotient, or LQ, is a measure of sectoral concentration relative to the distribution of employment in a reference region, in this case composed of all U.S. metropolitan regions (88.3% of all 201.6M U.S. jobs). A sector LQ of 1.0 has precisely the same share of total regional jobs as its counterpart sector's share of the reference region jobs. LQ values greater

[10] Sabrina Detrick, 1999. "The Post-Industrial Revitalization of Pittsburgh: Myths and Evidence." Community Development Journal 34(1), 4-12

than 1.0 indicate relative sectoral concentration of employment while values less than 1.0 identify sectors that are less well represented regionally than they are in the all-metro reference region. During the analysis period, the fastest growing sector – by far – is *Management of Companies and Enterprises*, which grew by more than 150%. The 1.88 LQ value for this sector also indicates that its employment share exceeds that of the all-metro reference region.

The 2001 data for the *Mining, Quarrying, & Oil & Gas* sector are unavailable, but as seen in the Appendix, Pittsburgh's 2019 employment in this sector exceeded 15,000 and its 2.57 LQ is the region's highest. This concentration is consistent with the region's energy-sector history and recent development of the Appalachian basin Marcellus shale natural gas play resources. The entire Pittsburgh region is enveloped by the Marcellus play.

Figure 3.1: Change in total full-time and part-time employment by NAICS industry: 2001-2019

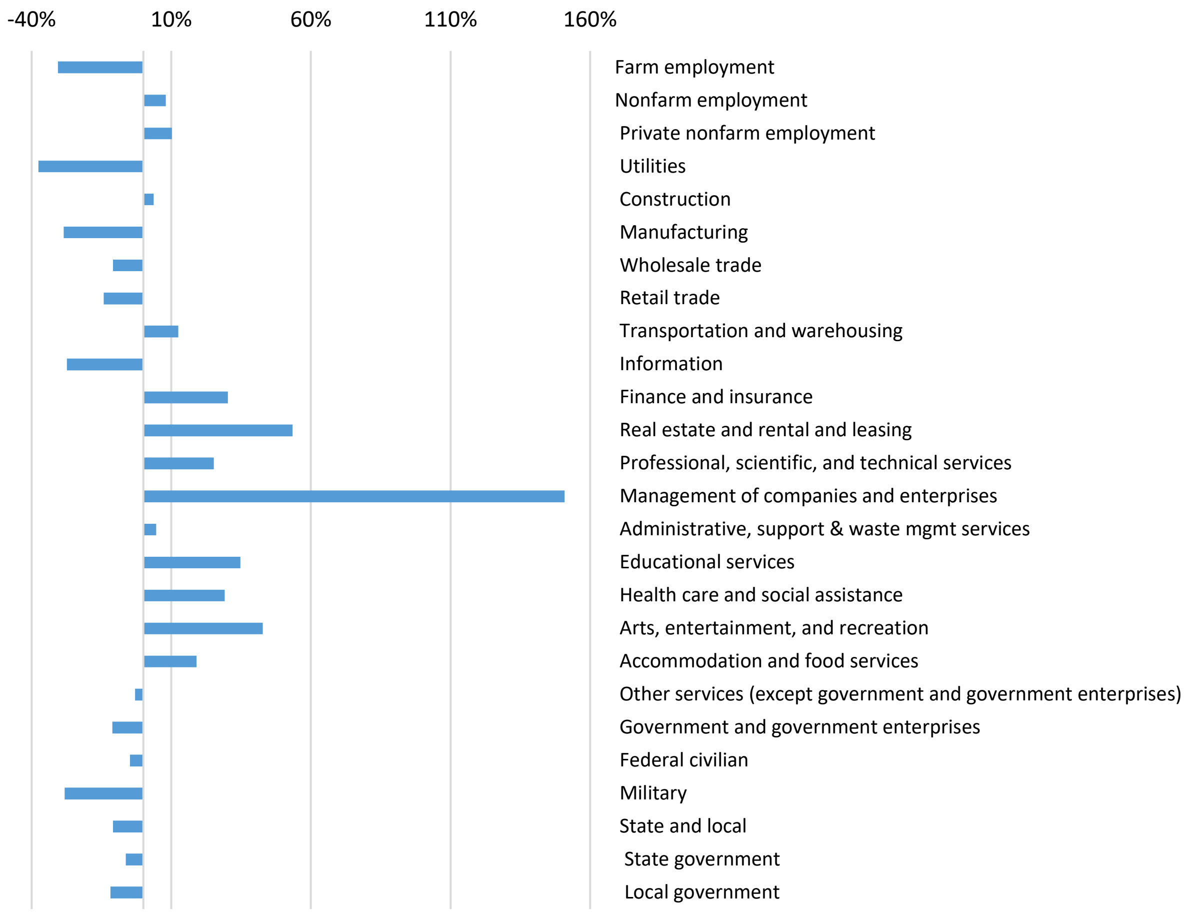

Table 3.1: Fastest growing industrial sectors, 2001-2019

Line Code	Description	2001 Jobs	2019 Jobs	Change 2001-2019	% Change 2001-2019	LQ
1300	Mgmt of companies & enterprises	16,488	41,358	24,870	150.8%	1.88
1100	Real estate and rental and leasing	37,266	57,177	19,911	53.4%	0.82
1700	Arts, entertainment, and recreation	26,190	37,391	11,201	42.8%	1.04
1500	Educational services	50,306	67,802	17,496	34.8%	1.76
1000	Finance and insurance	70,533	91,874	21,341	30.3%	1.13

Table 3.2 lists the same statistics for the industrial sectors with the five highest LQ values. *Management of Companies and Enterprises* again tops the list with its LQ value of 1.88. The second most concentrated industry relative to the all-metro reference region is *Educational Services*, highlighting their critical role in the Pittsburgh region's employment structure.

Table 3.2: Five most-concentrated industrial sectors relative to other U.S. metropolitan regions

Line Code	Description	2001 Jobs	2019 Jobs	Change 2001 - 2019	% Change 2001 - 2019	LQ
1300	Mgmt of companies & enterprises	16,488	41,358	24,870	150.8%	1.88
1500	Educational services	50,306	67,802	17,496	34.8%	1.76
300	Utilities	9,179	5,730	(3,449)	-37.6%	1.44
1600	Health care and social assistance	172,203	222,411	50,208	29.2%	1.28
1000	Finance and insurance	70,533	91,874	21,341	30.3%	1.13

4. Institutional Structure

The development path of the Pittsburgh region has been shaped in critical ways by its institutional structure. This section describes the unique character of the region's administrative configuration, university presence, and nongovernmental development organizations.

Administrative fragmentation

An important feature for understanding the politics of the Pittsburgh metropolitan area is its extreme administrative fragmentation, likely to be the highest in the United States. In Allegheny County alone, the county containing the City of Pittsburgh and the center of the larger metropolitan region, there are 130 local government entities, such as cities, townships, and boroughs. Combined they govern an area of 1,930 km^2 (740 square miles) and 1,250,578 (2020 census count) inhabitants. Since each of these governments has its own constituencies and objectives, the coordination of policies for the whole region can pose big challenges.

The fragmentation also limits the role of Pittsburgh's mayor, as many of the issues affecting the city are only incompletely under the city's jurisdiction. The mayor's authority is also restrained by the authority assigned to city council. Thus, the mayor must often persuade rather than direct or order.

Unlike many regions whose economic development paths have been tied to influential regional firms, Pittsburgh's high level of administrative fragmentation and consequently limited centralized authority created a context in which metro area development is and has been driven primarily by voluntary, multi-agency collaborations, cooperation with local and regional development organizations, and the strength and leadership of the academic sphere. The local and regional development organizations discussed next, have emerged in part as a response to these challenges.

Universities and the University of Pittsburgh Medical Center

The presence of highly ranked research institutions is an asset that has been critical to Pittsburgh's and its region's turnaround after the decline, particularly in employment, of the steel industry in the United States. The three most important of these are Carnegie Mellon University (CMU), the University of Pittsburgh (Pitt), and the University of Pittsburgh Medical Center (UPMC). The latter, with facilities throughout the region is the city's largest employer, followed by Highmark Health (insurance and health care provider), the United States government, and the University of Pittsburgh.

While all three of these institutions were important to sustaining the region's development efforts, interviewees reinforced the central role played by Carnegie Mellon University (CMU), which was the early driving force in the emergence of an important technology sector in Pittsburgh. Richard Cyert, who was CMU's president from 1972 – 1990,[11] set CMU on course to become a preeminent international center for computer science research and robotics and artificial intelligence. Himself an outstanding scholar with an international reputation, he led the school to national prominence "by implementing a strategy to pursue areas in which the university had the talent and expertise to make the most impact." Known for a willingness to make bold decisions and accept the accompanying risk, it was on his watch that the Robotics Institute and the School of Computer Science were established in 1979 and 1988, respectively.

Herbert Simon, who won the Nobel Memorial Prize in Economic Sciences in 1978, the Turing Award in Computer Science in 1976, and the National Medal of Science in 1986, shared the 1976 Turing Award with Allen Newell, who also received the National Medal of Science in 1992. These two outstanding scientists and CMU professors are credited with introducing artificial intelligence as a field of research and study in the 1950s.

Tom Murphy, Mayor of Pittsburgh 1994-2006 whom we interviewed, guessed that during his tenure, over 90 percent of startups where because of CMU. Another interviewee ventured that the Robotics Institute was probably two decades ahead of its time and results were, therefore, not immediately visible. Dr. Cyert's willingness to stay the course paid off richly in the longer run. Early in his presidency, he visited university leaders in North Carolina to learn from them what made the Research Triangle with Duke University, the University of North Carolina, and North Carolina State University, successful.

[11] https://www.cmu.edu/leadership/president/past-pres/index.html. Accessed October 16, 2022.

Local/regional development organizations

This list of organizations is incomplete and does not include all influential players in economic development. Rather, we chose the most visible and successful or, particularly in the case of organizations providing venture capital, ones that are representative. The role of foundations as supporters and sometimes co-instigators of development initiatives is important because their support shifted over time from relatively unfocused grant funding to "transformative" projects and program related investments. Thus, they made several very large grants, as much as $100 million, in support of an individual project. On several occasions they provided seed money that may otherwise not have been available. Largely due to the administrative fragmentation and lack of strong central authority, foundations sometimes pushed the city in positive directions as conditions for their monetary support. In many other industrial cities, foundations established by individuals who earned their fortunes in those cities aimed their support activities to places and institutions elsewhere. By contrast, large foundations in Pittsburgh focused their spending on this region. Carnegie-Mellon University is one of the institutions that was able to reach excellence thanks to the Mellon and Carnegie foundations.

Allegheny Conference

This is the oldest of the organizations discussed here. A particularly important strength is its ability to act as a trusted convener for formulating, discussing, and reaching consensus among diverse stakeholder on issues affecting the whole region. On its website it stresses that "The Allegheny Conference has a rich history of bringing together the region's public and private leadership over two generations to improve the economy and quality of life of the 10 counties of southwestern Pennsylvania" (Allegheny Conference —History - Allegheny Conference).[12]

The Allegheny Conference on Community Development was founded in 1944. Its initiators included the president of the Carnegie Institute of Technology (became Carnegie Mellon University in 1967). Its makeup encouraged collaboration between civic and business leaders and the leaders of the region's major educational institutions in support of regional development. According to one account, [13]

> During World War II, Pittsburgh Regional Planning Association President Richard King Mellon, Carnegie Institute of Technology President Robert Doherty and others were able to generate support among civic leaders to create a postwar planning committee. Incorporated as the Allegheny Conference on Community Development in 1944, the new organization served as a prominent coordinating mechanism for civic action –a vehicle to organize the private sector to work in partnership with government to improve the region's economy and quality of life.
>
> Initial sponsors included key officials of the public sector – Pittsburgh Mayor David L. Lawrence and Allegheny County Commissioner John Kane – and major segments of the private

[12] https://www.alleghenyconference.org/about/history/. Accessed October 16, 2022.

[13] https://www.alleghenyconference.org/wp-content/uploads/2016/08/AlleghenyConferenceHistory.pdf. Accessed November 13, 2022.

sector. Older private civic organizations provided initial leadership for the Conference until the late 1940s, when more corporate CEOs joined the executive committee. The Conference built consensus around existing proposals and focused support for those initiatives. It used persuasion to achieve community goals and formed partnerships with other agencies.

Among Allegheny Conference's first efforts was the successful drive to improve the then very poor air quality in the Pittsburgh metropolitan region, which was threatening its ability to attract industrial and business talent and investment.

In the 1990s, the Allegheny Conference expanded its geographic reach when it helped start the Southwestern Pennsylvania Growth Alliance. The Alliance brought together ten counties to coordinate requests to the state legislature for funding for development projects. The size of the Alliance was chosen to ensure that it had a sufficient number of members in the state legislature to pass the region's funding requests for its projects in the competition among the state's regions for such funds. In this, it has been successful in identifying and approving priority projects in its region and obtaining funding for them through the Alliance's coordinated efforts. These successes also encourage the continued participation of the local governments.

Another affiliate of the Allegheny Conference is the Pittsburgh Growth Alliance. It contains the same ten counties as the Southwestern Pennsylvania Growth Alliance, but differs in its mission, which is the marketing of the region to site selection consultants, prospective businesses, as well as individuals. It understands itself as a "development marketing group" for the region (About Us - Pittsburgh Region. Next is Now.).[14]

Ben Franklin Technology Partners

This organization was created in 1983, when the steel industry was in deep crisis and employment in the larger region's coal industry was also rapidly decreasing. It is a source of venture capital and maintains business incubators in support of start-up enterprises. This effort, which includes the Pennsylvania Department of Economic and Community Development, covers the whole state and is subdivided into four regions. Pittsburgh is part of the Southwest Pennsylvania region that includes nine counties; seven of these counties are adjacent to Allegheny County. The offices for this region are in Pittsburgh.

Heinz Endowments

The Heinz Endowments is a large grant-making foundation currently supporting projects and programs with more than $70 million a year.[15] It targets grants to southwestern Pennsylvania but considers applications from elsewhere. It strives to fund programs and projects that bring about "transformative change." Past awards supported cultural and educational programs and institution, as well as the acquisition of blighted and abandoned lands to transform them into urban green space. As noted below, the Heinz Endowments also shared the cost of an influential Brookings Institution study that resulted in the establishment of Innovate PGH.

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[14] https://pittsburghregion.org/about-us/. Accessed October 16, 2022.

[15] https://www.heinz.org. Accessed October 17, 2022.

PGH Innovation Works

Innovation Works strive to create a supportive eco-system for technology startups. It assists with securing funding, networking, and expertise. Since its beginning in 1999, Innovation Works has invested over $110 million and generated $3.3 billion on follow-on investment (Innovation Works).[16] It is also a partner of Ben Franklin Technology Partners. Relationships among different economic development organizations, private and public, are an important factor in their success as is helps with finding specialized expertise and disseminating information. The organization's webpage lists current startups and 32 companies that have either successfully established themselves and no longer need the services or have been acquired by an established company.

Innovate PGH

The focus areas of Innovate PGH (short for Pittsburgh) are artificial intelligence, life sciences and digital health, and advanced manufacturing.[17] It represents a coalition of important public and private institutions, such as Allegheny County, the City of Pittsburgh, the University of Pittsburgh and the University of Pittsburgh Medical Center, Carnegie Mellon University, the Allegheny Conference on Community Development, and several regional philanthropies. It was launched in 2018 based on recommendations in a report by the Brookings Institution. The Brookings study was funded by the Heinz Endowments and the Hillman Foundation. It is but one example of the significant role played by foundations in shaping and supporting the region's economic development.

A major objective of Innovate PGH is to increase the region's reputation and ability to function as a major international innovation hub. It is located in Oakland, the neighborhood of Pittsburgh that is home to the University of Pittsburgh, Carnegie Mellon University, and the main seat of the University of Pittsburgh Medical Center.

Metropolitan Planning Organization

The Southwestern Pennsylvania Commission (SPC) is the ten county region's Metropolitan Planning Organization, charged with planning, coordinating, and prioritizing state and federal transportation funds allocated to the region (Southwestern Pennsylvania Commission | pittsburghpa.gov).[18] Its efforts serve to improve the coordination of public transportation services from one jurisdiction to another. It is organized as a non-for-profit organization.

Pittsburgh Technology Council

The Pittsburgh Technology Council (PCT) was founded in 1983 during a time of economic crisis during which steel industry employment declined precipitously and had not yet reached its bottom.[19] PCT's primary mission is assisting with government relations, business development,

[16] https://www.innovationworks.org/. Accessed October 16, 2022.

[17] https://innovatepgh.com/about-1. Accessed October 17, 2022.

[18] https://pittsburghpa.gov/bac/southwestern-pa-com. Accessed October 16, 2022.

[19] https://www.pghtech.org. Accessed October 17, 2022.

talent retention, and marketing and visibility. It currently has 17 staff members and a well-connected board of directors that includes the University of Pittsburgh's Vice Chancellor for Research and Carnegie Mellon University's Dean of the College of Engineering.

Pittsburgh Works Together

This organization is a collaboration between business and labor unions.[20] Its focus on manufacturing makes it an economic development organization with a more traditional focus than those mentioned above. Momentum for its creation was in part a response to the inability of many dislocated workers to find productive alternatives in the face of Pittsburgh's traumatic structural economic change. It was created in 2020 and has not yet had a long time to create a record. However, it shares with other organizations mentioned in this report that its geographic focus goes well beyond the City of Pittsburgh to Southwest Pennsylvania and occasionally even farther beyond.

5. Interviews and Insights

Prior to the interviews, we provided each respondent with the following information to shape the conversations.

> To help focus our discussion, we want to give you just a bit more information regarding the project and its objectives. Writ large, the City of Vienna is seeking insights on how other cities achieve a strong economy along with high quality of life. Vienna would be most pleased to have in hand some economic success stories whose development path might be generalized and replicated in Vienna. There will be two parts to reports from each of several cities, one on the environment that has facilitated and enabled successes, and a second on the specifics of successful developments.
>
> We invite you to contribute to one or both foci as you see fit:
>
> - Contextual
>   - Policies and regulatory structures and changes that have contributed to successful development
>   - Nongovernmental organizations that have been successful in facilitating local economic development
>   - Other important characteristics of the local economic development milieu
> - Vignettes
>   - Descriptions of specific economic development success stories that are consistent with the quality-of-life

We also believe that Vienna is more focused on emerging trends than merely on employment growth, though the potential for contributions to employment levels is surely a plus.

Interviewees included:

[20] https://pghworks.com. Accessed October 17, 2022.

- Christopher Briem, Regional Economist, Center for Social and Urban Research, University of Pittsburgh
- Bill Flanigan, Chief Corporate Relations Officer, Allegheny Conference
- Tom Murphy, ex-Mayor, Pittsburgh
- Sean Luther, Executive Director, Innovate PGH

All interviewees commented on the role and importance of CMU, UPMC, and Pitt as critical assets in the economic recovery, and the economic development organizations plus foundations for providing ideas and direction and supporting the region's economic development.

Christopher Briem

Our first interviewee was regional economist Christopher Briem. He provided an informed overview of how Pittsburgh progressed from having a severely depressed economy to being considered a successful innovation hub and offering a high quality of life. A key moment in the re-emergence of Pittsburgh was the G-20 summit in 2009 because it brought journalists from across the United States and the world to the city. In addition to reporting on the summit, many visited different neighborhoods of the city and found them different (better, more interesting) than they had expected. The result were positive articles about Pittsburgh in the national and international press that changed its reputation as being part of the "rust belt.".

On quality of life issues, he cautioned us not to overlook that comparatively low housing prices were not only the result of a good supply of affordable housing, but also of the age of a large portion of the City of Pittsburgh's housing stock. In addition, he mentioned that traditional manufacturing, which made the region successful in the past, still had powerful supporters.

Tom Murphy

Tom Murphy was elected Mayor in 1994 and had previously served in the state legislature and understood how state government works. This was important for addressing issues too large for the city to fund that needed state funding to succeed. He credits the team that he was able to bring together, his "cabinet," with the success of the Mayor's Office.

His goal was to change the economy and create a city "with an entrepreneurial spirit." The Ben Franklin Partnership played a central role in this effort because entrepreneurship can flourish only if there is venture capital to support new ideas and approaches. Therefore, although Pittsburgh was at the time financially stressed, he ordered the creation of a venture fund by reducing municipal spending. This was not popular as the city eliminated or did not fill some 150 jobs, including police officers, but the workforce reduction enabled a $6 million shift from the city's municipal budget to what became known as the Pittsburgh Development Fund. Most of this money was used to purchase 6.07 km^2 (1,500 acres) of land to use as a development catalyst. The city further required that its municipal pension fund devote two percent to investment in venture capital.

A specific example of how this was accomplished concerns the opening of a Home Depot (big box) home improvement store in the city. Home Depot until then had built its large stores in suburban areas with immediate freeway access. Company representatives were not interested in the proposed location. The mayor contacted his Atlanta, Georgia counterpart, where Home Depot has its corporate headquarters. Through the office of the mayor of Atlanta, he established the contact with Bernard "Bernie" Marcus, the co-founder of this company. Tom Murphy and his team were eventually able to persuade Home Depot to build a store in East Liberty, a then struggling Pittsburgh neighborhood. This store became one of the company's most successful stores and provided jobs, including eventually managerial jobs, to residents of this neighborhood. This success encouraged the City of Pittsburgh to also pursue an expression of interest from Whole Foods, which then built its first and enormously successful store in the Pittsburgh region.

New baseball and football stadiums and a convention center were built shortly after Mayor Murphy's election. He credits these projects with creating $1.5 billion in additional development. His administration also dealt with public housing, by razing some 6,500 units and then in a public-private cooperative effort, building a slightly larger number of new ones. In the mayor's words, "the city was willing to invest in individuals when their interests coincided, and the city became an investment partner with private developers.

Among development projects, the newly established waterfront trails have been a dramatic change from the 1980s. Southside Works (Southside Works)[21] today is a premier example of Pittsburgh's riverfront redevelopment for recreation, housing, retail, and offices. Public waterfront access was made a requirement for riverfront business development and, as a result, there is now a continuous trail that goes as far as Pennsylvania's capital in Harrisburg and to Washington, DC.

Bill Flanagan

Allegheny Conference on Community Development (AC) is a very important institution in the Pittsburgh region's redevelopment success; Bill Flanagan serves as its Chief Corporate Relations Officer. In 2009 he served as the chair of the G-20 partnership, a public-private effort, that welcomed participants of the G-20 Summit (Bill Flanagan Biography (alleghenyconference.org)). In commenting on AC's role in creating the Southwest Pennsylvania Growth Alliance, he mentioned that it helped create a sense of place for the Pittsburgh Region where "Pittsburgh" is the recognizable brand. It also provides the region with an effective lobby and representation with state government by being represented by 47 members of the state house and 13 state senators. This has led to more state-supported projects in the region and is a strong incentive for the counties to participate.

Like other interviewees, he commented on the administrative fragmentation of the region and noted, however, that if Allegheny county were a single city, it would occupy rank 10 in the country's city hierarchy while Pittsburgh is presently ranked 68th based on population. Many of the cities ranked above Pittsburgh, were able to grow through annexing neighboring towns and cities. Pittsburgh was last able to annex two adjacent communities in 1955 and the most active period of annexations occurred in the early 1900s.

[21] https://southsideworks.com. Accessed October 16, 2022.

Sean Luther

Sean Luther, a Pittsburgh native, joined Innovate PGH in 2017, after having previously worked on economic development with organizations elsewhere. Like many others, he mentioned the region's political fragmentation, which made coalition building indispensable. For this reason, economic development in Pittsburgh has not been a "city-driven push."

Private foundations and university leadership cooperation have been critical. The University of Pittsburgh and especially CMU have been leading partners. The latter has a particularly strong technology transfer orientation. Vienna might well benefit from finding a way to replicate the way universities and business (co)operate here. Whoever figures out how to facilitate this will likely find great success.

Compared to European cities, there is little centralized federal ability to initiate local economic transformation. In the United States, cities are more accurately described as competing for new activities, funding, and investments than responding to federally driven initiatives, an approach that is seen by many as a race to the bottom.

Another critical difference between the EU and the United States is that many, if not most U.S. cities are entering into a post-industrial phase, whereas in the EU there seems to be a stronger tendency to hold on to and prolong manufacturing as an economic foundation. So, whereas Pittsburgh is truly a post-industrial city, European cities are more like "also-industrial" cities. This makes it imperative for Pittsburgh to make the tech economy work, because having largely left steel behind, without the tech economy there is little to nothing else for the city's future.

Mr. Luther cited Duolingo, established in 2009, as one of the success stories in Pittsburgh's new economy. This company, which distributes a scientifically based language learning app, could have left Pittsburgh but did not because the city is a good location for it. This was not a traditional university spinoff, though it was founded by a CMU professor and one of his Ph.D. graduates. The former had once before created a successful company that he later sold to Google. In other words, this was a team with experience that "… was brilliant and had the means of making a successful venture" (Sean Luther). This company has gone public and has a market valuation of $3.9 billion and about 700 employees.

But most of Pittsburgh's successes are more subtle and are the cumulative outcomes of seeds planted and decisions taken long ago. Leaders developed coalitions, collaborated and cooperated – necessitated by fragmented governmental structures – picked paths and, often despite popular opinion, stuck with them to create the innovative milieu that is now present in the Pittsburgh region. An example of a Pittsburgh success is IRobot in Boston (iRobot®: Robot Vacuums and Mops) which relies on technology developed in Pittsburgh.

The relationships between technology firms and research universities in Pittsburgh have so far not led to the creation of the kinds of large and internationally dominant firms as some that have originated in Silicon Valley or Boston. On the other hand, some large technology companies established facilities in Pittsburgh because of CMU's leadership in robotics. Google's autonomous driving research facility is the most prominent example. It succeeded in Pittsburgh because it was able to hire key members of its research team from CMU. Even earlier, Seagate, a large data storage company, came to Pittsburgh in the late 1990s and hired a CMU professor to lead its research facility. However, there are no companies created in Pittsburgh that have reached the dominance and stature of examples such as Cisco in Silicon Valley, Amazon in Seattle, or Grubhub in Boston. Some tech flagships are in Pittsburgh because of relationships with technology expertise. Argo AI, founded in 2016, is a successful pioneer in autonomous driving and has a market capitalization of $7.5 billion and employs some 1,800 workers. One of the two cofounders graduated from at the University of Pittsburgh, later worked for CMU and then for Google's autonomous driving program in Pittsburgh. The second cofounder earned an engineering Ph.D. from CMU. It did not go through the "normal" incubator process that many startups choose, but Pittsburgh's breadth and depth of expertise in this specialty, which began at CMU, was the key ingredient. This also persuaded Google in 2019 to locate its development unit in Pittsburgh. Such a research and development program would have been much more challenging to establish elsewhere.

Today's most successful innovation hubs are highly concentrated in urban environments and there is potential competition among them. Therefore, Pittsburgh cannot rely on its recent successes or it may lose to cities elsewhere. Thus, although Pittsburgh has great expertise in robotics, it has not yet successfully integrated this expertise with, e.g., health care services. In robotics, Boston is its most serious competitor and Detroit "is coming for the autonomous driving industry." In addition, Pittsburgh has inherited a legacy from its past that is still shaping the ways it is viewed, even by residents, as a traditional site for heavy industries and not as a world-class innovation hub.

6. Summary and Conclusions

The economic development story of the Pittsburgh regional economy scribes a long historical arc. From its early prominence as a steel industry giant in the latter half of the 19th century through the demise of steel in the latter half of the 20th century and to its transition to a major technology industry hub in recent decades, Pittsburgh has exhibited an ability to adapt to inevitable technological change and transition successfully to become the vibrant economic region we see today. "If there is a Pittsburgh lesson, it is that change is possible. There were few regions as specialized in just one thing the way Pittsburgh was for more than a century. Few would have imagined there was a future for Pittsburgh without steel."[22]

Far from an overnight success, the transition from steel to a modern dynamic economy has not been without immense challenges. Many in positions of influence were – and some continue to be – ardent supporters of the traditional historical reliance on heavy industry and manufacturing as the source of economic growth and development. Some would have replaced the declining manufacturing base in the heart of the city with similar heavy industrial activity, which likely would have preempted the city's environmental improvements and enhanced cultural milieu.

[22] Chris Briem, https://www.bizjournals.com/pittsburgh/print-edition/2014/07/04/christopher-briem-quantifying-pittsburgh-s.html. Accessed October 17, 2022.

Bold and visionary decisions taken over the last half century, often in the face of stiff opposition, laid a foundation for the Pittsburgh of today. Those who made these decisions began by identifying strengths and synergies. They developed long-run goals and objectives and developed strategies and tactics to achieve them, then had the courage to stay the course, sometimes in the face of staunch opposition and despite many potentially attractive intervening opportunities. They eschewed each "next big thing" and stayed the course. The story of Pittsburgh is counterpoint to economic development quick hits. As case in point, the city financed a national robotics center in the 90s, well ahead of its time, but the decision and the investment paid handsome dividends, as CMU is now one of the premier robotics centers in the world.

Partnership building is essential. A notable Pittsburg example is the group of 26 different partners in the development of the downtown Pittsburgh stadia (Tom Murphy). Nevertheless, successful economic development strategies are often tied strongly to specific individuals who champion their vision of the future and, while listening to constituents, are willing to make unpopular decisions and take actions that will alienate some. Necessary and substantial changes more often come from conflict than consensus. As case in point, in promoting the development of two of Pittsburgh's ballparks and a convention center, policymakers put to referendum a sales tax increase of 0.5%. When the referendum failed 30% to 70%, they decided despite opposition to find a way to pursue other funding and built the 26-partner coalition, and the projects became reality.

As Mayor Murphy stressed, in economic development strategies, people must accept that what a city was once is not necessarily what it will be in the future. Economic development professionals must recognize that a city's future might bear little resemblance to its past. The key is to know what you want, find the partners you need, and choose not to worry about the present if the plan for the future is correct. Risk aversion and analysis paralysis are barriers to effective economic development. Build with enthusiasm and strategic vision and know that economic development is an ongoing process where "success or failure will be determined by the speed and scale of actions taken by public, private, and civic leaders."[23]

[23] Andes, Scott. "Capturing the Next Economy: Pittsburgh's Rise as a Global Innovation City, (Washington DC: Brookings Institution, 2017). https://www.brookings.edu/wp-content/uploads/2017/09/pittsburgh_full.pdf. Accessed October 17, 2022.

Appendix: Employment by Industry, 2001-2019

Table A. 1: CAEMP25N Total full-time and part-time employment by NAICS industry 1/ (number of jobs); Pittsburgh, PA (Metropolitan Statistical Area)

Line Code	Description	2001	2019	Change	% Change	LQ
	Employment by place of work					
10	Total employment (number of jobs)	1,386,079	1,494,261	108,182	7.8%	1
	By type					
20	Wage and salary employment	1,187,028	1,227,489	40,461	3.4%	1.05
40	Proprietors' employment	199,051	266,772	67,721	34.0%	0.81
50	Farm proprietors' employment	8,078	5,777	(2,301)	-28.5%	0.89
60	Nonfarm proprietors' employment 2/	190,973	260,995	70,022	36.7%	0.81
	By industry					
70	Farm employment	9,970	6,921	(3,049)	-30.6%	0.64
80	Nonfarm employment	1,376,109	1,487,340	111,231	8.1%	1.00
90	Private nonfarm employment	1,237,833	1,364,445	126,612	10.2%	1.04
100	Forestry, fishing, and related	(D)	1,127	(n.a.)	(n.a.)	0.22
200	Mining, quarrying, & oil & gas	(D)	15,365	(n.a.)	(n.a.)	2.57
300	Utilities	9,179	5,730	(3,449)	-37.6%	1.44
400	Construction	83,643	86,670	3,027	3.6%	1.06
500	Manufacturing	127,585	91,227	(36,358)	-28.5%	0.99
600	Wholesale trade	50,852	45,300	(5,552)	-10.9%	0.92
700	Retail trade	164,939	141,575	(23,364)	-14.2%	1.03
800	Transportation and warehousing	53,399	60,081	6,682	12.5%	0.85
900	Information	30,578	22,213	(8,365)	-27.4%	0.82
1000	Finance and insurance	70,533	91,874	21,341	30.3%	1.13
1100	Real estate and rental and leasing	37,266	57,177	19,911	53.4%	0.82
1200	Professional, scientific, and tech svcs	94,259	118,052	23,793	25.2%	1.03
1300	Mgmt of companies & enterprises	16,488	41,358	24,870	150.8%	1.88
1400	Admin, support & waste mgmt svcs	71,216	74,502	3,286	4.6%	0.76
1500	Educational services	50,306	67,802	17,496	34.8%	1.76
1600	Health care and social assistance	172,203	222,411	50,208	29.2%	1.28
1700	Arts, entertainment, and recreation	26,190	37,391	11,201	42.8%	1.04
1800	Accommodation and food services	88,266	105,072	16,806	19.0%	0.93
1900	Other svcs (excl gov't & gov't enterprises)	81,947	79,518	(2,429)	-3.0%	0.93
2000	Government and government enterprises	138,276	122,895	(15,381)	-11.1%	0.70
2001	Federal civilian	19,275	18,356	(919)	-4.8%	0.84
2002	Military	8,661	6,219	(2,442)	-28.2%	0.44
2010	State and local	110,340	98,320	(12,020)	-10.9%	0.70
2011	State government	17,054	15,987	(1,067)	-6.3%	0.40
2012	Local government	93,286	82,333	(10,953)	-11.7%	0.82

Source: Bureau of Economic Analysis (https://apps.bea.gov). Legend/Footnotes: 1/ The estimates of employment for 2001-2006 are based on the 2002 North American Industry Classification System (NAICS). The estimates for 2007-2010 are based on the 2007 NAICS. The estimates for 2011-2016 are based on the 2012 NAICS. The estimates for 2017 forward are based on the 2017 NAICS. 2/ Excludes limited partners. Metropolitan Areas are defined (geographically delineated) by the Office of Management and Budget (OMB) bulletin no. 20-01 issued March 6, 2020. (D) Not shown to avoid disclosure of confidential information; estimates are included in higher-level totals. Last updated: November 16, 2021-- new statistics for 2020; revised statistics for 2016-2019.

Urban Manufacturing in San Francisco

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

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June 13, 2023

A note about geographic definitions. The report uses a flexible definition of the city region, depending on data availability and the analysis level.

- MSA: The broadest definition is the Metropolitan Statistical Area (MSA). An MSA is a multi-county geographic construct that attempts to encompass areas of urban concentration in terms of population and economic activity. The MSA definition is a statistical unit of analysis assigned by the U.S. Census Bureau and not a political unit. While MSAs generally include counties that form the region's industrial core, they may also include counties that are mainly residential, commercial, or governmental and, therefore, outside the main scope of analysis. However, because some economic data are readily available at the level of MSAs, the designation is used as a matter of convenience for some of the analysis.
- CORE CITY-REGION: A more focused geographic designation is the "Core Region." This consists of several counties surrounding the primary city containing the most industrial activity. Since more detailed sectoral statistics tend to be available at the county level, this customized collection of countries is used to reduce "noise" in the analysis.
- CITY: The most constrained geographic definition used in the study is the jurisdiction of the region's primary city, which is generally the most densely developed, most congested, has the highest operating costs, and has the highest level of contention over land uses. We mainly focus on industrial policies at this level.

We will use these designations throughout, although the MSA has been shortened after initial use, and Core City-Region has been shortened to Core Region. Our analytic strategy begins at the MSA level to pick up broader regional trends, then focus on the Core Region to investigate industrial structure in detail, and finally to conduct interviews and investigate policies as close to the City level as possible to observe the position of urban manufacturing where it is likely to come under the most extreme pressure. The logic is that if manufacturing occurs in high-cost urban settings, there must be good reasons for it! **In the case of San Francisco, we combine the San Francisco-Berkeley-Oakland and San Jose-Sunnyvale-Santa Clara MSAs because of the importance of "Silicon Valley" – which spans counties located in the two MSA – in driving the regional economy. The more focused City-Region excludes counties in the two MSAs that are mainly residential or rural to arrive at a four-county area consisting of San Francisco, Alameda, San Mateo, and Santa Clara counties. We refer to this more focused region colloquially as the San Francisco Bay Core Region.**

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1. Geographic situation

The geographic situation of the San Francisco study area relative to the United States and the other regions included in this study is shown in Figure 2.1. This analysis includes the San Francisco and San Jose MSAs in the broad analysis and a Core Region defined by the four-county area of San Francisco, Alameda, San Mateo, and Santa Clara counties. This region spans the two MSAs and has Silicon Valley at its heart. The ICT-related industries spawned by Silicon Valley companies now dominate the economies of all four Bay Area counties and have spilled over into adjacent counties excluded from our analysis, including Marin, Contra Costa, Solano, and Sana Cruz.

2. Historical background

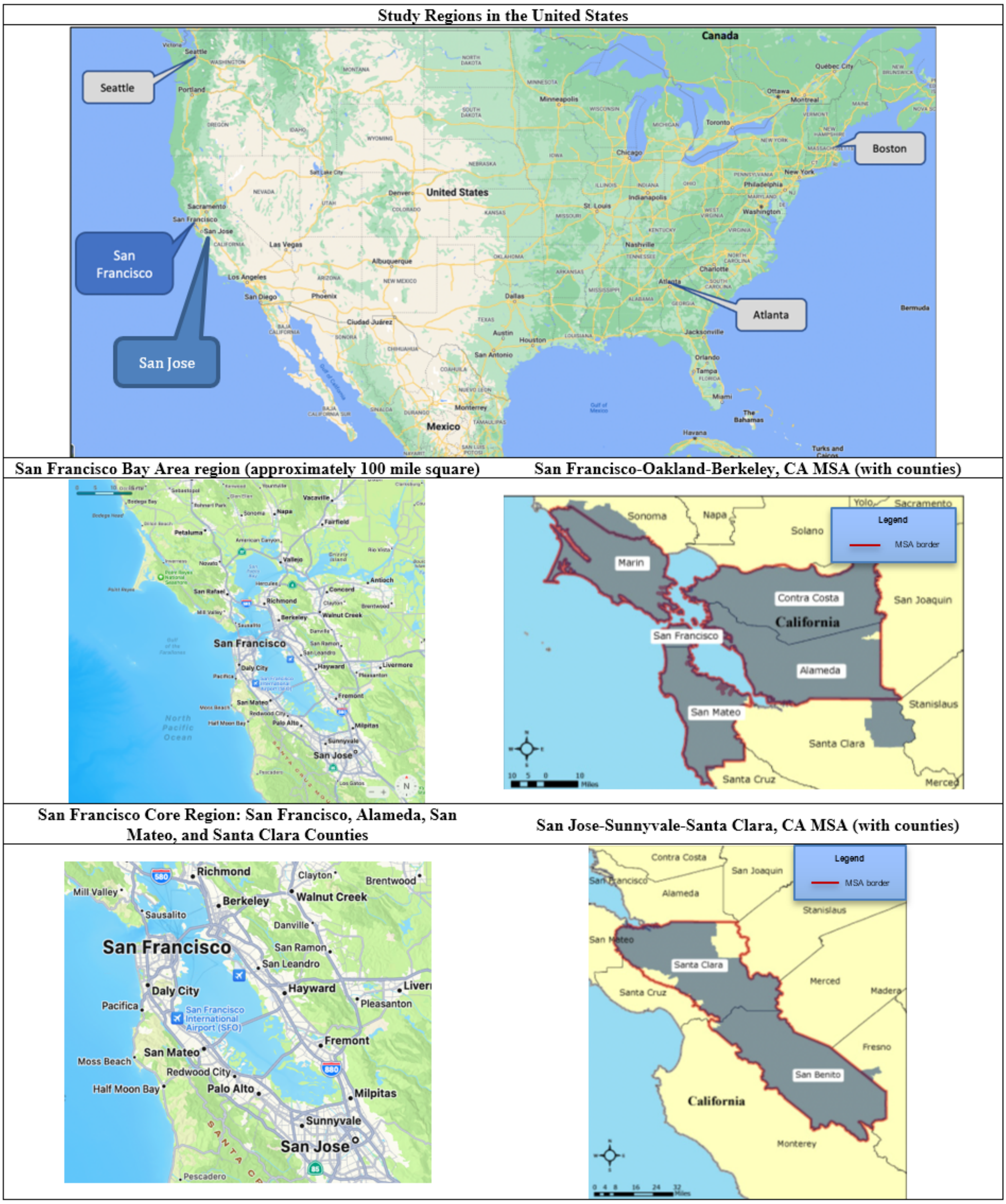
The region's industrial origins lie in the emergence of the City of San Francisco in the second half of the 19th Century. Like the other American cities in our study, San Francisco's early development was heavily influenced by its role as a transportation hub. San Francisco Bay is very unusual on North America's western shore because of its scale and scope. Yet, the relatively small mile-long opening to the Pacific Ocean, often hidden by the tule fog that commonly forms when hot weather inland draws cold air from the sea, led the first Spanish explorers to sail right past it as they mapped the shoreline (Golden Gate Highway and Transportation District, no date).

San Francisco was the first major city on the West Coast. Originally inhabited by Native Americans, the Ohlone. The Spanish arrived in 1726 and inhabited the place until 1821 when Mexico gained its independence from Spain. Mexico briefly held California until Americans seized it during the Mexican-American War of 1846-1848. Soon after the U.S. gained possession, the Bay area and the city became the center of commerce, supporting the gold rush of 1849 in the foothills and rivers of the Sierra Nevada Mountains, located about 200 miles inland. The city grew from 1,000 to 25,000 in a year, and San Francisco's position as the West Coast hub for business, finance, and manufacturing was cemented (National Geographic, no date).

From Cars to Trains: Regionalism and the Build Out of the Bay Area

The Second World War shaped much of San Francisco's urban patterns. As men boarded ships to attend the Pacific war and then returned, their families grew in the area. Much of the city's affordable housing stock was built during the war to house women and children of sailors and soldiers. After the war, thousands of individuals and families who experienced San Francisco during WWII either did not return home to their birth state or, soon after the war, migrated to San Francisco to live full-time in the city or elsewhere in the Bay Area. Between 1940 and 1950, the city gained 100,000 new residents. Rapid population growth pushed city infrastructure, housing, roads, and residential services to the breaking point (Mosier, no date).

Figure 2.1: San Francisco and San Jose in geographic context



Sources: Google Maps, Apple Maps, U.S. Centers for Medicare & Medicaid Services (https://www.dmecompetitivebid.com/palmetto/cbicrd2.nsf/DocsCat/Round%202~Competitive%20Bidding%20Areas~Boston-Cambridge-Quincy%20MA-NH~9K3PZB7325?open&navmenu=| |)

Manufacturing in San Francisco

While San Francisco is not known for heavy industry manufacturing, like other major American cities, such as Detroit and Chicago, it has a rich industrial history in shipping, manufacturing, and technology industries. San Francisco's industrial history can be traced back to the Gold Rush era of the mid-19th century when the city emerged as a major port and transportation hub. The city's deep-water harbor allowed large ships to dock and unload goods, making it an important center for trade and commerce. The Transcontinental Railroad's construction in the late 1800s further cemented San Francisco's role as a transportation hub, connecting the city to the rest of the country.

In the early 20th century, San Francisco became a manufacturing and industrial innovation center. The city was home to several manufacturing industries, including textiles, food processing, and shipbuilding. Levi Strauss invented blue jean trousers during the Gold Rush, and while manufacturing has long moved to Mexico and Asia, the company is still headquartered in San Francisco.[1]

The city's shipbuilding industry boomed during World War II, with numerous shipyards producing vessels for the war effort. The build-up for the Second World War, brought with it the growth of manufacturing outward toward the city of Oakland and up the northeastern side of the S.F. Bay toward Sacramento.

Given the topography of San Francisco, the ability of manufacturing to grow endlessly was not possible. San Francisco was initially based on manufacturing goods and services necessary to grow an isolated region.[2] San Francisco is a residential city as much as a commercial or industrial city. Over its life, the city has had big land-consuming industries, particularly in the mid-20th century, but the majority of the evidence of those industries is now gone, replaced by residential and commercial development.

Like the eastern seaboard, the coasts of southern and northern California were commandeered by the federal government during Second World War (National Park Service, no date). They had a tremendous impact on the development of the city of San Francisco and the Bay Area more generally. The Presidio was the most important Army Post on the Pacific shore. Around the Bay, shipyards, armaments factories, and other Navy and Army facilities breathed life into the Bay Area's economy. After the Second World War, the city lost much of its manufacturing, including the goods distribution and maritime industries. You can still see the remnants of the maritime industry when you travel along the Presidio and the Embarcadero. At one point, 15 or 20 quays were supporting the processing of goods sailing in and out of the city (ibid).

To the south of the city, high-tech industries of the 1960s were growing in counties surrounding the city of San Francisco. At the end of the Second World War, the rapid dissolution of war-related manufacturing was replaced by growth in commerce, including banking, finance,

[1] https://www.levistrauss.com/who-we-are/history/

[2] In the next section, we will discuss growth in the surrounding area of San Francisco, focusing on the most recent developments of technologically related industries.

legal services, and other activities. In short order, the city transformed from its typical four-story urban architectural form to 60 and 70-story office buildings. In 20 years, from the 1960s to the 1980s, San Francisco shifted its economic base from manufacturing and distribution to finance and business services (Council on Tall Buildings and Urban Habitat, no date).

By the end of the 1980s, many manufacturing facilities had shut down. Factories such as automobile assembly, home goods, and other industrial products ceased operations as companies bent out of business or moved production to lower cost locations in the U.S. or internationally. By the beginning of the 1990s, manufacturing facilities were being torn down or converted into office or residential spaces (Stacker, 2023). The downtown land use pattern grew up rather than out, hemmed in by the city's residential settlement pattern. Alongside the change in building style, residential sprawl began to fill the eastern and northern counties past Marin and into Solano and Contra Costa County.

In addition to producer service sector growth, San Francisco drew millions of tourists yearly to visit attractions found in the city. Tourism expanded starting in the late 19th century and continued unabated through the 20th century. By the end of the 20th century, estimates are that 14% of the city's private sector jobs catered to visitors from distant locations.[3] As the San Francisco airport expanded, so did tourism; soon, international tourism overtook domestic tourism, boosting the city into the world's list of the top 20 most visited cities.

In the 2000s, the growth of Silicon Valley began to have a significant impact on the City/County of San Francisco. Workers from burgeoning Silicon Valley-based internet and social media companies, including Google and Facebook began occupying office space in the City's neighborhoods. Former manufacturing sites were converted into office and residential spaces. This increased traffic congestion as "Google Busses" appeared in the city to transport workers south to offices in Silicon Valley, driving up housing prices, exacerbating existing trends toward gentrification in a city with limited undeveloped land, and placing ever greater pressure to convert remaining industrial properties to residential and retail use. Adding to the pressure were the rapid growth of "fintech" start-ups and other internet-based firms in ecommerce and other digital services, such as Twitter, which began to mix in with the traditional financial services companies located in the downtown Financial District.

Silicon Valley and Regional Path Dependence

As with Seattle, San Francisco's climate, landscape, preexisting culture, and connections to markets were distinctly different from earlier, denser, less mountainous settlement on the East Coast. Whether or not these differences, and relative isolation in the 19th Century, fostered innovation as industries grew to face novel challenges under greater constraints is debatable (Aydalot and Keeble, 1988). However, there is good evidence that this was the case for San Francisco. Historian Carey McWilliams (1949) writes:

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[3] https://sfgov.org/visitors

> *"The discovery of gold, in combination with other factors, notably the isolation of the West, gave California a distinct head start over the other western states as a center of manufacturing. Once these nascent industries were established, they had the effect of attracting other industries. It was, above all, the cultural peculiarities of the things demanded--novel forms of mining equipment and lumbering equipment--which provided the stimulus for industrial activity. It was for this reason, very largely, that California became a manufacturing center almost at the same time it became a State. The rapid growth in population explains the demand, but it was the novelty of the environment that stimulated local invention and manufacture. The primary dynamic of industry in California might, therefore, be said to lie in the novelty of the environment."*

The emergence of the ICT industry in the region this activity – which began even before the advent of the radio industry – can be traced to these characteristics. With electrification sweeping the country in the1890s, there was a need to transmit electricity from the hydroelectric power source developed in the Sierra Nevada mountains during the Gold Rush era nearly 200 miles to the San Francisco and other cities on the coast. Sturgeon (2000, p. 6) writes:

> *The electrical engineering departments at the University of California at Berkeley and Stanford University [in Palo Alto] were used by local power companies as test laboratories. For example, the pioneering use of lower-cost aluminum transmission cable during this period depended on tensile strength and conductivity tests conducted by Cal Berkeley's mechanical and electrical laboratories. In 1898, the first Professor of Electricity at Stanford, A.C. Perrine, collaborated with students and power company engineers to develop a high potential oil switch that made Sierra to San Francisco transmission possible. He then took a two-year leave of absence to consult for the Standard Electric Company of California, the company that completed the first line to San Francisco. …Bay Area electronics companies in the early years of radio closely match the structure of industrial organization so widely hailed in Silicon Valley today, albeit on a much smaller scale: a leading role for local venture capital; a close relationship between local industry and the major research universities of the area; a product mix with a focus on electronic components, production equipment, advanced communications, instrumentation, and military electronics; an unusually high level of inter-firm cooperation; a tolerance for spin-offs; a key role for local venture capital, and a keen awareness of the region as existing largely outside the purview of the large, ponderous, bureaucratic electronics firms and financial institutions of the East Coast—all of these well-known characteristics of Silicon Valley were as much in evidence in the 1910s, 1920s, and 1930s as they have been from the 1960s onward. In the jargon of the Valley, it seems that the key characteristics of Bay Area electronics, set in place so long ago, have proved to be readily "scalable" as the industry has grown in the region.*

The issue of path dependence in regional economies has been explored in depth by Martin and Sunley (2006). While the idea of path-dependance was first developed to explain tendencies for small beginnings in technological innovation to structure later choices, either for good or ill, economic geographers have explored the concept in the realm of regional economic development. According to Martin and Sunley's review of the literature, regional path dependance can have several possible sources: 1) natural resources, 2) sunk costs, local assets, and infrastructure, 3) local external economies and industrial specialization, 4) regional technological lock-in, 5) economies of agglomeration, 6) region-specific institutions, social forms, and cultural traditions, and 7) inter-regional linkages and inter-dependencies. If the notion that a region's existing resources, infrastructure, activities, and internal and external linkages help to structure future development is accepted, then several questions follow. Will early structures and tendencies lock a region into unproductive industries, routines, and outmoded institutions, or can a region "reinvent itself" as time goes on. If so, is a region's reinvention based on earlier patterns or on breaking with them? Is reinvention a one-time shift that could subsequently lead to negative lock-in, or is the tendency for reinvention itself a routine occurrence that can keep a region on the frontier of innovation and institutional evolution? Finally, can ongoing reinvention become a major force in changing external conditions to suit the region's strengths, as has apparently been the case with Silicon Valley.

3. Major Companies and Industries

Regardless of the reasons, the San Francisco Bay Core Region, and especially the San Francisco Peninsula and South Bay cities known as Silicon Valley, has become the world's most conspicuous example of positive path dependence, as it has long been home to a multitude of pioneering innovations in information and communications technology (ICT), industries that have become the motor of global economic growth, especially over the past 30 years since the emergence of the public internet.

Indeed, as the progression of technologies underlying ICT has taken place, Silicon Valley companies have been leaders, if not the primary innovators and dominant market leaders, for more than 100 years. Valley-based ICT companies led the way in long-distance radio communication leading up to World War I (Federal Telegraph in Palo Alto), vacuum tubes for aerial radio (Heinz and Company in San Francisco and San Bruno), long-distance telephony (Federal Telegraph), and eventually radar and radar antenna (Litton Industries in Palo Alto and Ampex in San Carlos). The first vacuum tube-based amplifier, or "repeater" tube, that made long-distance telephony and radio transmission possible was first developed in a Federal Telegraph lab in Palo Alto (Sturgeon, 2000). As vacuum tubes gave way to semiconductors as the basis for electronic communication, instrumentation, and computing in the 1950s and 1960s, Silicon Valley firms again led the way. The first solid-state transistors were developed at Bell Labs in New Jersey in the early 1950s, but large-scale commercialization was concentrated in a set of fris that spun off from Pal Alto's Fairchild Semiconductor, which acted at the root of a vast semiconductor "family tree" in the region, including National Semiconductor, AMD, and Intel. With the integration of more and more discrete electronic components such as transistors onto a single substrate, companies such as Intel began offering "microprocessors" that could be programmed and reprogrammed to accomplish any number of computing tasks, giving rise to the personal computers from Apple Computer in 1977 (in Palo Alto and now headquartered in Cupertino) and the Intel-based IBM PC in 1981 (Saxenian, 1991).

Specialized services, such as patent lawyers and venture capital firms, grew alongside these firms, providing ample resources for existing firms and start-ups alike (Suchman and Cahill, 1996;

Kenny and Florida, 2000), and the military continued to be a first order customer, providing deep pockets and proof-of-concept for technological innovations made in the region (Leslie, 2000). Standard University in Palo Alto offered laboratory space, an early industrial park aimed keeping local technology companies in the region, and an ongoing source of skilled labor (Leslie and Kargon, 1996).

As low-cost computing took hold across the world, the need emerged to connect them into wider networks to increase their combined power, share information, and monitor remote processes. The open Ethernet standard was developed at Xerox PARC in Palo Alto between 1973 and 1974, and Silicon Valley companies such as 3Com were Apple were successful in commercializing various solutions. The progression from local area networks (LANs), which connected computers in a single building or company campus, to wide area networks (WANs) and wireless networks (later to emerge as the WiFi standard) was also led in part by Silicon Valley companies such as Sun Microsystems, Oracle, and Cisco, which, in the 1990s grew alongside the internet and growing capabilities of information technology products and services (Markoff, 1998).

In more recent years, Silicon Valley, in the broadest sense that includes cities in San Francisco, Alameda, San Mateo, and Santa Clara, with offshoots in surrounding counties, has become a primary driver of the Digital Economy in the areas of internet search, social media, artificial intelligence, and the shift of traditional industries on-line, including finance, entertainment, retail, travel arrangements, real estate, transport, human resources, education, and many others, with numerous Silicon Valley technology companies, including Google, Facebook, and Apple, becoming the most valuable and influential companies in the world. As Table 3.1 shows, seven of the world's most visited websites are owned by companies headquartered in the San Francisco Bay Area.

Table 3.1: Top ten most visited websites globally, November 2020

Rank	Website	Monthly Visitors	Country of Origin	Headquarters City	Category
1	Google.com	92.5B	U.S.	Mountain View, CA	Search Engines
2	Youtube.com	34.6B	U.S.	San Bruno, CA	Video and Streaming
3	Facebook.com	25.5B	U.S.	Palo Alto, CA	Social Media
4	Twitter.com	6.6B	U.S.	San Francisco, CA	Social Media
5	Wikipedia.org	6.1B	U.S.	San Francisco, CA	On-line Encyclopedia
6	Instagram.com	6.1B	U.S.	Menlo Park, CA	Social Media
7	Baidu.com	5.6B	China	Beijing	Search Engine
8	Yahoo.com	3.8B	U.S.	Sunnyvale, CA	Search, News and Media
9	xvideos.com	3.4B	Czech Republic	Prague	Adult content
10	pornhub.com	3.3B	Canada	Toronto	Adult content

Source: Visual Capitalist, drawing data from SimilarWeb, https://www.visualcapitalist.com/the-50-most-visited-websites-in-the-world/

The evolution of ICT has left a rich industrial history in the region, with many early companies continuing to evolve and thrive, such as Intel, AMD, Hewlett-Packard, Apple, Cisco, Western Digital, Juniper Networks, and Oracle; and younger companies leveraging the internet emerging as highly successful or even dominant juggernauts, such as Google, Facebook, Twitter, Salesforce, GitHub, YouTube, Yelp, Slack, Craigslist, Netflix, Pixar, and many others. The richness of this ecosystem of firms is hinted at by the Appendix in Table A. 1, which contains a crowdsourced (unscientific and non-exhaustive) list of companies in the four-county San Francisco Bay Area Core region by sector, city, and county. Aside from homegrown companies, the list reveals many national and international firms that have invested in the region, including SAP (Germany), Ericsson (Sweden), Sony (Japan), Hitachi (Japan), Philips (Netherlands), and Fujitsu (Japan).

While many of these firms are software- and Internet-based, and hardware producers making high-volume products such as Apple, Cisco, and Western Digital have shifted manufacturing to lower-cost locations in East Asia and elsewhere (Gereffi, et. al, 2005), there continues to be significant electronics manufacturing capacity in the region, for prototyping and test-runs, low volume production of high-value products, and highly regulated products for aircraft and military applications.

4. Regional statistical profile

In November 2022, the civilian labor force (employment outside of government and military) in the combined San Francisco-Oakland-Berkeley MSA and San-Jose-Sunnyvale-Santa Clara MSAs (hereafter San Francisco/San Jose MSAs) numbered 3,291,800, with 3,189,600 employed. The unemployment rate of 5.8% was nearly twice the other three city regions included in the research, and well above the 3.6% rate for the United States as a whole. Labor markets have been tightening in the United States since the Global Financial Crisis in November 2009, when they reached 9.9%, with a brief spike to 14.7% at the onset of the Covid-19 pandemic in April 2020. According to Gedye (2021), San Francisco Bay Area's relatively high unemployment rate can be explained in part by its high share of employment in leisure, hospitality and other tourism-sensitive sectors hard hit by the pandemic; higher rates of job loss during the pandemic in high rent areas, and normal job churn in technology sectors.

Table 4.1: Labor force statistics, San Francisco/San Jose MSAs compared with three other city-regions, November 2022, thousands of jobs

	San Francisco/ San Jose	Seattle MSA	Boston MSA	Atlanta MSA
Civilian Labor Force	**3,291.80**	2,788.20	2,536.20	3,208.70
Employment	**3,189.60**	2,714.30	2,465.00	3,122.20
Unemployed	**102.20**	73.9	71.2	86.5
Unemployment Rate	**5.8%**	2.7%	2.8%	2.7%

The San Francisco/San Jose MSAs comprise a region that includes the cities of San Francisco and the East Bay cities of Berkeley and Oakland in northern Alameda County as well as Silicon Valley. Silicon Valley grew in two directions: from San Francisco south into cities in San Mateo County, including San Bruno, San Mateo, Redwood City, and Menlo Park, and also in Santa Clara County from Stanford University, in Palo Alto, to nearby cities such as Sunnyvale Mountain View, and Cupertino. Later, in the 1980s, what we now refer to as Silicon Valley expanded in San Jose and Milpitas, and eventually, in the 1990s, in Fremont in other cities in southern Alameda County. In essence, the main economic engine of the San Francisco Bay Area has come to extend in a ring spanning the southern portion of San Francisco Bay. There are limits to additional sprawl because The San Francisco Bay is surrounded by relatively small but steep and rugged mountains, limiting the land area available for traditional single-story industrial development (Figure 2.1).

According to the 2020 Census, the combined MSAs had an estimated population of 6,623732 in 2021. The San Francisco MSA's population of 4,749,008 places it 13th on the list of the U.S. MSAs with the largest population, while San Jose MSA's population of 1,952,185 gives it a rank of 36. Table 4.2 and Table 4.3 provide general statistical profiles of the San Francisco and San Jose MSAs. The area is more diverse than many others of similar size. The racial and ethnic makeup of the San Francisco MSA is 40% White, 29% Asian, 23% Latinx, and 7% Black. The San Jose MSA's racial and ethnic makeup is 32.5% White, 29% Asian, 26% Latinx, and 7% Black. The region's diversity is partially due to the level of immigration, which is much higher than the national average of about 14%. In the San Francisco MSA, nearly a third of the population is foreign-born, and a 42% speak a language other than English at home; while in the San Jose MSA, 40% of the population is foreign-born and 42% speak a language other than English at home. In the U.S. as a while only 13.6% of the population is foreign-board and 21.6% speak a language other than English at home.

Table 4.2: San Francisco-Oakland-Berkeley MSA basic statistics (2020/2021)

Indicator	Value
Population	4,747,008
Employer establishments	132,274
Race and ethnicity	
White	1,866,480 (39.2%)
Asian	1,306,262 (28.6%)
Latinx	1,086,206 (23.1%)
Black	335,135 (7.0%)
Language other than English spoken at home	41.9% (U.S. = 21.6%)
Foreign-born	31.2% (U.S. = 13.6%)
Median household income	$116,005 (U.S. = $69,717)
Employment rate	61.4% (U.S. = 58.6%)
Poverty rate	9.0% (U.S. = 12.8%)
Bachelor's degree or higher	51.8% (U.S. = 35.0%)
Median gross rent	$2,156 (U.S. = $1,191)
Home ownership rate	55.8% (U.S. = 65.4%)
Without health insurance	3.9% (U.S. = 8.6%)
Without an internet subscription	6.0% (U.S. = 9.7%)

Source: U.S. Census Bureau: https://data.census.gov/profile

Table 4.3: San Jose-Sunnyvale-Santa Clara MSA Basic Statistics (2020/2021)

Indicator	Value
Population	2,000,468
Employer establishments	50,047
Race and ethnicity	
White	649,847 (32.5%)
Asian	761,453 (38.0%)
Latinx	526,598 (26.3%)
Black	45,600 (2.3%)
Language other than English spoken at home	53.6% (U.S. = 21.6%)
Foreign born	39.6% (U.S. = 13.6%)
Median household income	$139,892 (U.S. = $67,717)
Employment rate	62.6% (U.S. = 58.6%)
Poverty rate	6.9% (U.S. = 12.8%)
Bachelor's degree or higher	54.0% (U.S. = 35.0%)
Median gross rent	$2,454 (U.S. = $1,191)
Home ownership rate	56.3% (U.S. = 65.4%)
Without health insurance	4.3% (U.S. = 8.6%)
Without an internet subscription	3.7% (U.S. = 9.7%)

Source: U.S. Census Bureau: https://data.census.gov/profile

Like other cities in our study, especially Boston and Seattle, the San Francisco Bay Region is a wealthy city, with a median household income of more than $162,000, in the San Francisco MSA and almost 140,000 in the San Jose MSA, double the national average of just under $70,000. The San Francisco MSA's poverty rate[4] is 9.0%, and the San Jose MSA's is just 6.9%, much lower than the national rate of 13%. However, with many high incomes, inequality is high. Employment rates in the MSAs are higher than the national average 58.6%. In the San Francisco MSA, it is 61%, and in the San Jose MSA it is 63%. Fifty-two percent of the San Francisco MSA's residents hold a Bachelor's Degree or higher, compared with only 35% nationwide, and in the San Jose MSA, the figure is 54%. Only 3.9 % of the San Francisco MSA population is without health insurance, compared with 8.6% nationally, and the figure is only slightly higher in the San Jose MSA at 4.3%. Only 6 % of households lack internet access in the San Francisco MSA, compared with 10% nationally, while in the San Jose MSA, the figure is a very low 3.7%

However, this economic success comes with challenges, especially with traffic congestion and high housing costs. The City of San Francisco suffers from the 7th worst traffic congestion in the United States, with 97 hours lost per commuter annually (Bartiromo, 2023). Median gross rent in the San Francisco MSA is nearly double the national average ($2,158 per month vs. $1,191 nationally), while average rents in the San Jose MSA are even higher, at $2,454 per month. Not coincidentally, home ownership is well below the national average in the San Francisco and San Jose MSAs (about 56% versus 65.4% nationally).

[4]According to the U.S. Census Bureau, a household is considered poor if its income is below a specific threshold set according to the Consumer Price Index. In 2021, this threshold was set at a total annual income of $36,500, or slightly more than $3,000 per month (see: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html).

5. Why manufacturing is important

To provide a broader context for trends at the city-region level, this section asks why manufacturing is essential. The section is included in all four reports prepared by our team with the reasoning that the national situation with manufacturing in the United States will go a long way toward making sense of our finding in each of the city-regions we examined in our research. However, readers may skip this section. The main finding is that manufacturing employment has been declining in most OECD countries for many decades, driven in part by automation but, in the past 20 years and especially for the United States, by the rise of export manufacturing in China and other low-income countries.

The benefits of manufacturing for economic and social development are long-heralded as a mechanism for shifting resources from low- to higher-productivity activities (Kuznets, 1971).[5] The faster the growth of the manufacturing sector, the more the productivity is enhanced because resources – significantly labor – are shifted away from traditional sectors such as agriculture, where technology is applied to maintain (or increase) output. As labor shifts out of agriculture, manufacturing takes up the slack, creating solid middle-class employment in urban areas, especially for workers without high levels of education, along with large-scale workplaces suitable for union organizing.

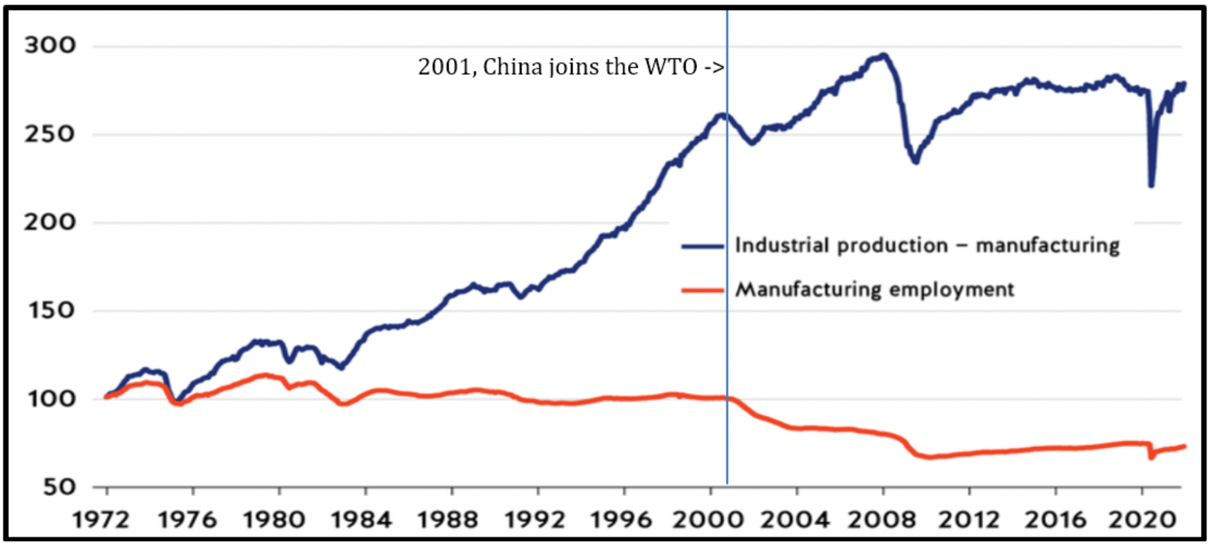
Kaldor (1967) focused more on productivity and exports within manufacturing than labor. He argued that GDP growth is higher when manufacturing's share is rising because it has increasing returns to scale and because of manufacturing's disproportionate contribution to a country's balance of payments through exports, which can be intra-regional or international. So, rising manufacturing output can generate regional and national wealth because of high value-added, steady productivity increases, and exports that create a positive revenue flow, even if manufacturing employment eventually grows more slowly or turns negative. This sectoral succession model assumes that once labor has been all but wrung out of agriculture through productivity increases, the same can happen with manufacturing as jobs in the services sector can take over as the engine of job creation, productivity increases, and export growth.

Manufacturing trends globally and in the United States

This process is ongoing in the United States and most other large OECD countries, where manufacturing output continues to grow, but employment is shrinking (Figure 5.1). At its peak in 1979, manufacturing employment in the United States reached 19.5 million, representing 22 percent of nonfarm employment. Forty years later, manufacturing employment stood at only 13 million, and its share fell to 9 percent. The dichotomy between output growth and employment decline is explained by productivity increases from automation, computerization, and better work organization and management practices, as predicted by models of sectoral succession.

[5] For example, with the shift of labor and capital from agriculture to manufacturing through industrialization.

Figure 5.1: US industrial production and manufacturing employment index, 1972-2020 (1972=100)



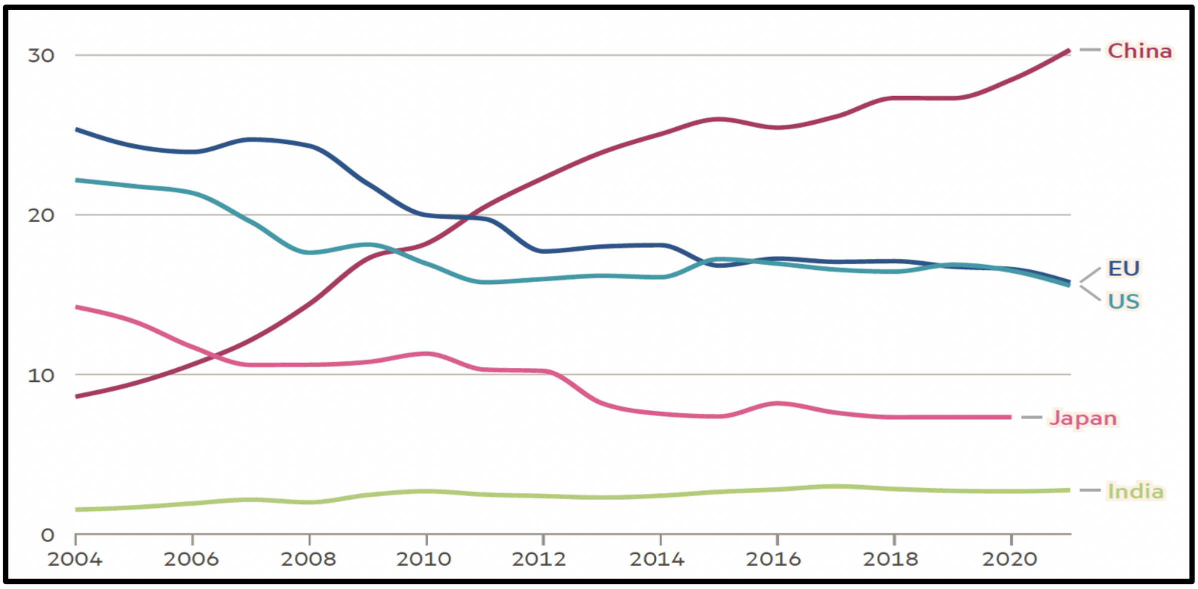
Source: Federal Reserve Bank of St Louis FRED database. Notes: Industrial Production: Manufacturing (NAICS), Index Jan 1972=100, Monthly, Seasonally Adjusted; Employment: All Employees, Manufacturing, Index Jan 1972=100, Monthly, Seasonally Adjusted.

However, the trend was super-charged for the United States in the 2000s by migrating large-scale export-oriented production to lower-cost countries in the developing world, especially China. This shift simultaneously increased import competition for remaining manufacturing plants, lowered prices, and increased consumer product variety in the United States.

The China Shock

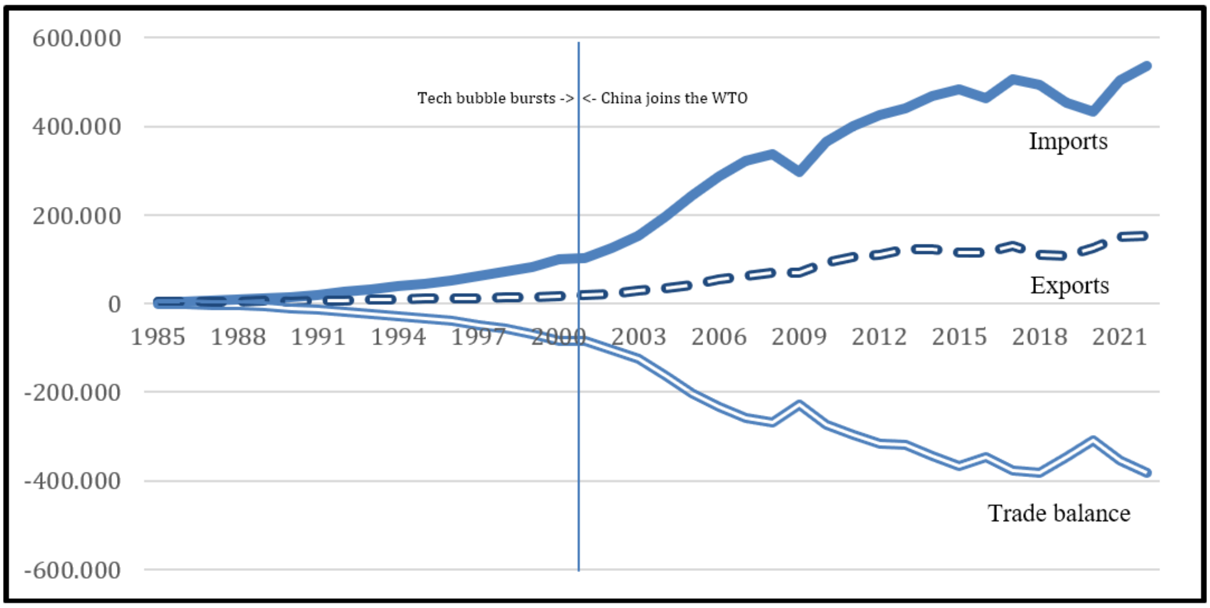
The net impact of offshoring manufacturing jobs on economic and social development is still being determined (Kirchner, 2022). Uneven effects are being felt in the manufacturing employment decline in the United States. Regions of historic manufacturing concentration are suffering greatly. Offshoring pushed China's share of global manufacturing value added to nearly 30% in 2021 from less than 10% in 2004 (Figure 5.2). This extraordinary rise created a massive trade deficit for the United States with China (see Figure 5.3).

Figure 5.2: Share of Global Manufacturing Value Added, 2004-2021 (percent)



Source: McGee (2023) for Financial Times based on World Bank data

Figure 5.3: US trade with China, 1985-2022



Source: U.S. Census Bureau: https://www.census.gov/foreign-trade/balance/c5700.html. Note: Figures are in U.S. million dollars on a nominal basis, not seasonally adjusted.

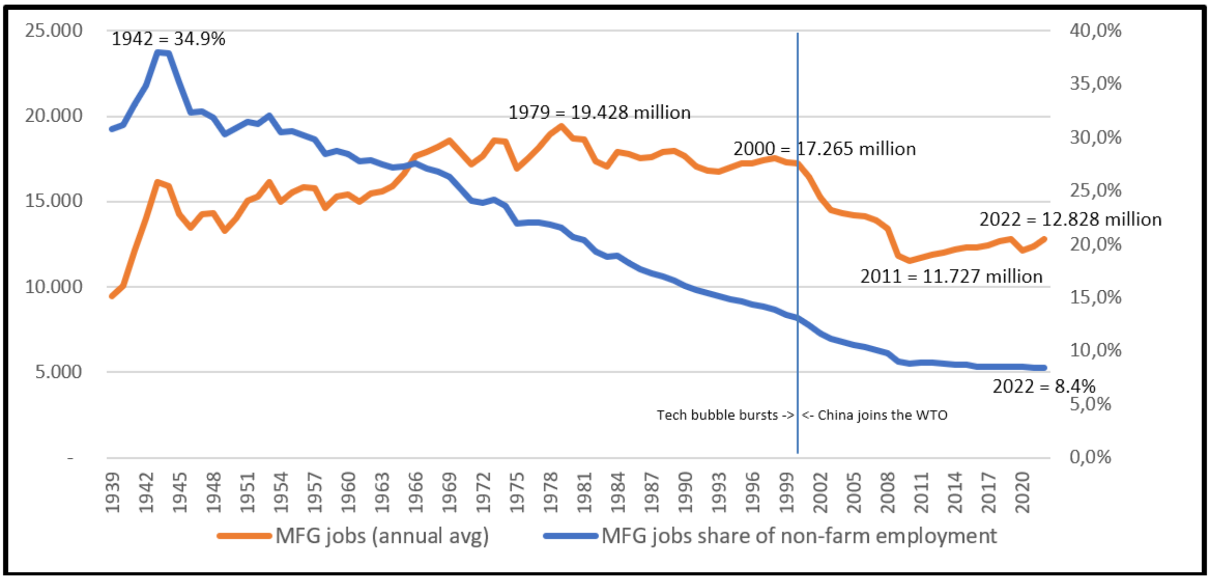
China's role as an export platform role exploded after it acceded to the WTO in 2001. This led to huge trade deficits with trading partners, especially the United States (see Figure 5.3). While the U.S. trade balance in services (including technology licenses, an indicator of China's technological dependence on the United States) has remained positive, the deficit with China in goods soared to US $382 billion in 2018 and leveled off since. Not coincidentally, this came on the heels of the bursting of the 'technology bubble' in the U.S. in 2001, which sent U.S. manufacturers scrambling to cut costs and access 'big emerging markets' in China, India, and Brazil – moves that often come with requirements to set up local production, conduct R&D, and (reluctantly and partially, at best) transfer technology to local joint venture partners. In this way, the 'China shock' set the stage for the political upheavals of 2016 and beyond. Autor et al. (2016, abstract) frame it this way:

> *China's emergence as a great economic power has induced an epochal shift in world trade patterns. Simultaneously, it has challenged much empirical wisdom about how labor markets adjust to trade shocks. Alongside the heralded consumer benefits of expanded trade are substantial adjustment costs and distributional consequences. These impacts are most visible in the local labor markets where the industries exposed to foreign competition are concentrated. Adjustment in local labor markets is prolonged, with wages and labor-force participation rates remaining depressed and unemployment rates remaining elevated for at least an entire decade after the China trade shock commenced. Exposed workers experience more significant job churning and reduced lifetime income. At the national level, employment has fallen in U.S. industries more exposed to import competition, as expected, but offsetting employment gains in other industries have yet to materialize.*

Manufacturing employment in the United States

Since its peak in 34% of total non-farm employment in 1942, during the height of World War Two, the share of manufacturing jobs in the United States workforce declined to its current low of 8.4% in 2022. However, this is mainly due to robust job growth in other sectors. The number of manufacturing jobs in the United States grew steadily after World War Two, peaking cyclically to a peak of 19.428 million in 1979, dropping gradually to 17.265 million in 2000, and then rapidly after China joined the WTO, to its modern low of 11.727 million in 2011. After that, manufacturing employment has been on a gradual rebound, to 12.828 million in 2022 (see Figure 5.4).

Figure 5.4: US manufacturing jobs (thousands), and share of non-farm employment, 1939-2022

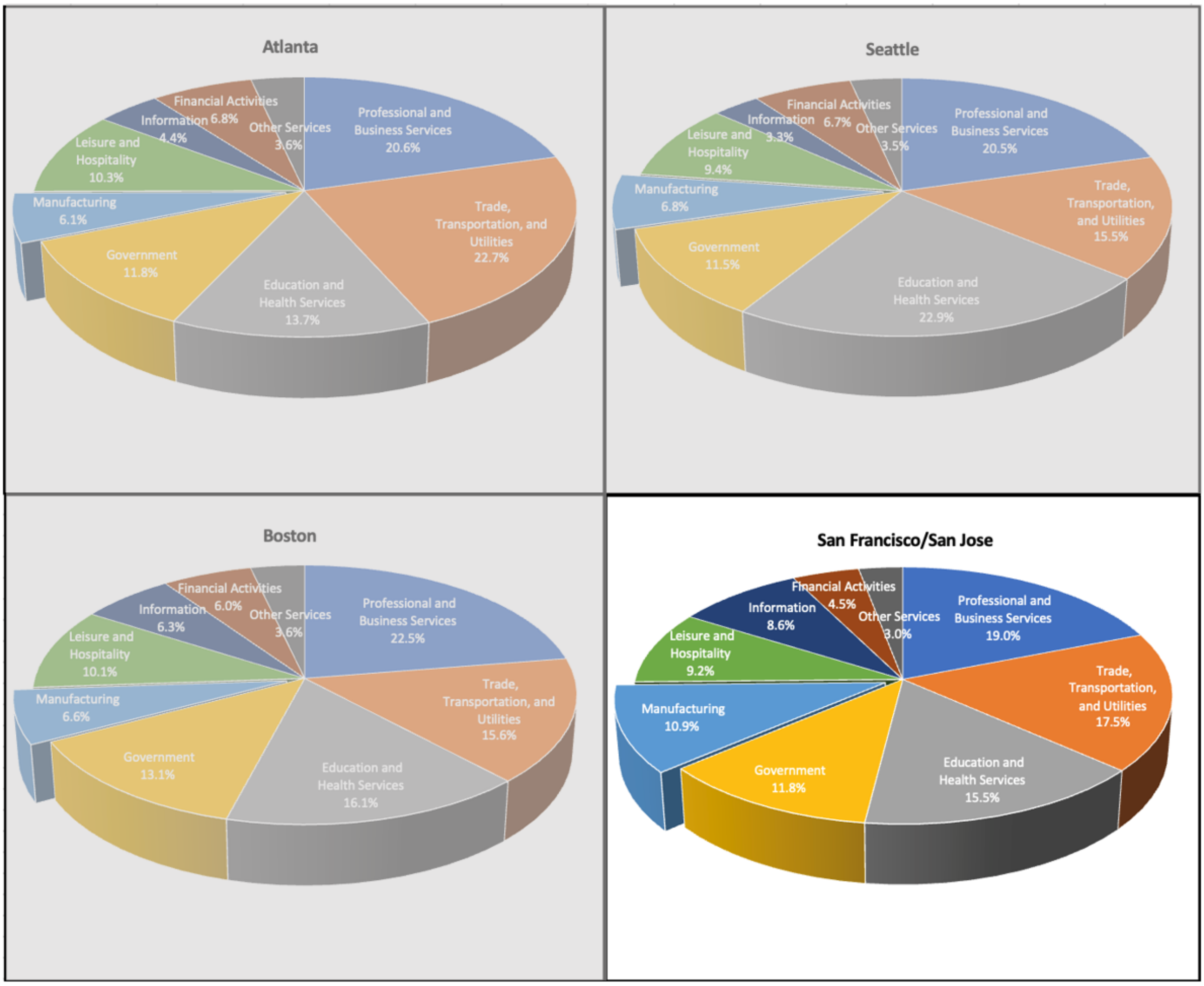


Source: Employment, Hours, and Earnings from the Current Employment Statistics Survey (National), U.S. Bureau of Labor Statistics

6. Manufacturing trends in the San Francisco Bay Area

This section discusses trends in manufacturing in the combined San Francisco and San Jose MSAs. In December 2020, manufacturing employment in the U.S. stood at 13 million, 8.4% of non-farm employment. Figure 6 shows that manufacturing employment was 10.9% of non-farm employment in the San Francisco/San Jose MSAs, significantly higher than the other three city-regions included in our study.

Figure 6.1: Jobs in the combined San Francisco and San Jose MSAs by major industry compared with three other city-regions, November, 2022



Source: MSA data from U.S. Bureau of Labor Statistics Regional Dataset, https://www.bls.gov/regions/

However, the sectoral mix is similar across all four regions, reflecting their roles as core governmental, educational, transportation, financial, trade, and tourism hubs for their states and surrounding areas. In San Francisco/San Jose, the largest private employer is trade, transportation, and utilities, reflecting the city region's role as a transportation hub on the U.S. West Coast.

How is manufacturing faring in San Francisco/San Jose?

In December 2022, the San Francisco/San Jose MSAs had about 329,000 manufacturing jobs, down from 427,000 in 1990, a decrease of 23%, as shown in Table 6.1 and the upper panel of Figure 6.2.

The loss of 97,700 manufacturing jobs in the San Francisco/San Jose MSAs over the 1990-2022 period is the most in our four city regions, but because of higher levels of manufacturing employment throughout the period the percentage loss of 23% was lower than Boston or Seattle.

Table 6.1: Manufacturing employment in the combined San Francisco and San Jose MSAs compared with three other U.S. city regions, total U.S. manufacturing employment, and total U.S. nonfarm employment, 1990-2022, thousands of jobs (only even years shown through 2010)

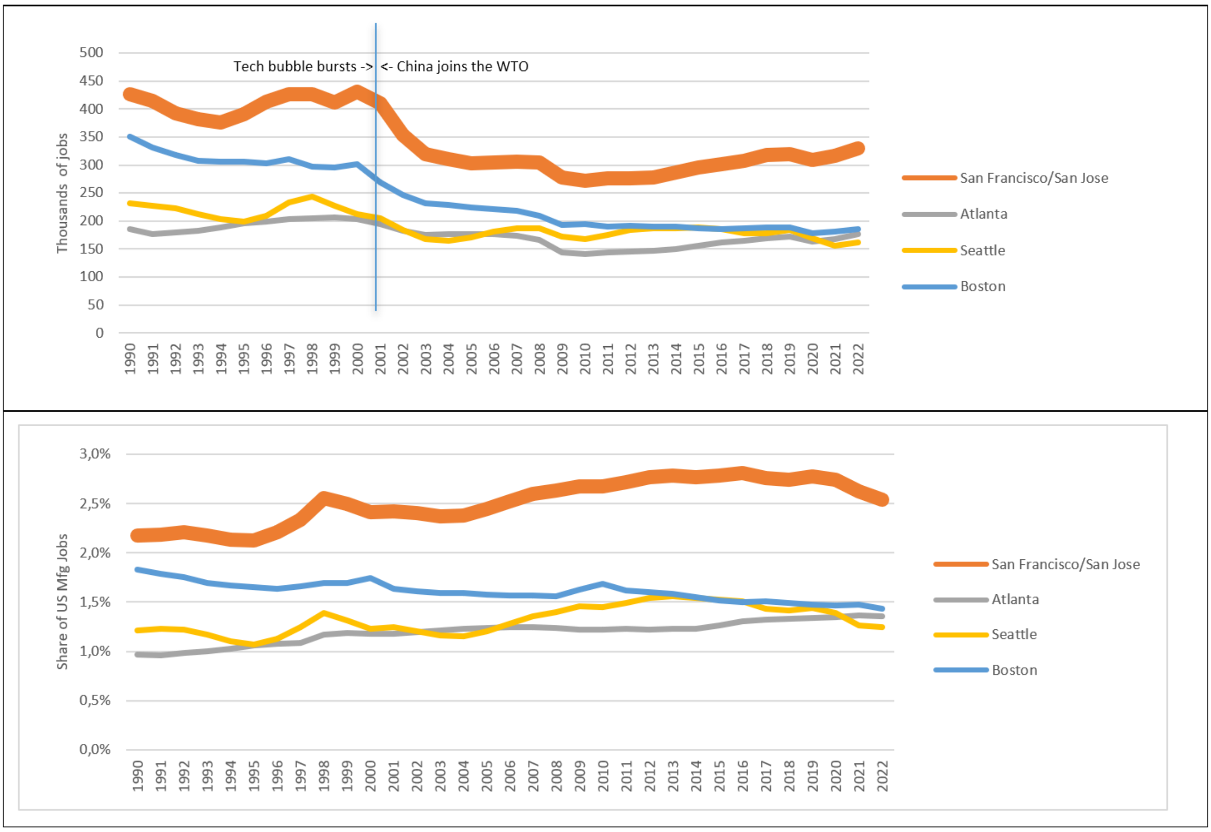
Year	San Francisco and San Jose MSAs	San Jose MSA	San Francisco MSA	Seattle MSA	Atlanta MSA	Boston MSA	US Mfg Emp	US Nonfarm Emp
1990	427	255	172	232	186	351.2	19,173	116,964
1992	393	230	163	222	179	317.5	18,149	115,968
1994	375	217	158	203	189	306.4	18,388	120,379
1996	413	241	171	209	200	302.9	18,527	125,461
1998	426	246	180	244	205	297.8	17,606	131,563
2000	431	252	179	213	204	301.0	17,288	137,228
2002	354	201	153	184	183	246.2	15,265	135,840
2004	310	168	142	165	176	228.1	14,302	136,851
2006	304	164	140	181	176	221.6	14,153	141,153
2008	304	168	136	187	166	208.8	13,412	141,576
2010	271	154	118	167	141	193.9	11,516	134,714
2011	276	158	118	175	144	190.2	11,729	136,258
2012	277	158	119	184	146	190.9	11,935	138,885
2013	278	158	120	188	147	190.0	12,023	141,103
2014	286	162	124	187	150	189.4	12,189	143,758
2015	295	165	130	188	156	187.0	12,332	146,634
2016	302	167	135	186	161	185.2	12,335	148,735
2017	308	167	141	179	165	187.2	12,440	150,654
2018	318	172	146	179	169	188.5	12,672	153,176
2019	319	172	147	184	172	188.4	12,806	155,324
2020	309	168	141	169	163	177.7	12,111	146,542
2021	316	169	147	155	168	181.5	12,331	150,740
2022	329	175	155	162	176	185.9	12,980	155,173
Emp. change 1990-2010	**(155.7)**	**(101.1)**	**(54.6)**	**(65.2)**	**(45.1)**	**(157.3)**	**(7,657.0)**	**17,750.0**
% change 1990-2010	**-36%**	**-40%**	**-32%**	**-28%**	**-24%**	**-45%**	**-40%**	**15%**
Emp. change 2010-2022	**58.0**	**21.0**	**37.0**	**(4.7)**	**35.3**	**(8.0)**	**1,464.0**	**20,459.0**
% change 2010-2022	**21%**	**14%**	**31%**	**-3%**	**25%**	**-4%**	**13%**	**15%**
Emp. change 1990-2022	**(97.7)**	**(80.1)**	**(17.6)**	**(69.9)**	**(9.8)**	**(165.3)**	**(6,193.0)**	**38,209.0**
% change 1990-2022	**-23%**	**-31%**	**-10%**	**-30%**	**-5%**	**-47%**	**-32%**	**33%**

Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

Also, the combined MSAs did participate in the national rebound in manufacturing employment after 2010 evident in the national figures in Figure 5.4 and the 8th column of Table 6.1. The combined MSAs gained 58,000 manufacturing jobs from 2010 to 2011, a rebound of 21%. This is reflected in the lower panel of Figure 7, which shows that the combined San Francisco/San

Jose MSAs increased its share of total national manufacturing employment from 1990 to 2010 (from 2.3% in 1990 to 2.7% in 2010) and has largely maintained it afterwards. In other words, San Francisco/San Jose MSAs has generally performed better than the other three city-regions and the national average, a trend that is certainly due to the strength of its ICT sector, even as the product focus continues to shift from hardware to software and on-line products and services.

Figure 6.2: Manufacturing employment and share of U.S. manufacturing employment in the combined San Francisco and San Jose MSAs compared with three other U.S. city regions, 1990-2022



Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

Which manufacturing sectors are important in the San Francisco Bay Core Region?

As mentioned in the introduction, we define the San Francisco Core Region as consisting of San Francisco, Alameda, San Mateo, and Santa Clara Counties. Table 6.2 lists the active manufacturing sectors in each of the four counties, ranked by June 2022 employment, with employment location quotients (LQs) of greater than 2.0 shaded for emphasis.

Unsurprisingly, San Francisco County, which is contiguous with the City of San Francisco and is the primary urban center of the region, has a low concentration of manufacturing firms relative to larger and more industrialized counties in the region. The largest manufacturing employer in the city is NAICS 334 Computer and electronic product manufacturing, a reflection of its proximity to Silicon Valley. The second largest employer is NAICS 311, Food manufacturing, likely a reflection of several venerable businesses such as the Ghirardelli Chocolate Company, founded in 1852, and corn chip and salsa maker Casa Sanchez, opened in 1925, as well as newer producers of boutique food items, such as Dandelion Chocolate Factory, founded in 2012. Related to this activity is NAICS 312 Beverage and tobacco product manufacturing, the 6th largest manufacturing employers in the city, which includes Anchor Brewing, founded in 1896 and recently sold to Sapporo of Japan.

Table 6.2: Employment and wages by major manufacturing industry, San Francisco Core Region, 2nd quarter 2022, ranked by June employment in each county (employment LOQs above 2.0 in shaded rows)

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees/ establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
San Francisco County							
NAICS 334 Computer and electronic product mfg.	79	5,122	65	342,292,066	5,271	1.0	0.8
NAICS 311 Food mfg.	175	2,195	13	32,774,337	1,166	0.3	0.1
NAICS 335 Electrical equipment, etc.	28	758	27	61,885,198	6,410	0.4	0.7
NAICS 339 Miscellaneous mfg.	78	751	10	24,965,577	2,526	0.2	0.2
NAICS 315 Apparel mfg.	56	686	12	12,518,807	1,379	1.5	0.9
NAICS 312 Beverage and tobacco product mfg.	53	648	12	11,863,904	1,430	0.4	0.2
NAICS 337 Furniture and related product mfg.	40	620	16	11,307,285	1,445	0.3	0.2
NAICS 323 Printing and related support activities	78	542	7	13,391,843	1,898	0.3	0.2
NAICS 332 Fabricated metal product mfg.	39	376	10	8,621,871	1,788	0.1	0.0
NAICS 325 Chemical mfg.	34	298	9	9,919,850	2,625	0.1	0.0
NAICS 327 Nonmetallic mineral product mfg.	19	281	15	6,610,534	1,799	0.1	0.1
NAICS 333 Machinery mfg.	28	245	9	12,262,791	3,914	0.0	0.1
NAICS 336 Transportation equipment mfg.	19	221	12	5,948,838	2,232	0.0	0.0
NAICS 314 Textile product mills	18	129	7	2,024,224	1,246	0.3	0.1
NAICS 321 Wood product mfg.	14	121	9	1,927,630	1,229	0.1	0.0
NAICS 316 Leather and allied product mfg.	13	81	6	1,301,186	1,256	0.6	0.3
NAICS 331 Primary metal mfg.	6	65	11	1,143,193	1,534	0.0	0.0
NAICS 322 Paper mfg.	4	31	8	1,057,245	2,652	0.0	0.0
NAICS 326 Plastics and rubber products mfg.	4	15	4	337,604	1,623	0.0	0.0
San Mateo County (including San Carlos)							
NAICS 325 Chemical mfg.	49	10,921	223	624,400,317	4,444	4.3	4.5
NAICS 334 Computer and electronic product mfg.	103	5,512	54	263,029,907	3,713	1.8	1.0
NAICS 311 Food mfg.	98	2,531	26	34,964,744	1,050	0.5	0.2
NAICS 339 Miscellaneous mfg.	88	1,812	21	61,495,303	2,673	1.0	0.9
NAICS 335 Electrical equipment, etc.	26	964	37	29,890,365	2,408	0.8	0.6
NAICS 332 Fabricated metal product mfg.	88	884	10	17,260,631	1,511	0.2	0.1
NAICS 323 Printing and related support activities	42	799	19	14,875,367	1,448	0.8	0.5
NAICS 336 Transportation equipment mfg.	20	480	24	16,191,126	2,698	0.1	0.1
NAICS 333 Machinery mfg.	35	427	12	11,678,329	2,078	0.1	0.1
NAICS 312 Beverage and tobacco product mfg.	38	373	10	4,060,664	873	0.4	0.1
NAICS 337 Furniture and related product mfg.	31	281	9	5,812,714	1,507	0.3	0.2
NAICS 331 Primary metal mfg.	6	217	36	6,111,864	2,160	0.2	0.1
NAICS 326 Plastics and rubber products mfg.	13	191	15	3,737,484	1,485	0.1	0.1
NAICS 327 Nonmetallic mineral product mfg.	17	178	10	4,231,848	1,839	0.2	0.1
NAICS 321 Wood product mfg.	8	137	17	2,555,809	1,486	0.1	0.1
NAICS 315 Apparel mfg.	7	132	19	1,232,780	718	0.5	0.2

NAICS 314 Textile product mills	8	40	5	750,696	1,397	0.1	0.1
NAICS 322 Paper mfg.	4	18	5	371,166	1,530	0.0	0.0
Alameda County (including Oakland and Fremont)							
NAICS 334 Computer and electronic product mfg.	354	20,366	58	628,434,548	2,386	3.6	2.2
NAICS 333 Machinery mfg.	175	9,330	53	293,126,584	2,419	1.6	2.0
NAICS 311 Food mfg.	259	9,051	35	139,786,294	1,188	1.0	0.9
NAICS 339 Miscellaneous mfg.	173	7,063	41	219,431,570	2,393	2.2	2.8
NAICS 332 Fabricated metal product mfg.	323	6,215	19	113,770,046	1,414	0.8	0.7
NAICS 325 Chemical mfg.	128	3,958	31	182,406,057	3,543	0.8	1.2
NAICS 312 Beverage and tobacco product mfg.	107	2,802	26	42,060,765	1,160	1.6	1.3
NAICS 335 Electrical equipment, etc.	86	2,613	30	72,851,198	2,166	1.2	1.4
NAICS 326 Plastics and rubber products mfg.	63	2,119	34	34,378,670	1,256	0.5	0.4
NAICS 327 Nonmetallic mineral product mfg.	80	1,692	21	35,143,508	1,595	0.8	0.7
NAICS 323 Printing and related support activities	136	1,465	11	24,695,291	1,299	0.7	0.7
NAICS 337 Furniture and related product mfg.	79	1,156	15	20,622,634	1,345	0.6	0.6
NAICS 321 Wood product mfg.	30	1,041	35	16,646,611	1,244	0.5	0.4
NAICS 322 Paper mfg.	19	901	47	18,674,527	1,550	0.5	0.4
NAICS 331 Primary metal mfg.	18	878	49	19,064,490	1,656	0.5	0.4
NAICS 315 Apparel mfg.	26	225	9	2,440,148	786	0.5	0.3
NAICS 314 Textile product mills	20	207	10	2,528,629	973	0.4	0.3
NAICS 324 Petroleum and coal products mfg.	6	148	25	3,179,892	1,735	0.3	0.1
NAICS 313 Textile mills	7	29	4	1,167,301	3,132	0.1	0.1
Santa Clara (including Palo Alto and San Jose)							
NAICS 334 Computer and electronic product mfg.	896	127,680	143	12,718,693,521	7,765	15.7	16.7
NAICS 332 Fabricated metal product mfg.	553	10,921	20	197,461,280	1,390	1.0	0.5
NAICS 333 Machinery mfg.	186	10,150	55	440,497,209	3,382	1.2	1.1
NAICS 336 Transportation equipment mfg.	46	6,220	135	244,918,294	3,075	0.5	0.4
NAICS 339 Miscellaneous mfg.	224	4,890	22	149,798,800	2,375	1.1	0.7
NAICS 335 Electrical equipment, etc.	106	4,345	41	167,375,422	2,979	1.4	1.2
NAICS 311 Food mfg.	143	2,938	21	60,959,644	1,621	0.2	0.1
NAICS 325 Chemical mfg.	86	2,357	27	94,906,359	2,997	0.4	0.2
NAICS 327 Nonmetallic mineral product mfg.	51	1,273	25	32,759,298	2,029	0.4	0.3
NAICS 312 Beverage and tobacco product mfg.	62	1,104	18	17,352,822	1,223	0.5	0.2
NAICS 323 Printing and related support activities	117	1,042	9	16,575,107	1,203	0.4	0.2
NAICS 337 Furniture and related product mfg.	80	921	12	17,867,313	1,502	0.3	0.2
NAICS 321 Wood product mfg.	32	477	15	6,989,265	1,122	0.2	0.1
NAICS 322 Paper mfg.	10	476	48	10,107,847	1,609	0.2	0.1
NAICS 326 Plastics and rubber products mfg.	19	208	11	3,458,533	1,287	0.0	0.0
NAICS 314 Textile product mills	13	196	15	2,691,165	1,062	0.3	0.1
NAICS 315 Apparel mfg.	6	48	8	1,736,090	2,744	0.1	0.1
NAICS 331 Primary metal mfg.	8	39	5	802,444	1,392	0.0	0.0
NAICS 316 Leather and allied product mfg.	4	14	4	345,758	1,505	0.1	0.1
Core region total	5,412	272,455	.	17,158,356,048	.	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

Moving south from San Francisco into San Mateo County we see that NAICS 325 Chemical manufacturing, which includes pharmaceutical manufacturing (NAICS 3254), is the largest manufacturing employer, with nearly 11,000 workers and an employment location quotient (LQ) of 4.3. This suggests that the region's original biotechnology cluster immediately south of the City of San Francisco is still viable, as both venerable firms such as Genentech (founded in 1976) and Gilead Sciences (founded in 1987), as well as younger firms such as Calico Life Sciences (founded in 2013 as a subsidiary of Google parent Alphabet), are located there.

Northern San Mateo County has also attracted international investment in the life sciences industry. For example, in 2014, Swiss pharmaceutical giant Roche acquired InterMune, a company founded in Brisbane in 1998, for $8.3 billion, renaming it Roche Molecular Systems (Cortez, 2014).

Moving further south into the heart of Silicon Valley in Santa Clara County and it's more recent expansion in Alameda country, we see clear evidence of the continued importance of electronics manufacturing in the region. NAICS 334 Computer and electronic product manufacturing is the top manufacturing employer in both counties. In Santa Clara County, which includes what is most commonly thought of as the "birthplace" of Silicon Valley – Stanford University in the city of Palo Alto – as well as the more recently developed areas in the northern section of the city of San Jose and the adjacent city of Milpitas, the industry employs 127,680, which yields an employment LQ of 15.7. The work takes place in 896 establishments employing, on average, 143 workers. The scale of the industry's economic impact in the region is suggested by the nearly 13 billion wages paid by these establishments in a single quarter (2nd quarter of 2022). All told, NAICS 334 employed nearly 158,680 in the four-county Core Region.

Which manufacturing and non-manufacturing industries does the San Francisco Bay Core Region specialize in?

The more detailed (4-digit) NAICS industries shown in Table 6.3 reveals the San Francisco Bay Core Region's specialties beyond manufacturing relative to other locations in the United States. The Table ranks all industries with an employment LQ of 2.0 or higher.

In the city/county of San Francisco, the ICT industry is the largest employer, by far, which is somewhat surprising given the city's traditional role as a center of finance and business services. The largest single industry in the City, in terms of employment, is NAICS 5415 Computer systems design and related services, with 71,846 employees working in 2,387 establishments. NAICS 5415 Computer systems design and related services; NAICS 5416 Management, scientific, and technical consulting services; NAICS 5182 Computing infrastructure providers, data processing, web hosting, and related services; NAICS 5132 Software publishers; and NAICS 5417 Scientific research and development services are also among the top seven employers in the city.

In addition, as the "Financial" section of Table 6.3 in the Appendix suggests, many of the finance-related companies in San Francisco are internet-mediated "fintech" companies such as Paypal, Coinbase, Yodalee, and Robinhood, even as they exist alongside more traditional banks and credit card companies such as Wells Fargo, First Republic Bank, and Visa. And this is only part of the infiltration of ICT companies into the City of San Francisco. The industries in the City of San Francisco with LQs of more than 9.0 are NAICS 5192 Web portals, & other info services, and NAICS 5182 Computer infrastructure, data processing, web hosting, and related services, reflecting the rapid growth of social media, information sharing, and retail platform companies in the City such as Meta (the parent of Facebook), Twitter, Dropbox, Airbnb, Craigslist, Instacart, and Pinterest. The city is also home to the two largest online ride hailing companies, Uber and Lyft. Even the city's long history as a home of apparel brands and retailers, such as Levi Strauss, the Gap, and Jos A. Bank, is now colored by the arrival of a new slate of online mediated brands and online marketplaces such as Stitch-fix, ModCloth, Everlane, and Zazzle.

Table 6.3: Employment and wages by detailed industry, San Francisco Core Region, 2nd quarter 2022, with employment LOQ >2.0, ranked (mfg. shaded)

	Number of establish -ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
San Francisco County							
NAICS 5192 Web portals, & other info serv.	66	8,557	130	817,830,436	7,383	9.5	6.4
NAICS 5182 Comp infra., data proc., web hosting	447	21,533	48	1,360,312,766	4,979	9.3	6.8
NAICS 5178 All other telecommunications	20	1,670	84	147,483,692	6,815	7.7	8.3
NAICS 5162 Media streaming & social networks	89	8,790	99	679,737,324	6,000	7.3	5.1
NAICS 4871 Scenic and sightseeing trans.	10	386	39	19,045,233	3,935	6.8	15.9
NAICS 5415 Computer systems design	2,387	71,846	30	4,528,057,374	4,904	5.9	4.8
NAICS 5223 Credit intermediation	125	8,236	66	705,390,545	6,695	5.1	6.9
NAICS 5132 Software publishers	704	15,188	22	894,804,821	4,526	4.8	2.8
NAICS 5259 Other investment pools and funds	62	345	6	16,092,622	3,864	4.1	2.1
NAICS 5239 Other financial investment activities	1,014	11,243	11	812,376,984	5,630	4.1	2.8
NAICS 7111 Performing arts companies	100	2,347	23	41,097,910	1,328	3.8	2.5
NAICS 8133 Social advocacy organizations	272	4,455	16	94,412,921	1,648	3.7	2.3
NAICS 4922 Local messengers and local delivery	29	3,001	103	113,776,985	2,919	3.6	4.9
NAICS 5615 Travel and reservation services	149	3,123	21	461,421,697	10,911	3.6	11.7
NAICS 8132 Grantmaking and giving services	308	2,720	9	78,783,946	2,246	3.6	2.3
NAICS 5414 Specialized design services	490	2,620	5	71,351,792	2,086	3.5	2.2
NAICS 7121 Museums and historical sites	72	2,805	39	45,005,878	1,266	3.4	2.4
NAICS 5418 Advertising and public relations	470	6,858	15	276,308,631	3,104	2.8	2.1
NAICS 5416 Mgmt., sci., and tech consulting	1,922	23,063	12	1,025,600,563	3,439	2.6	1.9
NAICS 5331 Lessors of nonfinancial assets	12	283	24	14,783,894	3,944	2.6	2.0
NAICS 5417 Scientific R&D services	380	11,348	30	1,439,231,218	9,973	2.6	3.9
NAICS 6241 Individual and family services	23,675	35,367	1	244,824,573	535	2.6	1.1
NAICS 6114 Business schools & mgmt. training	110	995	9	29,534,035	2,346	2.6	1.6
NAICS 6242 Community food & housing services	89	2,557	29	40,018,336	1,206	2.6	1.5
NAICS 7213 Rooming and boarding houses	8	115	14	1,485,752	1,000	2.5	1.6
NAICS 5411 Legal services	1,254	14,489	12	579,411,953	3,152	2.5	1.7
NAICS 8141 Private households	2,156	2,625	1	38,950,660	1,131	2.5	1.8

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
NAICS 8129 Other personal services	344	4,330	13	63,743,266	1,147	2.3	1.8
NAICS 7113 Promoters of perf. arts & similar	82	1,569	19	14,508,926	849	2.2	0.7
NAICS 5231 Securities and commodity contracts	217	4,900	23	395,678,678	6,446	2.1	1.4
NAICS 5131 Newspaper, periodical, book pubs.	198	3,145	16	112,559,219	2,788	2.1	1.4
NAICS 5616 Investigation and security services	126	9,565	76	117,710,979	937	2.0	1.0
NAICS 7224 Drinking places (alcoholic beverages)	355	4,075	11	37,366,001	718	2.0	1.3
San Mateo County (including San Carlos)							
NAICS 5417 Scientific and R&D services	540	30,198	56	1,528,606,482	3,946	12.1	7.4
NAICS 3254 Pharmaceutical and medicine mfg.	36	10,810	300	622,114,793	4,474	11.1	10.3
NAICS 4859 Other transit and ground transport	27	2,668	99	101,767,161	2,972	10.0	15.8
NAICS 5132 Software publishers	317	14,644	46	1,140,806,673	6,071	8.2	6.4
NAICS 4811 Scheduled air transportation	26	8,468	326	174,648,152	1,588	6.6	2.8
NAICS 5182 Computing infrastructure providers	165	5,703	35	381,793,919	5,220	4.4	3.4
NAICS 5239 Other financial investment activities	532	6,041	11	489,395,839	6,349	3.9	3.0
NAICS 6215 Medical and diagnostic laboratories	53	3,198	60	137,067,827	3,259	3.6	3.7
NAICS 8141 Private households	1,707	1,927	1	26,621,871	1,058	3.2	2.2
NAICS 4881 Support activities for air transport	18	2,032	113	22,283,685	854	3.1	1.1
NAICS 4885 Freight transportation arrangement	135	2,278	17	59,506,636	2,015	3.0	1.8
NAICS 7132 Gambling industries	4	868	217	15,697,252	1,384	2.9	2.1
NAICS 3113 Sugar & confectionery product mfg.	9	579	64	10,715,572	1,322	2.7	1.5
NAICS 5415 Computer systems design	1,027	16,713	16	925,801,438	4,307	2.4	1.7
NAICS 5259 Other investment pools and funds	21	109	5	8,513,097	6,082	2.4	2.0
NAICS 4922 Local messengers and local delivery	35	1,105	32	19,284,221	1,294	2.4	1.5
NAICS 6116 Other schools and instruction	268	3,042	11	22,008,905	587	2.4	1.2
NAICS 5222 Nondepository credit intermediation	80	3,883	49	189,577,402	3,800	2.3	1.9
NAICS 4853 Taxi and limousine service	52	333	6	5,770,555	1,337	2.1	0.9
NAICS 7223 Special food services	215	3,561	17	51,495,197	1,100	2.1	1.5
NAICS 3345 Electronic Instruments	50	2,445	49	90,279,304	2,878	2.0	1.2
Alameda County (incl. Oakland and Fremont)							
NAICS 3332 Industrial machinery manufacturing	70	6,115	87	206,118,697	2,580	9.0	10.0
NAICS 5417 Scientific and R&D services	495	25,916	52	1,126,121,476	3,401	5.6	4.9
NAICS 3341 Computer and peripheral equip. mfg.	46	4,331	94	145,031,455	2,596	5.1	1.6
NAICS 3344 Semiconductor manufacturing	118	7,616	65	239,519,855	2,418	3.8	2.7
NAICS 3113 Sugar and confectionery mfg.	16	1,421	89	26,297,311	1,422	3.5	3.3
NAICS 3391 Medical equip. & supplies mfg.	81	6,021	74	198,141,647	2,537	3.5	4.1
NAICS 6214 Outpatient care centers	302	17,922	59	561,289,534	2,404	3.4	4.2
NAICS 3345 Electronic instrument mfg.	141	7,343	52	211,583,943	2,242	3.3	2.6
NAICS 5182 Computing infrastructure providers	160	6,630	41	509,931,171	6,012	2.7	4.1
NAICS 3346 Disk drive manufacturing	17	159	9	6,046,117	2,969	2.6	2.2
NAICS 4922 Local messengers and local delivery	107	2,233	21	34,444,458	1,174	2.6	2.3
NAICS 5629 Remediation & waste mgmt. services	61	2,169	36	43,962,322	1,559	2.4	2.2
NAICS 8133 Social advocacy organizations	276	3,046	11	58,598,234	1,508	2.4	2.3
NAICS 3343 Audio and video equipment mfg.	9	235	26	4,666,663	1,525	2.3	0.9
NAICS 6241 Individual and family services	24,022	33,749	1	233,773,625	530	2.3	1.6
NAICS 3118 Bakeries and tortilla manufacturing	113	3,768	33	46,939,309	969	2.2	1.8
NAICS 4232 Furniture wholesalers	82	1,258	15	25,358,134	1,538	2.1	1.7
NAICS 6117 Educational support services	192	2,177	11	33,713,083	1,231	2.0	1.6

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
Santa Clara (including Palo Alto and San Jose)							
NAICS 3341 Computer & peripheral equip. mfg.	92	59,786	650	8,494,590,797	11,128	49.4	35.6
NAICS 5192 Web search portals etc.	162	47,248	292	4,957,161,850	8,019	34.7	22.9
NAICS 3344 Semiconductor manufacturing	465	39,831	86	2,886,427,005	5,593	13.8	12.3
NAICS 3332 Industrial machinery manufacturing	69	8,167	118	371,448,367	3,539	8.4	6.8
NAICS 5132 Software publishers	715	35,774	50	2,915,202,747	6,333	7.6	5.4
NAICS 3345 Electronic instrument manufacturing	245	20,624	84	854,389,193	3,268	6.5	3.9
NAICS 5415 Computer systems design	3,644	86,726	24	5,149,947,911	4,658	4.8	3.2
NAICS 3342 Communications equipment mfg.	53	2,891	55	131,117,171	3,335	4.5	2.8
NAICS 5417 Scientific R&D services	742	26,611	36	1,615,086,886	4,724	4.0	2.6
NAICS 5182 Computing infrastructure providers	378	12,211	32	1,089,227,860	6,911	3.5	3.3
NAICS 3359 Other electrical equipment mfg.	57	3,496	61	141,605,929	3,142	3.1	2.5
NAICS 5178 All other telecommunications	41	994	24	84,431,938	6,565	3.0	2.8
NAICS 4922 Local messengers and local delivery	69	3,699	54	230,082,303	4,843	3.0	5.9
NAICS 5223 Credit intermediation	173	6,087	35	263,401,674	3,304	2.5	1.5
NAICS 4236 Household appliance wholesalers	436	5,922	14	278,583,408	3,636	2.2	1.6
NAICS 3327 Machine shop manufacturing	352	5,191	15	94,418,395	1,397	2.1	1.0
Core region total	77,060	912,121	12	54,611,116,059	.	.	.

Source: LLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

To sum up, the infiltration of ICT across broad swaths of the economy – especially finance, retail, and entertainment – is part of larger national and global trends, but in San Francisco, in large part because of the proximity of established Silicon Valley-based companies, start-ups, venture capital, and specialized business and technical services, the emergence of the Digital Economy has been super-charged in recent years.

7. Policy institutions and practices

Regional policy institutions and mass transit

The San Francisco Bay Area comprises multiple multi-county and multi-city quasi-governmental jurisdictions that are part of the basic infrastructure of the city region. After the Second World War, a regional movement emerged in the San Francisco Bay Area, creating the five-county Association of Bay Area Governments (ABAG). Soon after, a plan created a mass transit system called Bay Area Rapid Transit (BART), which led to one of the most significant transit projects ever undertaken in the U.S.[6] While originally consisting of the five counties (Marin, Contra Costa, San Francisco, San Mateo, and Alameda). San Mateo and Marin Counties ultimately backed out of the system. A slightly downsized organization resulted and the system's backbone was completed in the early 1970s.[7] No doubt, San Francisco would now look very different had the growth of the transit system embraced the more distant suburbs. Even with BART, the area's bridges and highways continued to be jammed with commuters from the suburbs.

Another example of regionalism emerged to protect the Bay. The San Francisco Bay Conservation and Development Commission, established in the 1960s, was created to preserve the bay's quality and make possible public access where possible.

SFMade and associated initiatives

SFMade was founded in 2010 by a group if 12 initial founding companies, with city support, with the mission of helping manufacturers in the City of San Francisco start, stay, and grow in the city. There is also a focus on inclusion of traditionally excluded groups and the idea is that manufacturers are stable, pay decent wages, and provide opportunities for advancement. SFMade is similar to SeattleMade, and is part of a national organization for urban manufacturing, the *Urban Manufacturing Alliance*. Like the local chapters, the Alliance is supported by a philanthropic organization that includes a *mix of corporate, foundation, and government sponsors*. SFMade is intended to act as a "full-service hub that connects low-income job seekers to employment and training opportunities; provides local manufacturers with educational resources and customized, one-on-one services; and arms policy-makers with strategies and intelligence to create the conditions for home-grown manufacturers and their employees to thrive." It also brings "manufacturers into high school classrooms and creating internships to provide early exposure to the field." At the time of its founding, it was estimated that "estimated more than 300 San Francisco manufacturers make products spanning clothing, bags, belts, beer, wine, chocolate, coffee, electric bikes, electric motorcycles, recycled cement, dog collars, iPAD cases, furniture, jewelry, and even electronics. The majority of local manufacturers are located in the Southeastern neighborhoods - the Mission, Bayview, Central Waterfront, Lower Potrero, and South of Market – and draw a large percentage of their diverse workforce

[6] BART

[7] BART's "Airtrain" extension to San Francisco International Airport through San Mateo Country was eventually opened in 2003.

from the surrounding communities. A staggering 43% of our local manufacturers are owned by women." (SFMade, 2011). According to our primary research, a goal of SFMade is to keep the promotion of urban manufacturing front and center in the eyes of municipalities. The key issues are land use zoning, training, and making regulations compatible with manufacturing. The organization has a staff of 12, with people working on real estate issues, marketing, and workforce development, and a stable of experts to draw on when needed to help with specific topics. Peer-to-peer learning among members is encouraged. Covid-19, and subsequent inflation and supply-chain disruptions shifted the focus from growth to sustainability.

In 2016 SFMade helped launch a region-wide initiative called the *Bay Area Urban Manufacturing Initiative*, which now includes 31 cities.[8] The Initiative grew out of conversations taking place in the Urban Manufacturing Alliance. The Initiative mainly sponsors events and webinars. Cities within the region are different. For example, Fremont has the Tesla vehicle assembly plant, which is a big operation. At the same time, cities have similar problems in regard to industrial zoning, maintaining a skilled workforce, and training. The central question to be asked is, where does manufacturing fit into a city's economy?

The City of San Francisco

With the oil crisis and the decline of the traditional manufacturing industries of the Bay Area, San Francisco saw a population decline in the 1970s and early 1980s. And for about a decade, the population was steady. But it wasn't long before the city began to grow again, and this time, there was a concern that the direction of the city's growth could result in a decline in the quality of life for its residents. By the 1990s, the Bay Area became further stratified by income and race as area residents faced crushing traffic, rising housing costs, and the loss of good-paying jobs. To forestall this consequence, ABAG embraced several large-scale land-use plans focused on maintaining the city and its surrounding region as a residential and commercial city-region.[9] The city of San Francisco's growth and its residents' wealth further exacerbated the rising inequality between residents of the city property and communities in the surrounding region.

There is a lot of food processing and beverage production in the city, mostly boutique operations and lots of women entrepreneurs who eventually open a storefront. There are many of jewelry-makers like this as well. There are newer products being developed like fake meat, and specialty items such as boutique mayonnaise. During the pandemic many restaurants closed to the public and the city saw the emergence of "ghost kitchens", commissary operations that do delivery but have no storefront. This caused some anxiety when people saw popular restaurants disappearing and that these operations did not employ many people.

[8] Alameda, Antioch, Berkeley, Brentwood, Concord, Contra Costa County, Emeryville, Fairfield, Fremont, Hayward, Livermore, Milpitas, Morgan Hill, Napa, Newark, Oakland, Oakley, Petaluma, Pittsburg, Pleasanton, Richmond, San Francisco, San Jose, San Leandro, San Rafael, Santa Rosa, Sonoma County, South San Francisco, Union City, Vacaville, and Vallejo.

[9] https://abag.ca.gov

Sewing and garments have also been a key piece of the city's manufacturing base for a long time. SFMade has put a lot of effort into supporting these operations, trying to connect local clothing designers to local cut and sew operations. There are some metal manufacturers in the city, mainly boutique, small volume shops doing custom work. Some manufacturers have been in the city for many decades, including Anchor Brewing (recently sold to Sapporo), Heath Ceramics, and Casa Sanchez (Mexican food products). Pharmaceuticals are testing only, not production. Distribution is thriving, but there is more resistance to large scale Amazon warehouses, and less to smaller scale distribution of fresh flowers and produce. So tensions on conversion to distribution are still common. Overall, the approach to developing urban manufacturing capacity tends to be industry- and site-specific.

Government structure and practices

San Francisco's political history reflects a struggle to maintain economic and social diversity through a relatively progressive approach to land-use planning. Many policies in the city proper and the larger region were passed to control growth, starting in the 1970s and becoming increasingly aggressive in the 1980s. These policies took the form of rent control, land use regulation, limits on the scale and density of office buildings, and on protecting areas of the city previously home to low-rise industrial land uses.[10]

San Francisco has a strong Mayor form of mayoral/council government.[11] Being a county and a city at the same time creates complexity. City jurisdictions are represented by eleven geographically elected supervisors, and six additional elected officials represent specific functions of public safety, finance, records, and legal affairs. City operations under the Board of Supervisors include eight departments and agencies: transportation, youth, assessment appeals, board clerk, budget and legislative analyst, Local Agency Formation Commission, and Sunshine ordinance task force (Ibid, 2023).

Activities related to the city include more than eight different agencies. Another 70 programs and entities comprise agencies, commissions, and task forces. The Office of Economic and Workforce Development is separate from the Housing Authority, the Planning Commission, Redevelopment Agency, and Small Business Commission. The city is also part of numerous regional groups and agencies, including the ABAG, Metropolitan Transportation Commission, Bay Area Air Quality Management District, San Francisco Bay Regional Water Quality Control Board, and Bay Conservation and Development Commission.[12]

City Departments

City departments cover everything from judicial services to the maintenance of city streets. There are 98 departments in all, including a planning department that convenes weekly meetings about development around the city. The department maintains the General Plan and approves permits and licenses actions related to the zoning code. The board comprises seven

[10] https://sfplanning.org/land-use-and-community-planning

[11] https://sf.gov

[12] https://barc.ca.gov/about-us/member-agencies

Commissioners, four appointed by the Mayor and three appointed by the President of the Board of Supervisors.[13]

Of interest to this project, the city is divided into Community Benefits Districts (CBD). Residents and the city cooperate to maintain and improve the experience of individual neighborhoods. Members of the CBDs agree to pay an assessment. These funds are distributed based on local preferences. Seventeen CBDs cover much of the downtown area. Each defines its priorities and manages resources to address significant challenges and opportunities facing the city's neighborhoods. Services provided depend on the needs of individual districts and range from protective services, street beautification, homeless services, to public events.

Starting in 2000, the city began to change. South of Market's (SOMA) low-rise multi-story buildings were being converted into housing and office spaces for employees working in software-related industries. Companies like Google and Facebook rehabilitated or knocked down structures for offices. SOMA was quickly being transformed from inexpensive bars and low-cost hotel rooms to businesses employing young tech workers to design new products. With the pandemic, remote work led to a drastic reduction in foot traffic, and many retail businesses closed, spurring fears of a real estate "doom loop" exacerbated by increasing numbers of unhoused people on the streets, sometimes threatening workers and visitors (Koehn, 2023). The two populations co-exist uneasily, at best.

A city official mentioned that there is general support in San Francisco for urban manufacturing since people are concerned about gentrification and want their kids and immigrant communities to have jobs in the city. Still, many plans have been drawn up, and the process is contentious and drawn out, needing a lot of community input. There have been struggles with developers when plans limit the number of restaurants allowed and restrict the development of residential and office space. There have been successes, but there is constant pressure from developers to convert industrial space to more profitable uses, and efforts have been needed to strengthen protections. There have been efforts to streamline permitting, but inspections are needed and lots of drawings are required for manufacturing spaces and this raises the costs of development and improvement.

Pier 70 is a is a mixed-use development that includes restaurants, housing, and spaces intended for designer, makers, small manufacturers, and laboratories. The 28 acre site is centrally located on San Francisco's central waterfront. It includes meeting spaces to convene a variety of creative endeavors. The San Francisco's waterfront is public land, owned by the Port of San Francisco, and has historically been used for manufacturing. Most of the waterfront consists of ferry terminals, retail, and restaurants and activities aimed at tourists. In this sense Pier 70 is different and harkens to the city's more industrial past. But there is no significant production at Pier 70, mainly demonstration production lines for marketing and public relations.

The Eastern Neighborhoods Plan (ENP) is the main policy initiative to support urban manufacturing in the city of San Francisco. There is a long history of manufacturing in the Eastern Neighborhood of San Francisco, centered on shipbuilding. Like Seattle, San Francisco's traditional

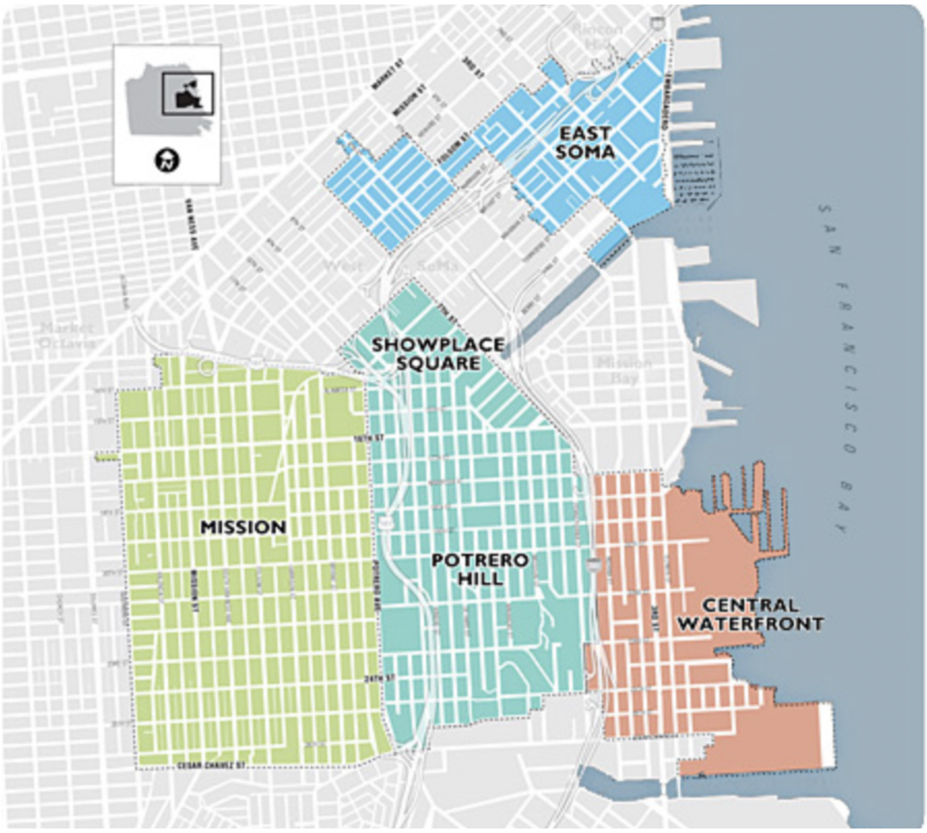
[13] https://sfplanning.org/planning-commission

industrial areas were adjacent to the port. After shipbuilding disappeared, there were many light manufacturers left. Another land use in SOMA was residential hotels, first for sailors and later for low-income people, especially single men. Housing and office space spilling over from the other side of Market St. was beginning to crowd out industrial use. This concerned some people. Manufacturers that needed to scale up did so outside the city. The goal of the ENP was to keep some manufacturing activities from moving outside the city. Fifty percent of the city's population did not have a college degree, and manufacturing pays more than service jobs. Industrial vacancy rates were low, at least until COVID, and so it could be argued that the demand was there.

The ENP not only protected manufacturing, but distribution and repair as well, in a zoning designation called production, distribution and repair (PDR). For a map of the areas included in the plan see Figure 7.1. According to our primary research, there was resistance from property developers when the idea for the Eastern Neighborhoods Plan was introduced in the early 2000s. However, the Plan was finally adopted in 2009 and now it is accepted because companies need to get things prototyped locally, and there is more demand for domestic manufacturing now that tension with China is rising. Companies are making climate technology products and satellites for internet access. There is also proximity to Moffett Field[14]. There is a shortage of land in the city's traditional industrial areas, though there may be a surplus now, after the pandemic.

[14] Moffett Field is a huge airfield that serves as defense aerospace defense research complex. It is operated by NASA, and houses several civilian and military air fleets. It also provides with long term leases to Google and others for aerospace-related R&D, including a Google spin-off making modern lighter than aircraft called Planetary Ventures. See: https://en.wikipedia.org/wiki/Moffett_Federal_Airfield

Figure 7.1: San Francisco's eastern neighborhoods



Source: San Francisco Planning: https://sfplanning.org/eastern-neighborhoods-plans

Practically, the ENP replaced M1- and M2 zoning, which permitted any kind of use with PDR, which excluded residential, office, and retail uses. This was very controversial. Developers those who already owned M-1 and M-2 properties that were to be rezoned were very upset. The front offices of big technology companies were also in opposition because they wanted the land for office and R&D space. Neighborhood groups were supportive, however, based on two motivations: 1) job creation and workforce development, and 2) slowing the encroachment of money/gentrification from west to east. Many policymakers were also in opposition. The Mayor at the time believed that the transformation of the city away from industrial activities was inevitable. However, the Board of Supervisors was supportive and Planning Department believed both office and manufacturing space could co-exist by increasing density in areas with office buildings. A bargain was struck that took half of M-1 and M-2 zones and made them PDR, and let the other half stay as mixed use. The height of buildings was also limited to eight stories. The process was completed in 2009. While it has been one of the most successful rezoning efforts in the city's history, it was very contentious. There were 25 public meetings. It has been described as the political battle of the 2000s. Since then, there have been huge increases in housing prices, so pressure has mounted and many developers are still unhappy.

Neighborhood groups feel that they did not get enough, and while they are opposed to gentrification, they are not always in favor of manufacturing on environmental justice grounds: they see manufacturing as polluting low-income communities, bringing in a lot of trucks, and so on. Nevertheless, there is still a constituency for the idea of urban manufacturing and planning staff remains supportive. Over the years, even the Mayor has embraced the concept. So it has remained intact, though things could always change in the future.

Industrial uses in the city when the ENP was being developed included high-end prototyping, fashion and industrial soft goods, food production, and catering and convention set up. There are also cement yards for construction projects on the waterfront -- you do not want trucks on the road with wet cement for more than 90 minutes. FedEx, Amazon, and UPS have tried to expand in the eastern neighborhoods and even though distribution is part of PDR they've been beaten back. Amazon is especially controversial. UPS is less so because their employees are unionized. At the same time, but there has been support for distribution activities in the city in part because food distribution has been a big part of the city's service to its homeless and low-income populations.

COVID changed things a lot. The office market dropped off, but demand for life sciences labs has continued to grow – and these are not allowed in PDR zones. Life sciences has its own designation, and places where it is allowed, especially near hospitals, such as in Brisbane, near the University of California San Francisco, in Mission Bay, and in Dogpatch.

Proposition X is a more recent effort, passed in 2016, to strengthen protections of PDR space established in the in the Eastern Neighborhoods Plan in 2009. Among other things, it designates that any demolished PDR space of more than 5,000 square feet be replaced by new PDR space. Our primary research suggests that that some advocates for urban manufacturing felt the additional protections were needed because developers were obtaining variances to current zoning regulations established under the Eastern Neighborhoods Plan, resulting in the gradual erosion of available industrial space, such as by trying to convert industrial spaces to parking garages and self-storage units. At the same time, PDR development was slowed down that could have improved areas where industrial space is very dilapidated. In some cases, Proposition X has made it hard for retail businesses like Starbucks to add stores in areas where they didn't have them, for example, and not everyone is happy about this, but at the same time it has proven to be a tool for historic preservation, which is sometimes at odds with economic development goals.

The Manufacturing Foundry is located in the Design District, 150 Hooper comprises four floors and has over 50,000 SF of multi-tenant, manufacturing space. Units range from 1000 square feet up to full floors (12,700 square feet). The property was developed by PlaceMade, "San Francisco's first non-profit industrial real estate development corporation with a mission is to sustain and grow manufacturing jobs for residents of urban communities by creating more real estate for manufacturing businesses in cities that is functional, accessible, and affordable." PlaceMade was launched in 2013 by SFMade. It houses another non-profit called Human Made, "San Francisco's first Advanced Manufacturing Training center that houses the city's most extensive open-access Design, Fabrication, and Prototyping Facility. Its mission is to empower individuals in our community to become the next generation of inventors, designers, and makers by providing access to the best training, tools, and facilities through workforce development and public training sessions."

8. Lessons from industry interviews

This section focuses on lessons from the research, including standard policy and business challenges urban manufacturing faces and a discussion of ten business models that might justify and sustain manufacturing in high-cost, congested urban settings. We illustrate these points with material collected during interviews with local companies and policy-oriented organizations. These challenges and workable business models used to structure the following sections appear to us to be common. We inserted comments from the interviews where appropriate when our interviews touched on these subjects. If there are no comments, it only means that the interviewees did not discuss these topics at particular length. We <u>do not</u> intend this to signal that such challenges are not present. Also, in many cases the material from the interviews outlines solutions to the identified challenges, not examples of the problems. Material from the interviews is in italics.

Common policy and business challenges for urban manufacturing

In our research, six main challenges for urban manufacturing emerged:

1. <u>High costs</u> (rent, taxes, wages, services, logistics)
    a. *The owner of a sewing contractor in San Francisco said that they can afford to be in San Francisco because they are in an undesirable (Bayview) neighborhood where there is trash on the street and rent is inexpensive. They have had the same landlord for decades and rent several units from him. They are next to a Superfund site and there are gangs, drugs, and lots of unhoused people around. Gates and all doors are kept locked at all times because there is a lot of theft.*
    b. *A small business owner in San Francisco told us that is very expensive to locate in San Francisco and opened their factory there because wanted to live in the city. They felt that the city's taxes, permitting, labor activism, and bureaucracy have pushed out a lot of small manufacturers. Construction costs are very high. Commercial kitchen builders are backed up, for example installing ten cafeterias for Facebook, so a small, one-off project for a small kitchen goes to the back of the line. They found that sub-contractors don't want the small, complex jobs when there is more lucrative work available. On the flip side, the company has been able to have access to capital and wealthy customers who understand premium products. While the traditional venture model wouldn't work for this type of business, San Francisco has billions in patient capital, so there are advantages to being in San Francisco as well.*
    c. *A city official mentioned that housing is still a challenge. There are neighbourhoods where rents are still reasonable, such as Bayview in the far east of the city, but transit is poor.*

2. <u>Lack of suitable industrial space</u> in both zoning regulation and existing building stock. This was sometimes alleviated by zoning plans that purposefully carved out space for urban manufacturing. Still, these plans were under constant pressure from developers seeking the use of properties for higher-value uses such as residential and retail.
    a. *A city official mentioned that the "sweet spot" the city aims for industrial operations in the city 25-50 workers in a building and that anything beyond that is too big.*
    b. *The owner of a small machine shop mentioned that they have had their rent subsidized with the help of SFMade.*
    c. *The founder of a specialty food producer in San Francisco told us that the company has a factory in the Mission neighborhood, a traditionally Latino area that is experiencing heavy pressure from gentrification. They were able to work with their investors to purchase the building to ensure they aren't priced out in the future.*
3. <u>Lack of support from government</u>.
    a. *An official from SFMade told us that the organization obtains 50% of its support from government contracts, including form the federal programs from the Manufacturing Extension Partnership and Small Business Administration, as well as city and state-level programs, and 40-50% from grants and contributions.*
    b. *The owner of a sewing contractor in San Francisco said that the city has offered help but they didn't see the value.*
4. <u>Lack or suitable workers</u>.
    a. *An official from SFMade told us that workforce issues are paramount for local manufacturers. The need for workers means that they need to look to historically underserved communities, immigrants, and formerly incarcerated people. According to this individual, the most important office for workforce and economic development in the region is the City of San Jose.*
    b. *The owner of a sewing contractor in San Francisco mentioned that there is a lack of suitable workers. Workers are getting older and there is no pipeline for new workers.*
    c. *The city has tried to help with workforce development for manufacturing. There is a program called Inside Manufacturing where high school students are brought into manufacturing operations as interns. On the skilled side, there is a CNC training program that takes place at Human Made.*
    d. *The owner of a small machine shop in San Francisco said that they have about 15 people in their office. They mentioned that newly hired operators have needed a lot of training.*
5. <u>Pollution and congestion</u>. There is a perception, often deserved, that manufacturing uses create noise, fumes, traffic, other uses. The surging popularity of bike lanes has come with a constituency opposed to the curb cuts needed to service the loading docks familiar at industrial facilities.

   a. *A city official mentioned that there are negative externalities that come with PDR space such as noise, smells, and traffic. Delivery trucks require loading zones and curb cuts on streets, and there can be fatalities when driveways cross bike lanes, so industrial development can be at odds with goals to reduce traffic fatalities in the city to zero.*[15]
6. Environmental justice critiques, where manufacturing's poor environmental record provides ammunition for project critics since urban spaces with available structures and land suitable for industrial zoning tend to be located in or near low-income and communities of color.
7. The need for more affordable housing for production workers necessitates long commutes. Interviewees report many challenges in recruiting workers from close-in neighborhoods, given steeply rising housing and other costs associated with living in our near urban downtowns. Several respondents noted that manufacturing workers tended to travel from lower-cost outer suburbs and complained that public transportation did not run at hours suitable for workers traveling to and from work on early morning or night shifts.
   a. *An official from SFMade noted that the region is big, and traffic is bad, so manufacturing workers often need to make long commutes. Keeping manufacturing close to the urban core where people live, especially in lower income neighborhoods, can help to alleviate this problem.*

Business model discussion

As we can see, manufacturing persists in the United States, even in high-cost urban environments. Our research asks, why is this the case? To get answers from the small sample investigated by our team (of four city regions with only six interviews in each), we have asked the question in the extreme: *Which business models appear to be viable and potentially sustainable in very high-cost and congested urban settings?* We found that urban manufacturing close in to the urban core is necessarily smaller in scale, more agile, and in some cases, more closely linked to innovation, and while it does provide employment opportunities for less educated workers and pathways for entrepreneurship, these opportunities are limited in scale. Nevertheless, urban manufacturing persists. This is true even when industrial space is hard to find, energy costs are high, logistics difficult, and housing unaffordable for production workers. Our research points to ten business models that motivated the interview subjects in the four city regions studied (and, presumably, elsewhere) to continue to engage in urban manufacturing:

1. The first relates to innovation, where production is co-located with R&D and new product development to support the iteration needed for prototyping and initial scale-up. We also note that dynamic innovation systems are usually linked to industries and scientific fields deeply rooted in an urban area. In San Francisco, electronic equipment is the main driver, though in our interviews with apparel manufacturers in the City, we heard similar reasons

[15] There is national-level network of cities with this goal led by bicycle advocates called Vision Zero, modeled on a Swedish program, of which San Francisco is a part. See: https://www.visionzerosf.org/ and https://visionzeronetwork.org/about/what-is-vision-zero/

for the persistence local manufacturing in urban areas. In such situations, long delays between product iterations necessitated by the tremendous geographical separation between innovation and production are impractical since manufacturing and product design engineers often need close contact. In some cases, new manufacturing techniques may need to be invented as part of the innovation process.

a. *An official from SFMade told us that there is steady demand for manufacturers that make prototypes and otherwise support customer R&D. However, these activities require higher skilled workers.*
b. *The owner of a sewing contractor in San Francisco told us that there is lots of innovation going on in the region and customers sometimes need to include fabric in their products, such as robots.*
c. *The owner of a small machine in San Francisco mentioned that there are many venture capitalists in San Francisco funding start-ups that need prototypes made for things like self-driving cars. These start-ups only have engineering teams, and need assistance with manufacturing. They need design assistance, metal casting, injection molding for the first 3-4 prototypes that they can show to their investors. Not all of these customers are in the city, but most are within a 1.5-2 hour drive. Some are elsewhere on the West Coast, for example in the Los Angeles Basin.*

2. The second relates to companies that need to be close to <u>specialized or skilled labor</u>.
3. The third is for products mainly produced in low-cost locations but need to be <u>rapidly replenished</u> during unexpected demand surges, such as air conditioners during a heat wave, snow shovels during a winter storm, or apparel and other fashion or seasonal items for which demand exceeds forecasts.
    a. *The owner of a sewing contractor in San Francisco said that rapid replenishment is not very common because costs are too high; air freight is a more common solution, since with ocean shipping you have to fill a container to make it affordable, and sharing a container might lead to damaged goods.*
4. The fourth is for low-volume items with standardized production processes but <u>high unit prices</u> that do not justify the challenges inherent in distant production, such as repairing and maintaining machinery and producing luxury goods.
    a. *The owner of a sewing contractor in San Francisco told us that they only technical soft goods, not consumer garments, since the field is too competitive and costs are too high. The owner has a background in chemistry and physics, and can talk to engineers.*
5. The fifth is <u>custom-made products</u>, such as one-off prototypes or unique crafts or art objects.
    a. *The owner of a sewing contractor in San Francisco said that they sometimes make ceiling covers and other pieces for museum exhibits.*

6. The sixth is "non-tradable" goods and processing activities for which production and consumption are best co-located and localized. One example that has come up in our research is the development and processing of fresh and specialty food items, either for retail or institutional markets, such as local "farm-to-table" food supply chains. Of course, many other products -- aside from such donor-derived therapies and personal services – do have the potential to be exported beyond their home region. An example might be recipes or food processing innovations developed in the context of local food systems that can be codified, scaled, and produced in volumes exceeding local demand for export beyond the region. So, a path for manufacturing growth can be from non-tradable to tradable products. This emphasizes the importance of business development, branding, scale-up, and distribution.
    a. *The owner of a sewing contractor in San Francisco told us that one-off prototypes do not generate enough income. If they start with prototypes, the goal is to move into low to medium volume production.*
    b. *The owner of a small machine shop located in in San Francisco described how helping design engineers with prototypes showed them that many technology companies want to test products in a manufacturing environment but have no machinery or experience in manufacturing. So they developed a national business in setting up manufacturing pilot lines in the R&D labs of technology companies across the country. They have done this sort of facility set up for Facebook in San Francisco, and Peloton in Manhattan for example. Architects can create the space, but not populate it with working machinery. All the machines in these facilities are production grade and programmable, but usually semi-manual, since engineers only make a few items at a time for testing purposes. R&D is not about efficiency or quality, it is about flexibility and variety. Sometimes these lines are just for show, like the Autodesk Technology Center demonstration line on Pier 9 in San Francisco. This business developed further into training, since design engineers generally have no experience operating (often) dangerous machinery, and companies face legal exposure of personnel are not trained and safety procedures are not developed. The company provides facilities set-up and documentation for specific machine tools, 3D printers, and process control like RFID. Engineers need months of training just to be able to turn a machine on safely. So the safety team becomes the client for tasks such as drawing up shop policies, PPE rules, safety procedures, etc. This has turned into an education division of the company. Revenues are about 40% from prototype manufacturing and design assistance, 40% from facilities set up, and 20% from education services. Prototype production is still small scale, and is better done locally, since the process can last for a year and a half. But the facilities set-up and training parts of the business are shorter term and can take place anywhere. All this growth has been organic, through word of mouth. This is a specialized service that is hard to market, but there are not many competitors.*

7. The seventh is for highly regulated products or products with regulatory requirements for domestic sourcing. This has historically been the case, especially for products for the military and other government purchases. However, in recent years domestic production requirements have been extended to a broader range of materials and products, such as those used for infrastructure projects. While there are many reasons to locate these new investments outside of existing high-cost industrial regions, such as those listed above, there may be reasons, such as those listed here, to do so. In addition, the availability of funds from the Federal Government to support domestic manufacturing can provide opportunities for local actors (states, counties, cities, universities, and industry groups) to gain access to new funding to support local industrial ecosystems, especially if there are viable industries or even the remnants of dying industries present in the region.
    a. *The owner of a sewing contractor in San Francisco mentioned that designs for defense contracts are very outmoded; sometimes designs are unchanged for 20 years, based on drawings can be from the 1940s. The contractor cannot make any suggestions for improvements, since approvals for changes will not be granted. On the other hand, the business sometimes gets orders for military products that are overdesigned with too many features; they won't make these products. Defense work tends to be very low volume.*
8. The eighth is legacy manufacturing plants that have operated for many decades. The company often owns the real estate, processes are stable, and older machinery is fully amortized. Such activities can be characterized as "hanging on," however. Unless industrial zoning is explicitly protected, they are under constant pressure for redevelopment for higher-value land uses, such as housing or offices.
    a. *An official from SFMade mentioned that there is a place for traditional manufacturers in the city in areas such as consumer goods and food manufacturing. They add vibrancy, and historically San Francisco has had an entrepreneurial spirit, and this bleeds into manufacturing.*
9. The ninth is for products where there is an imperative to shrink the geography of supply chains to reduce their carbon footprint.
    a. *Note: this topic was only mentioned in one of our Boston interviews.*
10. The tenth is for companies seeking to avoid offshoring costs beyond unit prices: tariffs, shipping delays, hidden management costs, and quality problems that increase scrap and rework costs can be expected when manufacturing is sourced internationally. Unexpected supply chain disruptions have been especially pronounced in recent years, leading buyers to look for manufacturers closer to end use (nearshoring and reshoring).
    a. *An official from SFMade told us that reshoring is increasing the appeal of locally made products, and that this provides business to contract manufacturers and also small companies that have their own products in small volumes that which are impractical to produce overseas.*

b. *The owner of a sewing contractor in San Francisco mentioned that about 6% of products made overseas have defects, and that this leads to orders to make repairs to imported products, especially at the higher-end. There is also a lot of cost and time involved in shipping. Overseas plants require travel and many small business owners don't want to do that. There have been a lot of supply chain delays caused by the shippers, not suppliers. Packages are sometimes dumped outside without refrigeration. This is not just pandemic-related. It has been going on for a long time. FedEx drivers used to have dedicated routes and have good relationships with customers, but not anymore.*

Low volume, high mix, and shared production

The general (non-scientific) impression from across the four case studies conducted by our team is that the most viable form of manufacturing in high-cost urban areas tends to be low-volume, small-scale, and with modest employment benefits. The norm is lower productivity and less effective utilization of equipment. A possible exception uncovered in the research is medium-volume facilities which produce a *high mix of items*. Such facilities can support all of the roles outlined above except for legacy manufacturing, which is, by definition, non-replicable. In high-mix production environments, manufacturing output can be substantial, but production runs for any one product will tend to be relatively short. The challenge is to keep capacity utilization high in the face of varying requirements. This is more than just a matter of equipment utilization. For example, materials managers in high-mix environments must coordinate the flow of various inputs (materials, parts, and components), and machinery must have fast set-up times and flexible tooling. High variability means that high-mix manufacturing resists automation. While there is a range of newer technologies aimed at increasing the productivity of high-mix production, such as cobots, 3D printing, manufacturing resource planning, and other business process software aimed at streamlining high-mix production, they remain expensive and unproven, and adoption rates are low in smaller manufacturing companies (Waldman-Brown, 2020). Advanced manufacturing can also elevate the importance of a high-quality workforce, but with better-trained workers comes the additional challenges of availability and high costs. It is common for only a few business functions to be carried out within the urban area, such as final assembly and last-minute configuration, and those functions that benefit from proximity to R&D (e.g., prototyping).

- *The owner of a sewing contractor in San Francisco argued that because they are small and nimble, the company is able to change jobs quickly, and shrink a six-month lead time to six weeks. On the high side volumes are 5-10 thousand units. At more that 20 thousand, customers are told to go overseas, but then the company can provide consulting advise on overseas production.*
- *The owner of a small machine shop in San Francisco said that they are low-volume, making 500 or fewer parts at a time. The company does do prototypes for start-ups, but most of these projects evolve into low volume production. Projects typically involve 20-30 local parts vendors. Local vendors are preferred so we can check on production. Higher volume production often involves redesign, and while the company doesn't do high volume production, they can help with the resign.*

The general impression from our research highlights two types of manufacturing that persist in high-cost urban environments that are both beneficial and sustainable: manufacturing related to innovation and production of non-tradable, particularly specialty foods. This is because these types of manufacturing are less cost-sensitive than higher-volume production and because there are social benefits beyond manufacturing employment to be garnered, such as supporting innovation and a diverse population of entrepreneurs. One promising avenue for scaling suitable diverse products and pathways for entrepreneurship is shared facilities, either in not-for-profit accelerators or for-profit contract manufacturers. These facilities can offer certifications, share the cost of plant and equipment, and offer various ancillary services, such as business consulting, design assistance, pooled purchasing, and help to find customers and marketing. When shared facilities work as they should, the next challenge comes when successful products need to scale past the high-mix setting to dedicated medium-volume facilities.

Again, a general (non-scientific) impression from the four case studies conducted by our team is that in high-cost-urban settings, industrial property and workforce shortages often force these firms to relocate outside the urban core. Nevertheless, reliance on R&D and start-ups can be sustainable if there is a steady flow of new products, new entrepreneurs, and small businesses focused on scaling the production of manufactured goods. However, fostering a robust pipeline of new companies and products requires specialized financial and educational resources focused on manufacturing entrepreneurship. If manufacturing is to be captured in the region, it also requires a sustained focus on urban manufacturing by city and state-level policy-makers, which is often lacking as political regimes change and the demands of industries better suited to high-cost urban settings take precedence.

9. Concluding remarks

The City of San Francisco and the larger Core Region have long served as the hearth of the most profitable innovations of the 20th and early 21st Centuries. As such, the region is unique. The companies and industries of Silicon Valley have created untold wealth and changed the world, for good and ill, and continue to drive human progress, though toward what end remains unclear. Because of continued dynamism of Silicon Valley's technology sector, low-to-medium volume manufacturing to support R&D, prototyping and medium-volume production of higher-cost items, manufacturing in the combined MSAs continue to be relatively vibrant, experiencing a much smaller decline in manufacturing employment than the other three MSAs covered in our research, as shown in Figure 5.4.

Continuous regional growth, punctuated by brief but sometimes severe pauses and crises, have led a string of prognosticators to erroneously predict that the problems being generated by the region's success – pollution, traffic congestion, high housing costs, and inequality –would lead to its immanent decline (e.g., Saxenian, 1984). However, these problems and pressures are real, and in recent years, they have been especially intense in the City of San Francisco, with its limited land area and natural beauty attracting hordes of wealthy technology workers, entrepreneurs, and residents. Industrial production and land uses within the city have not been immune from these pressures. However, like the other three cities we examined in our research, there is institutional support for manufacturing, even though the process of promoting and preserving manufacturing within city limits has been contentious and pressure to transform industrial space to higher value purposes more in keeping with the industries that are driving the regional economy is constant and rising.

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Appendix

Table A. 1: List of Companies in the San Francisco Bay Area Core Region

Sector/Company	City	County
Aerospace/defense		
Lockheed Martin Space Systems	Palo Alto, Sunnyvale	Santa Clara
Space Systems Loral	Palo Alto	Santa Clara
Made In Space, Inc.	Mountain View	Santa Clara
NASA Ames Research Center	Moffett Field	Santa Clara
L3 Technologies	Menlo Park, San Leandro, and Santa Rosa	San Mateo
Apparel		
Mountain Hardwear	Richmond	Alameda
Jos. A. Bank	Fremont	Alameda
Stitch Fix	San Francisco	San Francisco
Allbirds	San Francisco	San Francisco
Betabrand	San Francisco	San Francisco
Dolls Kill	San Francisco	San Francisco
Everlane	San Francisco	San Francisco
Gap Inc.	San Francisco	San Francisco
Levi Strauss & Co.	San Francisco	San Francisco
ModCloth	San Francisco	San Francisco
Tea Collection	San Francisco	San Francisco
Bebe	Brisbane	San Mateo
Poshmark	Redwood City	Santa Clara
Zazzle	Redwood City	Santa Clara
Automotive		
Lucid Motors	Newark	Alameda
Motiv Power Systems	Hayward	Alameda
Cruise (subsidiary of General Motors)	San Francisco	San Francisco
Zoox	San Carlos	San Mateo
Byton	Santa Clara	Santa Clara
Nio	San Jose	Santa Clara
Rivian	Palo Alto	Santa Clara
Waymo	Mountain View	Santa Clara
Biotechnology		
Anthera Pharmaceuticals	Hayward	Alameda
Mendel Biotechnology, Inc.	Hayward	Alameda
Chiron	Emeryville	Alameda
Nektar Therapeutics	San Francisco	San Francisco
Signature BioScience	San Francisco	San Francisco
Calico (subsidiary of Alphabet)	South San Francisco	San Mateo
Genentech	South San Francisco	San Mateo
Gilead Sciences	Foster City	San Mateo
Roche Molecular Systems	Belmont	San Mateo
Intuitive Surgical	Sunnyvale	Santa Clara
23andMe	Mountain View	Santa Clara
Verily Life Sciences	Mountain View	Santa Clara

Sector/Company	City	County
Consumer goods		
Clorox	Oakland	Alameda
Bianchi USA	Hayward	Alameda
Benefit Cosmetics	San Francisco	San Francisco
Method	San Francisco	San Francisco
Sephora	San Francisco	San Francisco
GoPro	San Mateo	San Mateo
Kleenspeed Technologies	Mountain View	Santa Clara
Specialized Bicycle Components	Morgan Hill	Santa Clara
Creative/design		
Ammunition	San Francisco	San Francisco
IDEO	San Francisco	San Francisco
Landor Associates	San Francisco	San Francisco
Traction (agency)	San Francisco	San Francisco
fuseproject	San Francisco	San Francisco
Education		
Magoosh	Berkeley	Alameda
Quizlet	San Francisco	San Francisco
Remind	San Francisco	San Francisco
Chegg	Santa Clara	Santa Clara
Course Hero	Redwood City	Santa Clara
Coursera	Mountain View	Santa Clara
Khan Academy	Mountain View	Santa Clara
Udacity	Mountain View	Santa Clara
Electronics		
Logitech	Newark	Alameda
Adaptec	Milpitas	Alameda
Dust Networks	Hayward	Alameda
Antec	Fremont	Alameda
Asus	Fremont	Alameda
Lam Research	Fremont	Alameda
Silicon Graphics (acquired by Rackable Systems)	Fremont	Alameda
Synnex	Fremont	Alameda
Fitbit	San Francisco	San Francisco
Jawbone	San Francisco	San Francisco
Digidesign	Daly City	San Mateo
Monster Cable Products	Brisbane	San Mateo
Advanced Micro Devices (AMD)	Sunnyvale	Santa Clara
Fujitsu Computer Products of America	Sunnyvale	Santa Clara
Juniper Networks	Sunnyvale	Santa Clara
NetApp	Sunnyvale	Santa Clara
Silicon Image	Sunnyvale	Santa Clara
Agilent Technologies	Santa Clara	Santa Clara
Applied Materials	Santa Clara	Santa Clara
Brocade Communications Systems	Santa Clara	Santa Clara
Genesis Microchip	Santa Clara	Santa Clara
Hitachi Data Systems	Santa Clara	Santa Clara
Intel	Santa Clara	Santa Clara

Sector/Company	City	County
Marvell	Santa Clara	Santa Clara
Nvidia	Santa Clara	Santa Clara
Terayon	Santa Clara	Santa Clara
Altera	San Jose	Santa Clara
Broadcom Inc.	San Jose	Santa Clara
Cisco Systems	San Jose	Santa Clara
Fairchild Semiconductor	San Jose	Santa Clara
Hewlett Packard Enterprise	San Jose	Santa Clara
Hitachi Global Storage Technologies	San Jose	Santa Clara
Integrated Device Technology	San Jose	Santa Clara
Maxim Integrated	San Jose	Santa Clara
Philips Lumileds Lighting Company	San Jose	Santa Clara
Sanmina-SCI	San Jose	Santa Clara
Sony Optiarc America Inc.	San Jose	Santa Clara
Supermicro	San Jose	Santa Clara
Western Digital	San Jose	Santa Clara
Xilinx	San Jose	Santa Clara
Hewlett Packard	Palo Alto	Santa Clara
Nest Labs	Palo Alto	Santa Clara
Synopsys	Mountain View	Santa Clara
JDS Uniphase	Milpitas	Santa Clara
KLA Tencor	Milpitas	Santa Clara
Solectron Corporation	Milpitas	Santa Clara
Touchstone Semiconductor	Milpitas	Santa Clara
Rambus	Los Altos	Santa Clara
Apple Inc.	Cupertino	Santa Clara
Seagate Technology	Cupertino	Santa Clara
Barracuda Networks	Campbell	Santa Clara
Energy		
Energy Recovery Inc.	San Leandro	Alameda
Mosaic Inc.	Oakland	Alameda
PG&E	Oakland	Alameda
Sungevity	Oakland	Alameda
Sunrun	San Francisco	San Francisco
SolarCity	San Mateo	San Mateo
SunEdison	Belmont	San Mateo
Bloom Energy	Sunnyvale	Santa Clara
Cupertino Electric	San Jose	Santa Clara
Rosendin Electric	San Jose	Santa Clara
SunPower	San Jose	Santa Clara
Engineering and Construction		
Swinerton	San Francisco	San Francisco
Webcor Builders	San Francisco	San Francisco
DPR Construction	Redwood City	San Mateo
Katerra	Menlo Park	San Mateo
Entertainment		
Pandora Radio	Oakland	Alameda
Pixar	Emeryville	Alameda

Sector/Company	City	County
Capcom U.S.A.	San Francisco	San Francisco
Crunchyroll	San Francisco	San Francisco
Dolby Laboratories	San Francisco	San Francisco
Industrial Light & Magic	San Francisco	San Francisco
Niantic	San Francisco	San Francisco
Philo	San Francisco	San Francisco
Sega of America	San Francisco	San Francisco
Ubisoft	San Francisco	San Francisco
Zynga	San Francisco	San Francisco
Roblox Corporation	San Mateo	San Mateo
Sony Interactive Entertainment (PlayStation)	San Mateo	San Mateo
Electronic Arts	Redwood City	San Mateo
Netflix	Los Gatos	Santa Clara
Financial		
Block, Inc.	San Francisco	San Francisco
Brex	San Francisco	San Francisco
Calypso Technology	San Francisco	San Francisco
Coinbase	San Francisco	San Francisco
First Republic Bank	San Francisco	San Francisco
Lending Club	San Francisco	San Francisco
SigFig	San Francisco	San Francisco
SoFi	San Francisco	San Francisco
TPG Sixth Street Partners	San Francisco	San Francisco
Visa, Inc.	San Francisco	San Francisco
Wells Fargo Bank	San Francisco	San Francisco
Fisher Investments	Woodside	San Mateo
Franklin Templeton Investments	San Mateo	San Mateo
Yodlee	Redwood City	San Mateo
Robinhood	Menlo Park	San Mateo
Robert Half International	Menlo Park	San Mateo
Silicon Valley Bank	Santa Clara	Santa Clara
Bill.com	San Jose	Santa Clara
FICO (Fair Isaac Corporation)	San Jose	Santa Clara
PayPal	San Jose	Santa Clara
Food and drink		
21st Amendment Brewery	San Leandro	Alameda
Ghirardelli Chocolate Company	San Leandro	Alameda
Otis Spunkmeyer	San Leandro	Alameda
Dreyer's Grand Ice Cream	Oakland	Alameda
Häagen-Dazs	Oakland	Alameda
Black Angus Steakhouse	Los Altos	Alameda
Annabelle Candy Company	Hayward	Alameda
Columbus Salame	Hayward	Alameda
Mountain Mike's Pizza	Hayward	Alameda
Shasta	Hayward	Alameda
Takaki Bakery (Andersen Institute of Bread and Life)	Hayward	Alameda
Clif Bar	Emeryville	Alameda
Peet's Coffee & Tea	Emeryville	Alameda

Sector/Company	City	County
Annie's Homegrown	Berkeley	Alameda
PowerBar	Berkeley	Alameda
Anchor Brewers & Distillers, LLC	San Francisco	San Francisco
Extreme Pizza	San Francisco	San Francisco
See's Candies	South San Francisco	San Mateo
Togo's	San Jose	Santa Clara
Impossible Foods	Redwood City	Santa Clara
Blue Bottle Coffee (subsidiary of Nestle)	Oakland	Santa Clara
Healthcare		
Kaiser Permanente	Oakland	Alameda
Castlight Health	San Francisco	San Francisco
One Medical	San Francisco	San Francisco
Eargo	San Jose	Santa Clara
Palo Alto Medical Foundation	Palo Alto	Santa Clara
Internet		
Ask.com	Oakland	Alameda
Airbnb	San Francisco	San Francisco
Craigslist	San Francisco	San Francisco
DoorDash	San Francisco	San Francisco
Dropbox	San Francisco	San Francisco
Ebates	San Francisco	San Francisco
Instacart	San Francisco	San Francisco
Pinterest	San Francisco	San Francisco
Salesforce.com	San Francisco	San Francisco
Slack Technologies	San Francisco	San Francisco
Poll Everywhere	San Francisco	San Francisco
Postmates	San Francisco	San Francisco
Tripping.com	San Francisco	San Francisco
Twitch	San Francisco	San Francisco
Twitter	San Francisco	San Francisco
Uber (228)	San Francisco	San Francisco
Wikimedia Foundation	San Francisco	San Francisco
Yelp	San Francisco	San Francisco
Zendesk	San Francisco	San Francisco
Zoosk	San Francisco	San Francisco
SurveyMonkey	San Mateo	San Mateo
YouTube (subsidiary of Alphabet Inc.)	San Bruno	San Mateo
Box	Redwood City	San Mateo
Poshmark	Redwood City	San Mateo
Meta (formerly Facebook)	Menlo Park	San Mateo
LinkedIn	Sunnyvale	Santa Clara
Cisco	San Jose	Santa Clara
eBay	San Jose	Santa Clara
Zoom Video Communications	San Jose	Santa Clara
Evernote	Redwood City	Santa Clara
Rubrik	Palo Alto	Santa Clara
Yummly (subsidiary of Whirlpool Corporation)	Palo Alto	Santa Clara
Alphabet Inc. (formerly Google)	Mountain View	Santa Clara

Sector/Company	City	County
Google (subsidiary of Alphabet Inc.)	Mountain View	Santa Clara
Quora	Mountain View	Santa Clara
Media		
Daily Review	Hayward	Alameda
University of California Press	Berkeley	Alameda
Dwell	San Francisco	San Francisco
POPSUGAR Inc.	San Francisco	San Francisco
San Francisco Chronicle	San Francisco	San Francisco
Complex (magazine)	San Francisco	San Francisco
Future US	South San Francisco	San Mateo
Communication Arts	Menlo Park	San Mateo
San Jose Mercury News	San Jose	Santa Clara
Mobile media		
MobiTV	Emeryville	Alameda
TubeMogul	Emeryville	Alameda
Bleacher Report	San Francisco	San Francisco
Networking and telecommunications		
Pacific Telemanagement Services	San Leandro	Alameda
ZPE Systems	Fremont	Alameda
Fortinet	Sunnyvale	Santa Clara
Juniper Networks	Sunnyvale	Santa Clara
Avaya	Santa Clara	Santa Clara
Arista Networks	Santa Clara	Santa Clara
Ericsson	Santa Clara	Santa Clara
Palo Alto Networks	Santa Clara	Santa Clara
A10 Networks	San Jose	Santa Clara
Brocade Communications (Broadcom)	San Jose	Santa Clara
Cisco (64)	San Jose	Santa Clara
Extreme Networks	San Jose	Santa Clara
F5 Networks	San Jose	Santa Clara
Minerva Networks	San Jose	Santa Clara
NETGEAR	San Jose	Santa Clara
Barefoot Networks (Intel)	Palo Alto	Santa Clara
Aryaka Networks	Milpitas	Santa Clara
Real estate		
Digital Realty	San Francisco	San Francisco
Jay Paul Company	San Francisco	San Francisco
LiquidSpace	San Francisco	San Francisco
Prologis	San Francisco	San Francisco
Trulia	San Francisco	San Francisco
Retail		
California Closets	Richmond	Alameda
Safeway (subsidiary of [Albertsons])	Pleasanton	Alameda
Jos. A. Bank	Fremont	Alameda
Ross Stores	Dublin	Alameda
Cost Plus Inc.	Alameda	Alameda
Gap.com	San Francisco	San Francisco
Gymboree	San Francisco	San Francisco

Sector/Company	City	County
Levi's	San Francisco	San Francisco
Macys.com	San Francisco	San Francisco
Minted	San Francisco	San Francisco
Pottery Barn	San Francisco	San Francisco
Sephora	San Francisco	San Francisco
Timbuk2	San Francisco	San Francisco
Williams-Sonoma, Inc. (489)	San Francisco	San Francisco
Walmart.com	San Bruno	San Mateo
Shutterfly	Redwood City	San Mateo
Zazzle	Redwood City	San Mateo
Software		
Sybase (SAP)	Dublin	Alameda
AppDynamics	San Francisco	San Francisco
DocuSign	San Francisco	San Francisco
Dropbox	San Francisco	San Francisco
GitHub	San Francisco	San Francisco
New Relic	San Francisco	San Francisco
Piggybackr	San Francisco	San Francisco
Pivotal Software (VMware)	San Francisco	San Francisco
Splunk	San Francisco	San Francisco
Imperva	San Mateo	San Mateo
Neo4j	San Mateo	San Mateo
Bloombase	Redwood City	San Mateo
Box	Redwood City	San Mateo
Pyze	Redwood City	San Mateo
Qualys	Foster City	San Mateo
Genesys	Daly City	San Mateo
Trimble	Sunnyvale	Santa Clara
Malwarebytes	Santa Clara	Santa Clara
McAfee	Santa Clara	Santa Clara
ServiceNow	Santa Clara	Santa Clara
TeleNav	Santa Clara	Santa Clara
Adobe Inc. (285)	San Jose	Santa Clara
Business Objects	San Jose	Santa Clara
Nutanix	San Jose	Santa Clara
Objectivity, Inc.	San Jose	Santa Clara
Sage Intacct	San Jose	Santa Clara
Cloudera	Palo Alto	Santa Clara
Medallia	Palo Alto	Santa Clara
Palantir Technologies	Palo Alto	Santa Clara
People Power Company	Palo Alto	Santa Clara
SAP	Palo Alto	Santa Clara
TIBCO Software	Palo Alto	Santa Clara
VMware	Palo Alto	Santa Clara
Intuit(445)	Mountain View	Santa Clara
Mozilla	Mountain View	Santa Clara
Symantec (461)	Mountain View	Santa Clara

Sector/Company	City	County
Transportation and logistics		
Lime	San Francisco	San Francisco
Lyft	San Francisco	San Francisco
Uber	San Francisco	San Francisco

Source: Wikipedia, accessed May 2, 2023.

Urban Manufacturing in Seattle

Case study submitted to WIFO (Austrian Institute of Economic Research), Vienna

Timothy Sturgeon and Amy Glasmeier

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A note about geographic definitions. The report uses a flexible definition of the city region, depending on data availability and the analysis level.

- MSA: The broadest definition is the Metropolitan Statistical Area (MSA). An MSA is a multi-county geographic construct that attempts to encompass areas of urban concentration in terms of population and economic activity. The MSA definition is a statistical unit of analysis assigned by the U.S. Census Bureau, not a political unit. While MSAs generally include counties that form the region's industrial core, they may also include counties that are mainly residential, commercial, or governmental and, therefore, outside the main scope of analysis. However, because some economic data are readily available at the level of MSAs, the designation is used as a matter of convenience for some of the analysis.
- CORE CITY-REGION: A more focused geographic designation is the "core region." This consists of several counties surrounding the primary city containing the most industrial activity. Since more detailed sectoral statistics tend to be available at the county level, this customized collection of countries is used to reduce "noise" in the analysis.
- CITY: The most constrained geographic definition used in the study is the jurisdiction of the region's primary city, which is generally the most densely developed, most congested, has the highest operating costs, and has the highest level of contention over land uses. We mainly focus on industrial policies at this level.

We will use these designations throughout, although the MSA has been shortened after initial use, and Core City-Region has been shortened to Core Region. **In the case of Seattle, the MSA and the Core City-Region coincide as they both consist of three counties, Snohomish, King, and Pierce.** Our analytic strategy begins with the MSA/Core Region to pick up regional trends, then focuses on our interview results investigate industrial practices and policies as close to the city level as possible to observe the position of urban manufacturing where it is likely to come under the most extreme pressure. The logic is that if manufacturing occurs in high-cost urban settings, there must be good reasons for it!

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1. Historical background

The geographic situation of Seattle relative to the United States and the other three regions investigated by our team is shown in Figure 1.1. Although inhabited by Native Americans for 4000 years or more, Seattle is a comparatively young city, with the first white settlers arriving in 1851. The city's early development path was relatively slow compared with the towns east of the Rockies; the city was firmly settled only in the late 19th Century. Early trade focused on timber and fish, sold to settlements up and down the proximate coast, and eventually exported to Asia. On the edge of the Pacific Ocean and separated from the more developed U.S. Eastern seaboard by a vast and rugged continent, in its early development Seattle was as likely to look across the Pacific and the Asian continent for economic opportunity as relying on trade with the East Coast.[1] The city's deep-water port, which opened in 1911, also played a significant role in its industrial growth, allowing for efficient import and export of goods.

With the railroad's arrival, this changed somewhat in the late 19th and early 20th centuries, contributing to Seattle's emergence as an important manufacturing center. The city's first primary industry was lumber, which boomed in the late 1800s due to the abundance of trees in the surrounding forests. The lumber was used to build houses, ships, and other structures. Seattle became one of the leading lumber producers in the country as forests in the East and Midwest of the country became depleted. As the city grew, the fishing industry, with salmon being the primary catch, continued to drive canning and shipbuilding. Fish were processed and canned in factories along the waterfront, known as the "Fishermen's Terminal."

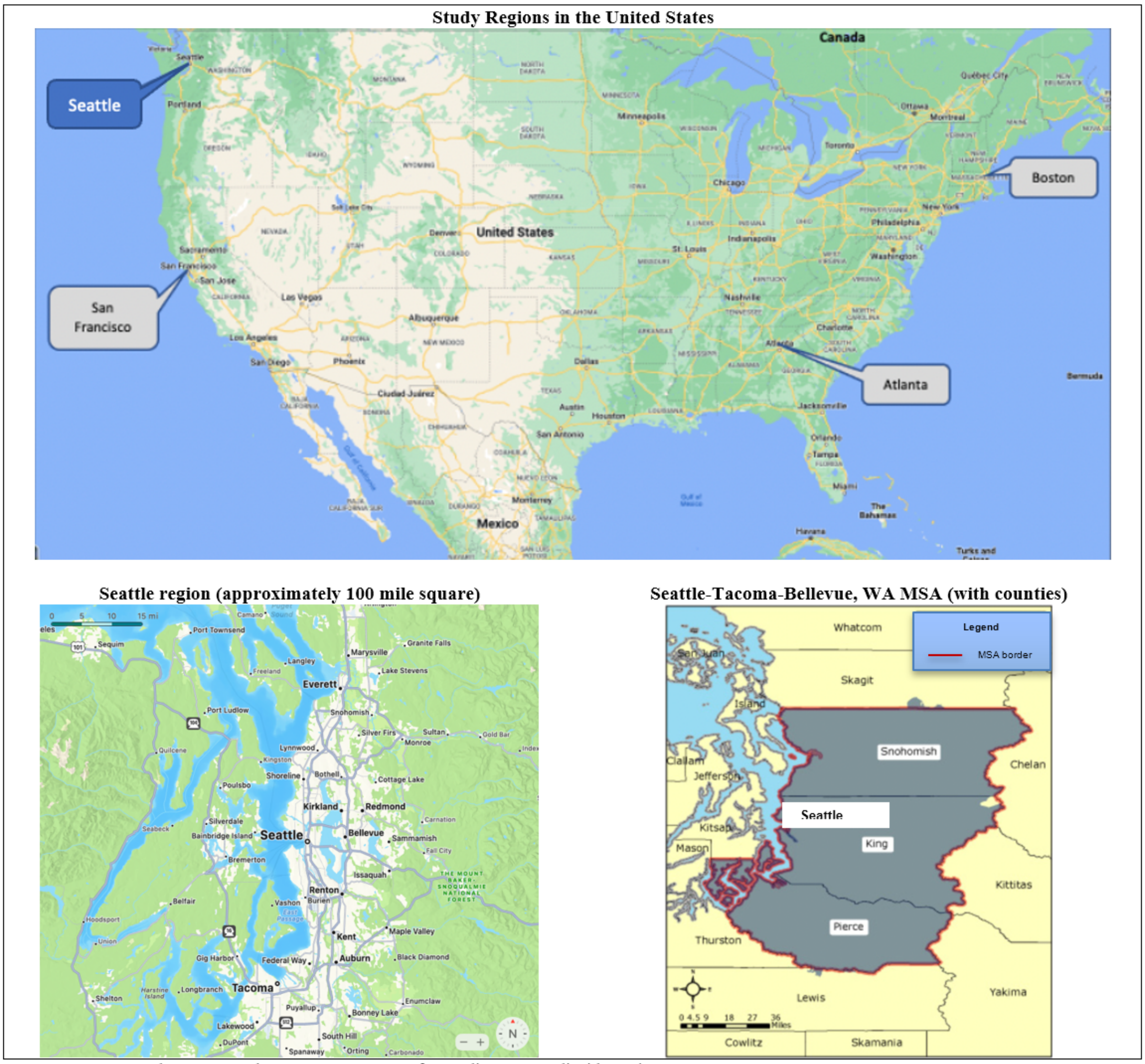
Shipbuilding grew beyond fishing and ocean shipping vessels during World War I and World War II with the construction of naval vessels and cargo ships. The building of the interstate highway system further cemented Seattle's position as an essential transportation hub on the West Coast.

Despite the decline of some of these industries over the years, Seattle's industrial heritage remains an integral part of its identity and economy. Many old factories and warehouses have been repurposed as offices, shops, and restaurants, and the city continues attracting businesses and entrepreneurs from various industries.

As with San Francisco, Seattle's climate, landscape, preexisting culture, and markets distinctly differed from earlier settlements on the East Coast. Whether or not this difference, and relative isolation, fostered innovation as industries grew to face novel challenges under greater constraints is debatable (Aydalot and Keeble, 1988). Regardless of the reason, Seattle is home to pioneering inventors in three critical industries: aircraft, software, and retail, including e-commerce.

[1] https://www.seattle.gov/cityarchives/seattle-facts/brief-history-of-seattle. Accessed 03/07/ 2023

Figure 1.1: Seattle in its geographic context



Sources: Maps: Google Maps, Apple Maps, U.S. Centers for Medicare & Medicaid Services

2. Major Industries and companies

Very broadly speaking, Seattle is a city and region with a bi-modal firm size distribution. On one hand, several important multinational companies have been founded in the City or its immediate vicinity. As of December 2021, the Seattle metropolitan was home to eleven Fortune 500 companies: Internet retailer Amazon (ranked #2), Costco Wholesale (#12), Microsoft (#15), coffee chain Starbucks (#125), truck maker Paccar (#159), Nordstrom department stores (#289), timber and lumber company Weyerhaeuser (#387), logistics firm Expeditors

International (#299), air carrier Alaska Airlines (#459) and travel web site Expedia (#500).[2] On the other hand, Seattle is famous for its many small craft producers of items as diverse as beer, spirits, and jewelry.

As this list suggests, major companies have emerged in Seattle over the years in a diverse set of industries. However, several stand out: 1) transportation equipment design and manufacturing (Boeing and Paccar), 2) retail and logistics (Amazon, Costco, UPS, Starbucks, Nordstrom, and Expeditors International, and 3) software and web services (Microsoft, Amazon Web Services, and Expedia). In this section, we highlight three of Seattle's most important firms, Boeing, Microsoft, and Amazon. While only Boeing is centrally focused on manufacturing, Microsoft and Amazon have also diversified into electronic hardware, and, according to our interviews, make regular uses of local R&D labs and contract manufacturers to help develop prototypes and initial product runs. In addition, all large technology companies in Seattle have attracted and trained thousands of engineers, some of whom have left to found their own companies in the area. Finally, all three have been major contributors to the region's science, technology, engineering and mathematics (STEM) education system, an investment that has not only served to fill the ranks of their own engineering divisions, but has also fostered hundreds of local start-ups.

Boeing

The Boeing Company is among the largest global aerospace manufacturers in the world. Its main business is to design, manufacture, and service long hail commercial airplanes, but also produces rotorcraft, rockets, satellites, telecommunications equipment, and missiles, and is the third-largest defense contractor in the world based on 2020 revenue. International sales from these combined businesses have made the company the United States' largest exporter by dollar value.[3]

The company has played a major role in the aviation industry since 1916, when William Boeing founded the Pacific Aero Products Company in Seattle, later renamed Boeing Airplane Company. The company's first airplane, the B&W, was completed in 1916, and it went on to produce several military aircraft during World War I. During the 1920s and 1930s, Boeing became a leading manufacturer of commercial aircraft with the Model 80, which was an early all-metal airliner, and the Model 247, the first modern airliner with a low-wing design and retractable landing gear. Boeing's military aircraft production continued during World War II with several important bomber aircraft, including the B-17 Flying Fortress and the B-29 Superfortress. After World War II, Boeing focused again on commercial aircraft, introducing the 707 jet airliner in 1958. This was followed by the 727, 737, and 747 models, which became some of the most successful airliners in history. Boeing has continued to innovate and expand its product line, introducing the 757, 767, and 777 in the 1980s and 1990s. Boeing also continues to produce military aircraft, including the F-15 Eagle, F/A-18 Hornet, and the AH-64 Apache attack helicopter (Boeing).

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2 List of companies based in Seattle - Wikipedia

3 https://people.defensenews.com/top-100/

The 787 Dreamliner project was launched in 2004, and the first plane was flown in 2009. The project cost $8 billion to develop and was the first airliner with a composite carbon-fiber fuselage and wings, which reduced weight and increased fuel efficiency. The design also increased the plane's range, opening up new carrier routes.[4] By the time it debuted, the 787 already had orders for 677 planes worth $100 billion (Pallini and Rains, 2020).

The 787 programs were marked by two interrelated shifts in operational strategy for the company: outsourcing and offshoring. While almost all aircraft companies outsource critical parts like jet engines and avionics, Boeing embarked on an aggressive program of outsourcing many more parts and components to save costs through competitive bidding and to bring on non-unionized suppliers. The company also shifted some of its aircraft assembly to a new plant in Charlotte in 2011 – in the right-to-work state of North Carolina – and consolidated production of the 787 models there in 2020. Offshoring was undertaken in part to lower costs and in part to help win contracts with state-connected airlines around the world. For example, the 787's main wing was initially produced by Mitsubishi in Japan. In return, Japan's All Nippon Airways (ANA) placed a $6 billion order for 50 planes in 2004, Boeing's most significant order for a new passenger jet aircraft.

Arrangements with "risk suppliers" like Mitsubishi also involved the co-design of critical parts and a financial stake by suppliers in the program's eventual success (Sturgeon et al., 2013). The increase in outsourcing in the context of such a complex, novel aircraft project led to massive problems with system integration and long delays. As a result, after a year and a half of test flights, the first Dreamliner was finally delivered to All Nippon Airways (ANA) on September 26, 2011, nearly ten years following its initial order (Pallini and Rains, 2020).

Boeing has faced several other challenges throughout its history, including the cancellation of the Boeing 2707 supersonic transport project in 1971 and the grounding of the 737 MAX in 2019 following two fatal crashes. However, the company has remained a major player in the aerospace industry and remains, along with Europe's Airbus, one of two successful producers of long-haul commercial aircraft in the world.

It is hard to overstate the impact of Boeing on Seattle. At the end of 2022 Boeing had 60,244 employees in Washington State (Nall and Halverson 2023). The company provides good-paying jobs to its mostly unionized workers, owns thousands of acres of land, and has spun off hundreds of aerospace-related companies.[5] Apparently, most of these spin-offs have been organic in nature. Boeing venture capital arm, HorizonX, opened in 2017, had only invested in about a dozen companies when it was sold to a private equity firm in 2021 (CNBC, 2021). Because of the outsourcing push with the 787 program, many small suppliers in the Seattle region continue to receive contracts for parts, components, equipment, and services. According to Mayer (2013), a critical moment in the life of Seattle and Boeing arose when Boeing

[4] The longest-ever nonstop Boeing 787 flight was operated by Comlux in March 2021, flying 12,106 miles from Seoul, South Korea, to Buenos Aires, Argentina. The ultra-long-haul flight lasted 20 hours and 19 minutes (Pallini and Rains, 2020).

[5] https://www.britannica.com/topic/Boeing-Company

consolidated its data processing activities into one operation, forming a skilled labor pool that went on to fill jobs in companies like Microsoft, Amazon, and Expedia.

In addition to its new manufacturing complex in Charlotte, North Carolina, which makes the company's newest commercial airliner, the 787, the Boeing moved its official headquarters from Seattle to Chicago in 2001, and is currently in the process of moving to it to Arlington, Virginia to help it win government military contracts. However, Seattle remains an important location for the company. The 737, 747, 767 and 777 airliner will continues to be produced there (AP, 2020). It has not "moved away" as much as it has expanded elsewhere.

Microsoft

Microsoft Corporation develops, licenses, and sells computer software, consumer electronics, and personal computers. It is one of the largest software makers in the world and has had a significant impact on the development of the personal computer industry.

Bill Gates and Paul Allen were high school friends in Seattle. In 1975, Bill Gates went off to Harvard but soon dropped and left Cambridge, Massachusetts to join Allen in Albuquerque, New Mexico to develop a software interface for a primitive personal computer (PC), the Micro Instrumentation and Telemetry Systems (MIPS) Altair 8800. Microsoft's first product for MIPS was the Microsoft Disk Operating System (MS-DOS), created in BASIC, a university-developed programming language that had been in use since the 1960s.[6] In 1981, in a half-hearted foray into the nascent field of PCs, IBM decided not to spend the money needed to develop componentry and software internally. It outsourced most inputs, including the central processor, to Intel and the operating system to the fledgling Microsoft (Sturgeon, 2002). As the popularity of the IBM PC surged beyond imagination, MS-DOS allowed the company to become a dominant player in the personal computer industry, essentially a duopoly, along with its much smaller arch-rival Apple. In 1985, in a defensive move against Apple Computer's more intuitive graphical user interface, Microsoft adapted and rebranded MS-DOS as Windows. After winning a lawsuit with IBM that allowed them to sell to any PC producer, MS-DOS/Windows became the world's most widely used PC operating system.

During the 1990s, Microsoft faced several legal challenges, including antitrust lawsuits from the US government and the European Union, which accused the company of monopolistic practices in combining Windows with its popular application software, Microsoft Office. In 2001, Microsoft was ordered to split into two companies, but this decision was overturned on appeal.

In the 2000s and 2010s, buoyed by its success in operating systems and application software, the company branched out – often defensively – into new areas, including an internet browser (Internet Explorer), a search Engine (Bing), the Xbox video game console, the (unsuccessful) Windows Phone operating system, and the Surface line of tablets and notebook computers.

When Satya Nadella took over as CEO after Bill Gates stepped down in 2014, he expanded the company's focus into cloud computing and artificial intelligence. Microsoft Azure, the

[6] BASIC stood for Beginner's All-purpose Symbolic Instruction Code. It was developed by John G. Kemeny and Thomas E. Kurtz at Dartmouth College in the mid 1960s (https://www.britannica.com/technology/BASIC).

company's cloud computing platform, has become one of the leading cloud services in the industry, and Microsoft has also invested heavily in AI research and development. Today, Microsoft is one of the largest and most successful technology companies in the world, with a market capitalization of over $2 trillion.[7]

Microsoft's history in Seattle can be traced back to its early days as a startup, when Gates and Allen relocated the company to their hometown. Microsoft initially rented office space there in the Northgate area of the city, north of downtown (Russo, 2020). However, the company soon outgrew that space and began construction on its campus near Redmond, Washington. The first building on the campus, Building 1, was completed in 1986. Since then, Microsoft has continued expanding its Seattle area presence. The company owns a huge Redmond, Washington campus comprising 83 buildings, 502 acres, and 8 million square feet of office space.

Over the years, Microsoft has contributed to the local economy in Seattle and the surrounding region. In addition to creating thousands of high-paying jobs, the company has invested heavily in local infrastructure and education initiatives, partnering with local schools and universities to support STEM education and workforce development programs. The company has actively participated in the local technology community, sponsoring events and initiatives such as the Seattle Tech Meetup and the Microsoft Imagine Cup. In 2018, Microsoft announced a $500 million investment in affordable housing in Seattle, citing the need to address the region's growing homelessness crisis (Byron and Varyu, 2023).

A recent round of layoffs of about 2,800 employees in Seattle (part of a global round of layoffs of about 10,000) (Soper, 2023) will not do much to dissipate Microsoft's impact on the region. It employs 221,000 workers worldwide, 80,000 in the U.S. and 50,000 in the Seattle area.[8] Ten years ago, the Washington Technology Industry Association estimated that 148 local firms in the region were Microsoft spinoffs.[9] Other studies of Seattle highlight Microsoft's key role in diversifying the city's industrial base (Audretsch and Lehmann, 2005).

Amazon

Amazon.com, founded by Jeff Bezos in 1994, has become one of the world's largest and most successful online retailers, streaming media providers, and cloud services companies. The company's history in Seattle can be traced back to its early days as a startup, when Bezos worked out of his garage in Bellevue, Washington, to take advantage of growing opportunities in e-commerce. The company has been headquartered in Seattle ever since.

Starting as an online book retailer, Amazon eventually diversified into selling almost any type of item that could be shipped via package express, including apparel, home goods, and eventually groceries, all supported by a vast network of warehouse fulfillment centers across the world, and eventually, company-owned last mile delivery vans.

[7] https://www.britannica.com/topic/Microsoft-Corporation

[8] https://www.macrotrends.net/stocks/charts/MSFT/microsoft/number-of-employees

[9] https://www.washingtontechnology.org/about/

However, the company's presence in media has continued to grow with e-books, the Kindle e-book reader, the Alexa home assistant, and a streaming video service called Amazon Prime offered to e-commerce customers paying an annual fee in exchange for free rapid shipping.

In 2006, the company leveraged its vast and robust in-house IT services infrastructure to provide cloud services to other customers, launching Amazon Web Services (AWS). AWS quickly gained popularity among developers and businesses, and the company began expanding its offerings and building a network of data centers worldwide. In 2010, AWS opened its first data center outside the United States in Dublin, Ireland. Since then, the company has continued to expand its global footprint, with data centers in regions such as Asia Pacific, Europe, and South America.[10] In recent years, AWS has become the largest cloud services provider in the world. In the first quarter of 2022, AWS held a 33% market share (ahead of Microsoft's 22% and Google's 10%). Clients include Airbnb, Twitter, McDonalds, Pfizer, and Amazon's competitor in streaming media, Netflix. Most recently, the company has launched new services, such as artificial intelligence and machine learning tools, and has also worked to improve the security and reliability of its cloud infrastructure (Davis, 2022).

In Seattle, Amazon initially rented office space in the SoDo neighborhood of the city, located between the seaport and downtown. However, the company soon outgrew its initial space and began construction on its own campus in the South Lake Union area of downtown Seattle. The first building on the campus, known as the 'Amazon.com Tower,' was completed in 2002. Since then, Amazon has continued to expand its presence in the Seattle area, including the architecturally significant 'Amazon Spheres' office complex.[11] Amazon's office and R&D space now spans more than 40 buildings in the city, in South Lake Union, Denny Triangle and Downtown.[12]

Over the years, Amazon has been an important contributor to the local economy in Seattle and the surrounding region. Amazon's Housing Equity Fund represents a $2 billion commitment to "preserve and create more than 20,000 affordable homes in three communities where we have a high concentration of employees: Washington State's Puget Sound region (including Seattle); the Arlington, Virginia region; and Nashville, Tennessee. It will help create inclusive housing developments and preserve existing housing through below-market loans and grants to non-traditional and traditional housing partners, public agencies, and minority-led organizations supporting communities of color." (Amazon.com, housing equity). The company has also partnered with local schools and universities nationwide to support STEM education and workforce development programs. In 2012, the company created the Amazon Web Services Cloud Computing Center at the University of Washington.

[10] https://aws.amazon.com/about-aws/global-infrastructure/

[11] https://seattletravel.com/amazon-spheres-guide-how-to-visit-hours-tours-and-more/

[12] https://www.builtinseattle.com/2019/03/08/coolest-features-amazon-seattle-headquarters

3. Regional statistical profile

In November 2022, the civilian labor force (employment outside of government and military) in the Seattle-Tacoma-Bellevue MSA (hereafter Seattle MSA) numbered 2,788,200, with 2,714,300 employed. The result is a historically low unemployment rate of 2.7%, similar to the other city regions examines by our team, except for San Francisco, which has a higher rate (see Table 3.1). The rate for the United States as a whole was 3.6%. Labor markets have been tightening in the United States since the Global Financial Crisis in November 2009, when they reached 9.9%, with a brief spike to 14.7% at the onset of the Covid-19 pandemic in April 2020.

Table 3.1: Labor force statistics, Seattle-Tacoma-Bellevue MSA compared with three other city regions, November 2022, thousands of jobs

	Seattle MSA	Boston MSA	Atlanta MSA	San Francisco/ San Jose
Civilian Labor Force	**2,788.20**	2,536.20	3,208.70	3,291.80
Employment	**2,714.30**	2,465.00	3,122.20	3,189.60
Unemployed	**73.9**	71.2	86.5	102.20
Unemployment Rate	**2.7%**	2.8%	2.7%	5.8%

Table 3.2 provides a general statistical profile of the Seattle MSA. This region occupies the coastal cities in Washington State surrounding Puget Sound, one of several deep-water ports on the west coast of the U.S. (see Figure 1.1). According to the 2020 Census, the Seattle MSA had a population of 4,018,762, making it the 15th largest in the United States.

The MSA is less diverse than many others of similar size. The racial and ethnic makeup is 60% White, 15% Asian, 11% Latinx, and 6% Black. The region's lack of diversity is offset somewhat by a relatively high level of immigration. Nearly a fifth of the population is foreign-born, and a quarter speak a language other than English at home.

Table 3.2: Seattle-Tacoma-Bellevue MSA basic statistics (2020/2021)

Indicator	Value
Population	4,018,762
Employer establishments	108,431
Race and ethnicity	
White	2,415,355 (60.1%)
Asian	617,399 (15.3%)
Latinx	450,476 (11.2%)
Black	246,767 (6.1%)
Language other than English spoken at home	24.9% (U.S. = 21.6%)
Foreign born	20.0% (U.S. = 13.6%)
Median household income	$101,721 (U.S. = $69,717)
Employment rate	63.3% (U.S. = 58.6%)
Poverty rate	8.6% (U.S. = 12.8%)
Bachelor's degree or higher	46.8% (U.S. = 35.0%)
Median gross rent	$1,730 (U.S. = $1,191)
Home ownership rate	61.0% (U.S. = 65.4%)
Without health insurance	5.6% (U.S. = 8.6%)
Without an internet subscription	4.8% (U.S. = 9.7%)

Sources: U.S. Census Bureau: https://data.census.gov/profile

On average, Seattle is a wealthy city, with a median household income of almost $102,000, compared to the national average of just under $70,000. The MSA's poverty rate[13] is 8.6%, compared to nearly 13% nationwide. For many, the region offers economic opportunity and a good quality of life. The employment rate is higher than the national average (63.3% vs. 58.6%). Forty-six percent of the Seattle MSA's residents hold a Bachelor's Degree or higher, compared with only 35% nationwide. 5.6% are without health insurance, compared with 8.6% nationally. Only 4.8% of households lack internet access, compared with 10% nationally.

However, economic success comes with challenges, especially with traffic congestion and high housing costs. Seattle suffers from the 20th worst traffic congestion in the United States, with 46 hours lost per commuter annually (Bartiromo, 2023). Median gross rent is far above the national average ($1,730 per month vs. $1,191 nationally), and home ownership is well below the national average (61% versus 65.4% nationally).

4. Why manufacturing is important[14]

To provide a broader context for trends at the city-region level, this section asks why manufacturing is essential. The section is included in all four reports prepared by our team with the reasoning that the national situation with manufacturing in the United States will go a long way toward making sense of our finding in each of the city-regions we examined in our research. However, readers may skip this section. The main finding is that manufacturing employment has been declining in most OECD countries for many decades, driven in part by automation but, in the past 20 years and especially for the United States, by the rise of export manufacturing in China and other low-income countries.

The benefits of manufacturing for economic and social development are long-heralded as a mechanism for shifting resources from low- to higher-productivity activities (Kuznets, 1971).[15] The faster the growth of the manufacturing sector, the more productivity is enhanced because resources – significantly labor – are shifted away from traditional sectors such as agriculture, where technology is applied to maintain (or increase) output. As labor shifts out of agriculture, manufacturing takes up the slack, creating solid middle-class employment in urban areas, especially for workers without high levels of education, along with large-scale workplaces suitable for union organizing.

Kaldor (1967) focused more on productivity and exports within manufacturing than labor. He argued that GDP growth is higher when manufacturing's share is rising because it has increasing returns to scale and because of manufacturing's disproportionate contribution to a country's balance of payments through exports, which can be intra-regional or international. So,

[13] According to the U.S. Census Bureau, a household is considered poor if its income is below a specific threshold set according to the Consumer Price Index. In 2021, this threshold was set at a total annual income of $36,500, or slightly more than $3,000 per month (see: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html).

[14] This sub-section is included in all reports to provide context.

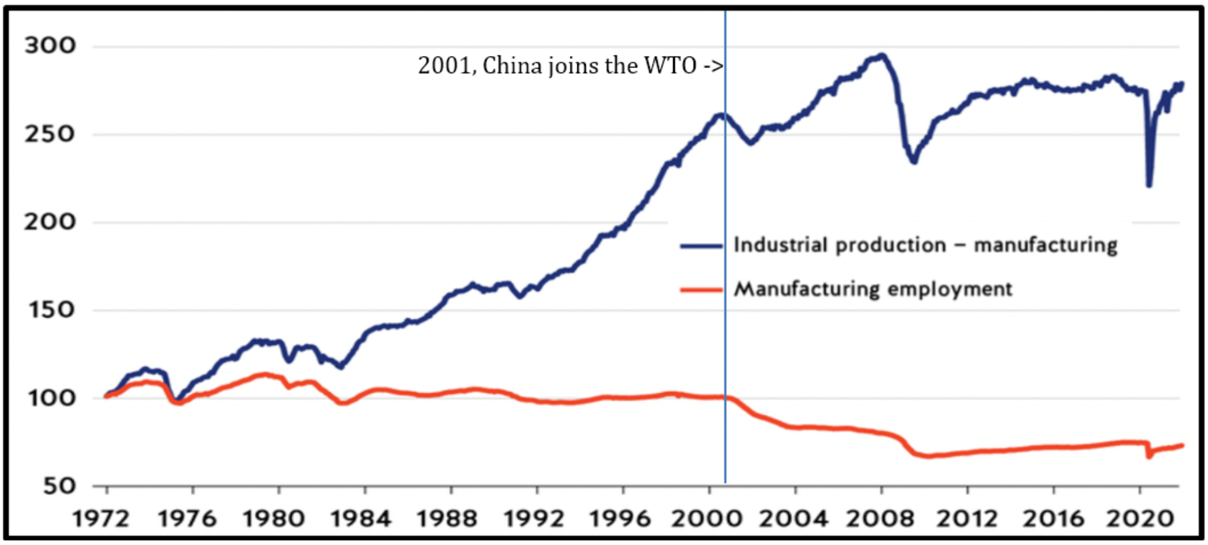
[15] For example, with the shift of labor and capital from agriculture to manufacturing through industrialization.

rising manufacturing output can generate regional and national wealth because of high value-added, steady productivity increases, and exports that create a positive revenue flow, even if manufacturing employment eventually grows more slowly or turns negative. This sectoral succession model assumes that once labor has been all but wrung out of agriculture through productivity increases, the same can happen with manufacturing, as jobs in the services sector can take over as the engine of job creation, productivity increases, and export growth.

Manufacturing trends globally and in the United States

This process is ongoing in the United States and most other large OECD countries, where manufacturing output continues to grow, but employment is shrinking (Figure 4.1). At its peak in 1979, manufacturing employment in the United States reached 19.5 million, representing 22 percent of nonfarm employment. Forty years later, manufacturing employment stood at only 13 million, and its share fell to 9 percent. The dichotomy between output growth and employment decline is explained by productivity increases from automation, computerization, and better work organization and management practices, as predicted by models of sectoral succession.

Figure 4.1: US industrial production and manufacturing employment index, 1972-2020 (1972=100)



Source: Federal Reserve Bank of St Louis FRED database. Notes: Industrial Production: Manufacturing (NAICS), Index Jan 1972=100, Monthly, Seasonally Adjusted; Employment: All Employees, Manufacturing, Index Jan 1972=100, Monthly, Seasonally Adjusted.

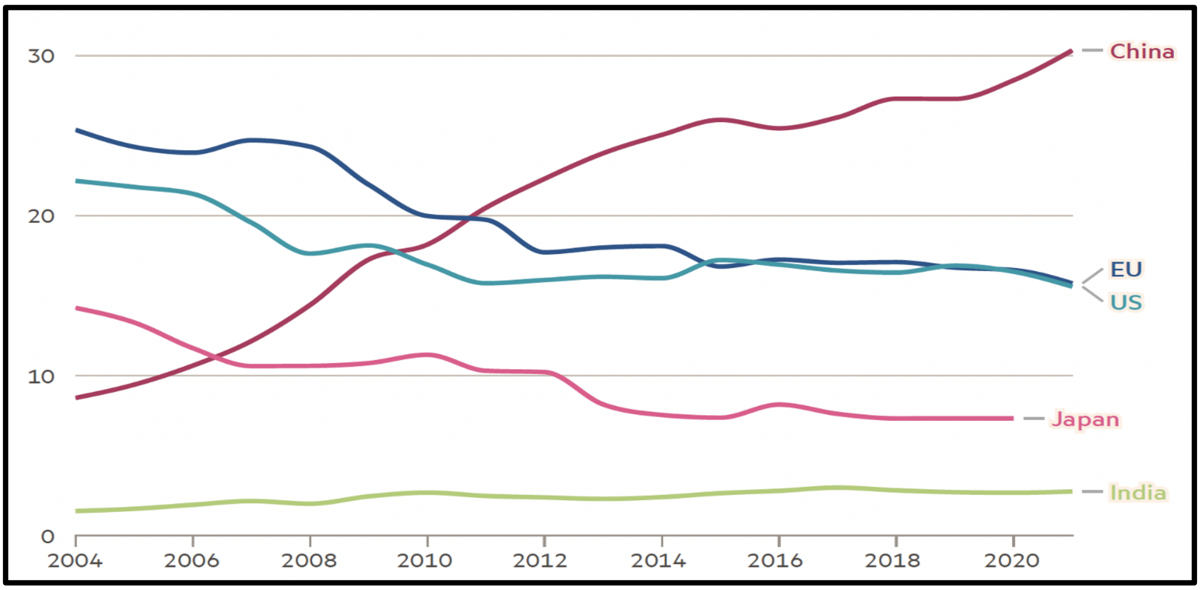
However, the trend was super-charged for the United States in the 2000s by migrating large-scale export-oriented production to lower-cost countries in the developing world, especially China. This shift simultaneously increased import competition for remaining manufacturing plants, lowered prices, and increased consumer product variety in the United States.

The China Shock

The net impact of offshoring manufacturing jobs on economic and social development is still being determined (Kirchner, 2022). Uneven effects are being felt in the manufacturing employment decline in the United States. Regions of historic manufacturing concentration are suffering greatly. Offshoring pushed China's share of global manufacturing value added to nearly 30% in 2021 from less than 10% in 2004 (Figure 4.2). This extraordinary rise created a massive trade deficit for the United States with China (see Figure 4.3).

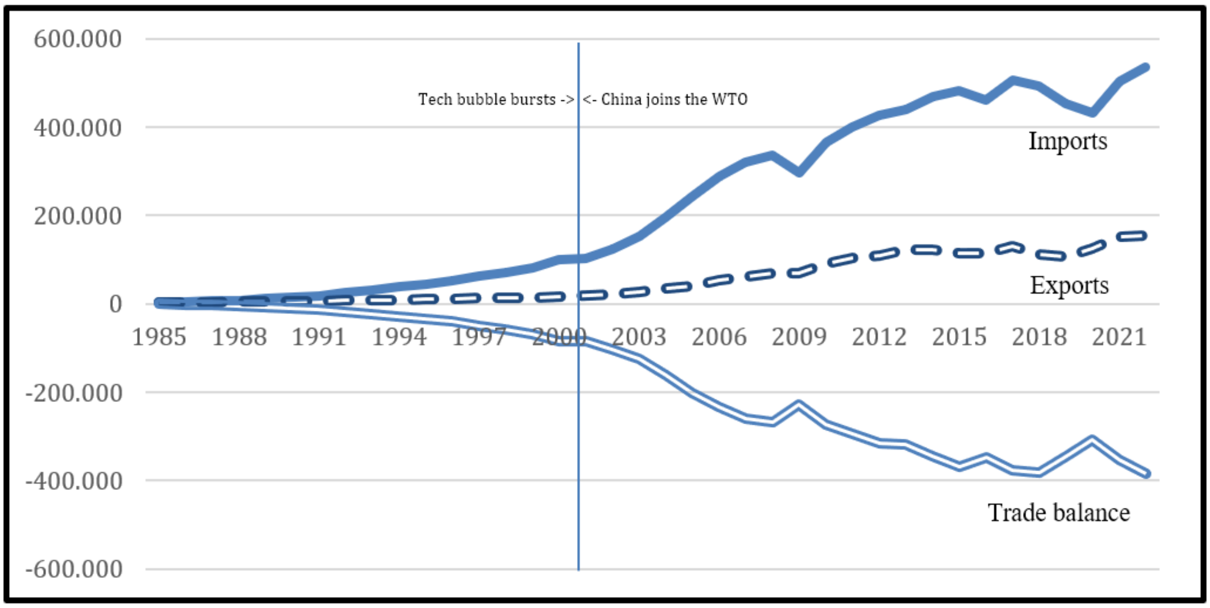
China's role as an export platform role exploded after it acceded to the WTO in 2001. This led to huge trade deficits with trading partners, especially the United States (see Figure 4.3). While the U.S. trade balance in services (including technology licenses, an indicator of China's technological dependence on the United States) has remained positive, the deficit with China in goods soared to US $382 billion in 2018 and leveled off since. Not coincidentally, this came on the heels of the bursting of the 'technology bubble' in the U.S. in 2001, which sent U.S. manufacturers scrambling to cut costs and access 'big emerging markets' in China, India, and Brazil – moves that often come with requirements to set up local production, conduct R&D, and (reluctantly and partially, at best) transfer technology to local joint venture partners.

Figure 4.2: Share of Global Manufacturing Value Added, 2004-2021 (percent)



Source: McGee (2023) for Financial Times based on World Bank data

Figure 4.3: US trade with China, 1985-2022



Source: U.S. Census Bureau: https://www.census.gov/foreign-trade/balance/c5700.html. Note: Figures are in U.S. million dollars on a nominal basis, not seasonally adjusted.

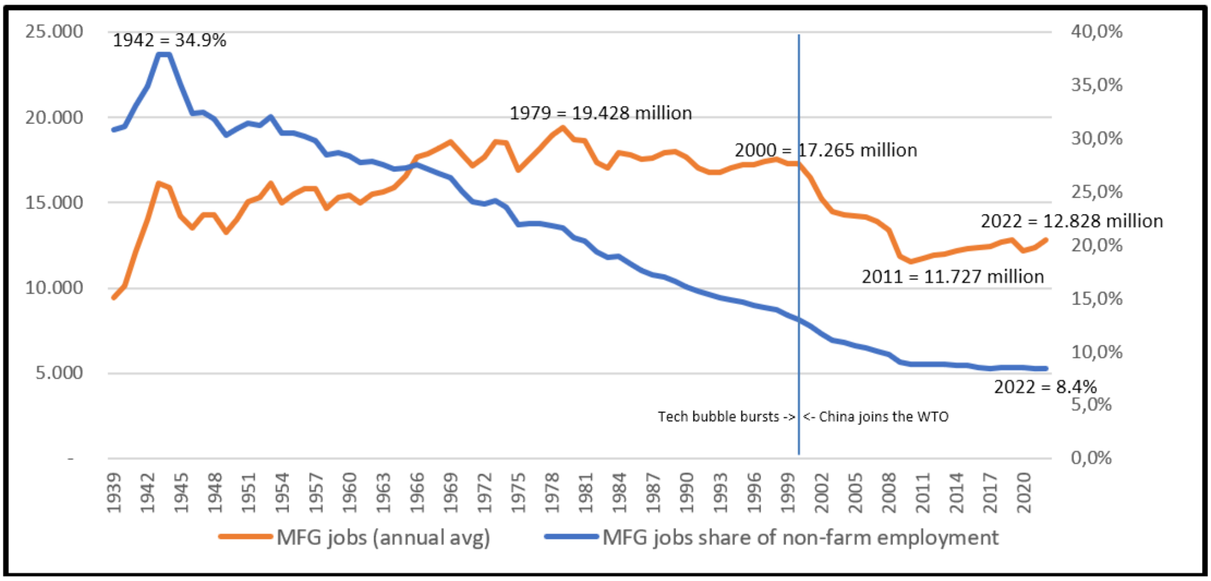
In this way, the 'China shock' set the stage for the political upheavals of 2016 and beyond. Autor et al. (2016, abstract) frame it this way:

> *China's emergence as a great economic power has induced an epochal shift in world trade patterns. Simultaneously, it has challenged much empirical wisdom about how labor markets adjust to trade shocks. Alongside the heralded consumer benefits of expanded trade are substantial adjustment costs and distributional consequences. These impacts are most visible in the local labor markets, where the industries exposed to foreign competition are concentrated. Adjustment in local labor markets is prolonged, with wages and labor-force participation rates remaining depressed and unemployment rates remaining elevated for at least an entire decade after the China trade shock commenced. Exposed workers experience more significant job churning and reduced lifetime income. At the national level, employment has fallen in U.S. industries more exposed to import competition, as expected, but offsetting employment gains in other industries have yet to materialize.*

Manufacturing employment in the United States

Since its peak of 34% of total non-farm employment in 1942, during the height of World War Two, the share of manufacturing jobs in the United States workforce declined to its current low of 8.4% in 2022. However, this is mainly due to robust job growth in other sectors. The number of manufacturing jobs in the United States grew steadily after World War Two, peaking cyclically to a peak of 19.428 million in 1979, dropping gradually to 17.265 million in 2000, and then rapidly after China joined the WTO, to its modern low of 11.727 million in 2011. After that, manufacturing employment has been on a gradual rebound, to 12.828 in 2022 (see Figure 4.4).

Figure 4.4: US manufacturing jobs (thousands), and share of non-farm employment, 1939-2022



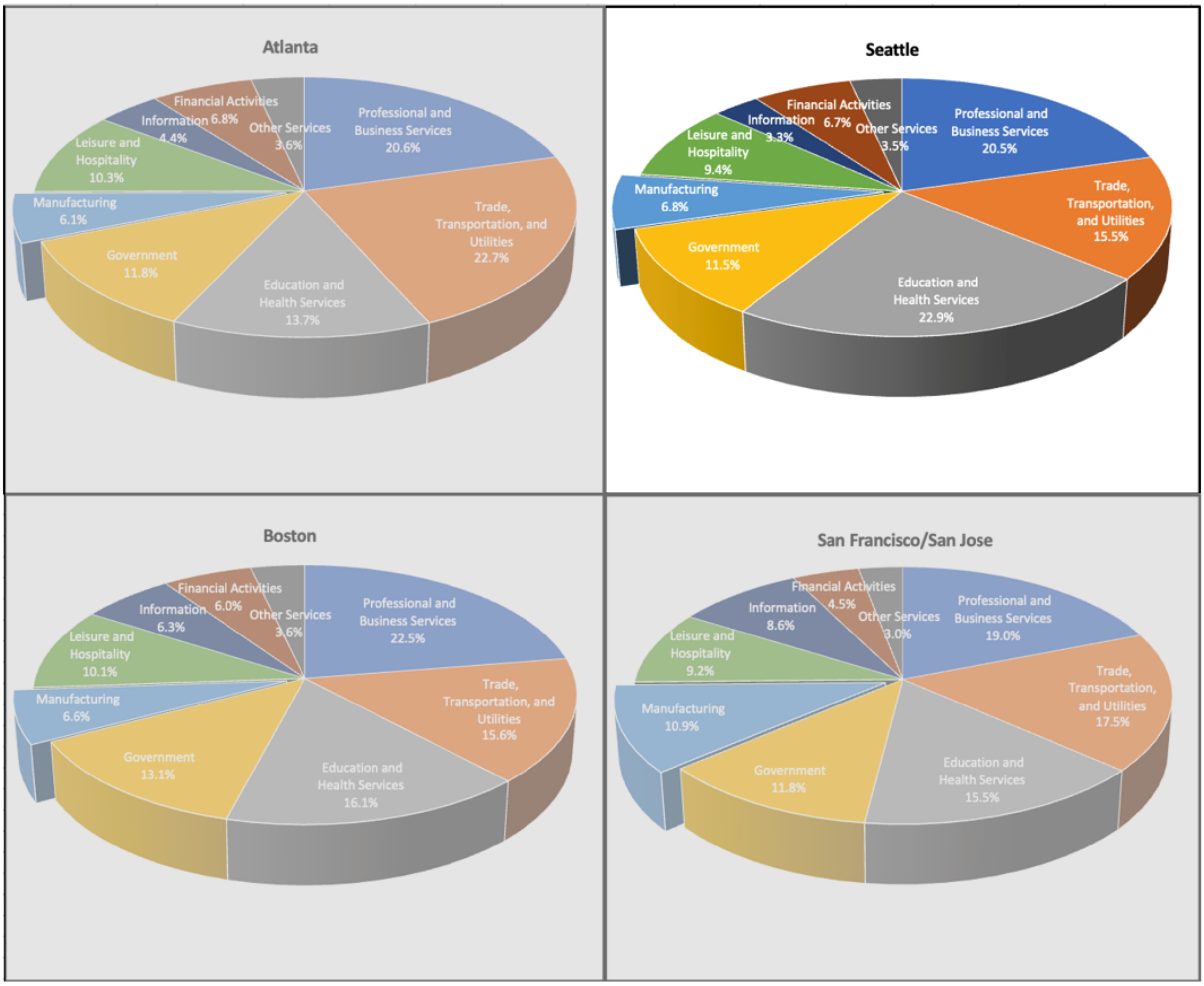
Source: Employment, Hours, and Earnings from the Current Employment Statistics Survey (National), U.S. Bureau of Labor Statistics

5. Manufacturing Trends in Seattle

This section discusses trends in manufacturing in the Seattle metropolitan region (defined here by the Seattle-Tacoma-Bellevue MSA (hereafter Seattle MSA), which is contiguous with what we define as Seattle's core region, consisting of the three counties of Snohomish, King, and Pierce). It discusses the importance of manufacturing relative to other regional sectors.

In December 2020, manufacturing employment in the U.S. stood at 13 million, 8.4% of non-farm employment. Figure 5.1 shows that manufacturing employment was 6.8% of non-farm employment in the Seattle MSA.

Figure 5.1: Seattle-Tacoma-Bellevue MSA jobs by major industry compared with three other city-regions, November, 2022



Source: MSA data from U.S. Bureau of Labor Statistics Regional Dataset, https://www.bls.gov/regions/

However, the sectoral mix is similar across the three regions examined by our team, reflecting their roles as core governmental, educational, transportation, financial, trade, and tourism hubs for their states and surrounding areas. In Seattle, the largest private employer is health and education services, reflecting the city's role for as a destination for health care services for the state of Washington and rural areas beyond. Major health care providers in Seattle MSA include the University of Washington Medical Center, the Virginia Mason Medical Center, the Swedish Medical Center, the Evergreen Health Medical Center (in Kirkland), and Harborview Medical Center.[16] Led by the University of Washington, with an undergraduate enrollment of more than 36,000, the region is home to at least 22 two and four-year colleges and universities.[17]

[16] https://patch.com/washington/seattle/these-8-washington-hospitals-are-among-best-u-s-newsweek

[17] https://www.usnews.com/best-colleges/rankings/seattle

Still, such concentrations of health and educational services are common in major U.S. MSA. Our team has not been able to explain the exceptionally high employment in this sector.

How is manufacturing faring in Seattle?

In December 2022, the Seattle MSA had about 162,000 manufacturing jobs, down from 232,000 in 1990, a decrease of 30%, as shown in Table 5.1 and the upper panel of Figure 5.2.

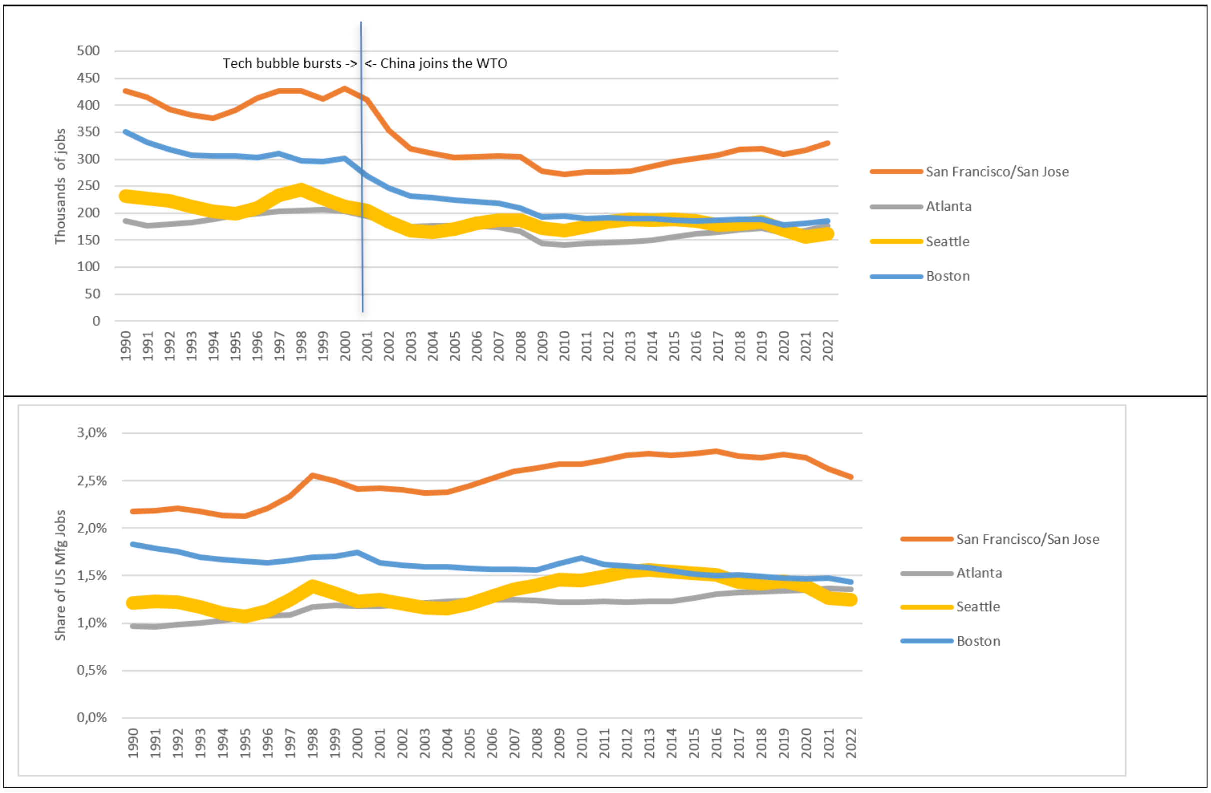
Table 5.1: Seattle-Tacoma-Bellevue MSA manufacturing employment compared to three other U.S. city regions, total U.S. manufacturing employment, and total U.S. nonfarm employment, 1990-2022, thousands of jobs (only even years shown through 2010)

Year	Seattle MSA	Atlanta MSA	Boston MSA	San Francisco and San Jose MSAs	San Jose MSA	San Francisco MSA	US Mfg Emp	US Nonfarm Emp
1990	232	186	351.2	427	255	172	19,173	116,964
1992	222	179	317.5	393	230	163	18,149	115,968
1994	203	189	306.4	375	217	158	18,388	120,379
1996	209	200	302.9	413	241	171	18,527	125,461
1998	244	205	297.8	426	246	180	17,606	131,563
2000	213	204	301.0	431	252	179	17,288	137,228
2002	184	183	246.2	354	201	153	15,265	135,840
2004	165	176	228.1	310	168	142	14,302	136,851
2006	181	176	221.6	304	164	140	14,153	141,153
2008	187	166	208.8	304	168	136	13,412	141,576
2010	167	141	193.9	271	154	118	11,516	134,714
2011	175	144	190.2	276	158	118	11,729	136,258
2012	184	146	190.9	277	158	119	11,935	138,885
2013	188	147	190.0	278	158	120	12,023	141,103
2014	187	150	189.4	286	162	124	12,189	143,758
2015	188	156	187.0	295	165	130	12,332	146,634
2016	186	161	185.2	302	167	135	12,335	148,735
2017	179	165	187.2	308	167	141	12,440	150,654
2018	179	169	188.5	318	172	146	12,672	153,176
2019	184	172	188.4	319	172	147	12,806	155,324
2020	169	163	177.7	309	168	141	12,111	146,542
2021	155	168	181.5	316	169	147	12,331	150,740
2022	162	176	185.9	329	175	155	12,980	155,173
Emp. change 1990-2010	**(65.2)**	**(45.1)**	**(157.3)**	**(155.7)**	**(101.1)**	**(54.6)**	**(7,657.0)**	**17,750.0**
% change 1990-2010	**-28%**	**-24%**	**-45%**	**-36%**	**-40%**	**-32%**	**-40%**	**15%**
Emp. change 2010-2022	**(4.7)**	**35.3**	**(8.0)**	**58.0**	**21.0**	**37.0**	**1,464.0**	**20,459.0**
% change 2010-2022	**-3%**	**25%**	**-4%**	**21%**	**14%**	**31%**	**13%**	**15%**
Emp. change 1990-2022	**(69.9)**	**(9.8)**	**(165.3)**	**(97.7)**	**(80.1)**	**(17.6)**	**(6,193.0)**	**38,209.0**
% change 1990-2022	**-30%**	**-5%**	**-47%**	**-23%**	**-31%**	**-10%**	**-32%**	**33%**

Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

The loss of 70,000 manufacturing jobs in the Seattle MSA is the second most in our four city regions after Boston. Also, the MSA did not participate in the national rebound after 2010 evident in the national figures in Figure 4.4 and the 8th column of Table 5.1 as did the Atlanta and San Francisco city regions. Instead, the Seattle MSA lost another 4,700 manufacturing jobs in that period, for an additional decline of 3 percent. This is reflected in the lower panel of Figure 5.2, which shows that Seattle slightly increased its share of total national manufacturing employment from 1990 to 2010 (from 1.2% in 1990 to 1.5 % in 2010), but then lost share afterwards, arriving at a 1.3% share of U.S. manufacturing in 2022. In other words, Seattle did not suffer from the degree of manufacturing job loss as the country (or Boston) did from 1990 to 2010, but did not participate in the national rebound experienced since 2010. One reason could be that Boeing has been adding new jobs at its 737 plant in Charlotte, North Carolina, which opened in 2011, rather than add jobs in the Seattle MSA.

Figure 5.2: Seattle-Tacoma-Bellevue MSA manufacturing employment and share of U.S. compared



Source: MSA data from U.S. Bureau of Labor Statistics: State and Area Employment, Hours, and Earnings dataset

Which manufacturing sectors are important in Seattle?

As mentioned in the introduction, we define the Seattle-Tacoma-Bellevue MSA as equivalent to Seattle's core region, as both encompass the three counties of Snohomish, Pierce, and King (where the city of Seattle is located, see Figure 1.1). Table 5.2 lists the manufacturing sectors for the three counties, ranked by June 2022 employment, with employment location quotients (LQs) of greater than 2.0 shaded.

Unsurprisingly, King County, which contains the cities of Seattle and Bellevue – the urban core of the region, has a low concentration of manufacturing firms relative to national averages. The major exception is NAICS 336 Transportation equipment mfg., which employed 37,500 in the second quarter of 2022, giving it a LQ of 2.2. Boeing has a cluster of buildings in the City's South Park area, south of downtown, which is flanked by the Boeing Field Airport and Interstate 5 on one side and the Duwamish Waterway on the other, providing access via land, sea, and air.

Table 5.2: Employment and wages by major manufacturing industry, Seattle core region, NAICS 3-digit industries, 2nd quarter 2022, ranked by June employment in each county (employment LOQs above 2.0 in shaded rows)

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
King County (Including Seattle and Bellevue)							
NAICS 336 Transportation equipment mfg.	175	37,496	214	1,096,796,608	2,282	2.2	2.0
NAICS 311 Food mfg.	370	12,025	33	206,232,306	1,295	0.7	0.6
NAICS 334 Computer and electronic product mfg.	205	7,037	34	258,352,449	2,811	0.7	0.4
NAICS 332 Fabricated metal product mfg.	295	5,576	19	97,538,434	1,348	0.4	0.3
NAICS 339 Miscellaneous mfg.	312	5,364	17	139,139,722	1,988	0.9	0.8
NAICS 333 Machinery mfg.	158	4,397	28	89,234,737	1,563	0.4	0.3
NAICS 312 Beverage and tobacco product mfg.	247	3,789	15	53,793,264	1,109	1.2	0.8
NAICS 327 Nonmetallic mineral product mfg.	87	2,844	33	53,830,482	1,459	0.7	0.5
NAICS 323 Printing and related support activities	168	2,379	14	41,919,330	1,322	0.7	0.5
NAICS 326 Plastics and rubber products mfg.	50	2,140	43	34,388,150	1,230	0.3	0.2
NAICS 322 Paper mfg.	25	1,381	55	24,411,354	1,361	0.4	0.2
NAICS 325 Chemical mfg.	149	1,255	8	30,611,443	1,890	0.1	0.1
NAICS 335 Electrical equipment, etc.	62	1,228	20	29,253,863	1,843	0.3	0.2
NAICS 337 Furniture and related product mfg.	85	898	11	13,042,133	1,125	0.2	0.2
NAICS 315 Apparel mfg.	56	861	15	13,901,829	1,236	1.0	0.7
NAICS 321 Wood product mfg.	48	689	14	12,033,052	1,325	0.2	0.1
NAICS 314 Textile product mills	52	676	13	10,003,831	1,118	0.7	0.5
NAICS 331 Primary metal mfg.	18	537	30	13,648,010	1,947	0.2	0.1
NAICS 324 Petroleum and coal products mfg.	7	77	11	3,025,502	3,076	0.1	0.1
Snohomish County (including Everett)							
NAICS 336 Transportation equipment mfg.	90	32,900	366	928,622,747	2,191	10.1	13.5
NAICS 334 Computer and electronic product mfg.	52	4,447	86	130,459,302	2,254	2.1	1.6
NAICS 332 Fabricated metal product mfg.	178	3,504	20	53,920,747	1,194	1.3	1.2
NAICS 311 Food mfg.	72	1,467	20	17,099,962	885	0.5	0.4
NAICS 333 Machinery mfg.	36	1,413	39	30,066,241	1,647	0.7	0.7
NAICS 325 Chemical mfg.	44	1,343	31	34,654,928	1,991	0.8	0.8
NAICS 337 Furniture and related product mfg.	46	1,047	23	15,549,855	1,136	1.4	1.6
NAICS 339 Miscellaneous mfg.	87	921	11	13,239,692	1,095	0.8	0.6
NAICS 321 Wood product mfg.	34	788	23	14,305,346	1,292	1.0	1.2
NAICS 326 Plastics and rubber products mfg.	19	652	34	10,051,645	1,200	0.5	0.4
NAICS 327 Nonmetallic mineral product mfg.	28	605	22	10,744,753	1,366	0.8	0.8

	Number of establish-ments	Employ-ment (June 2022)	Avg. employees / establish-ment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
NAICS 323 Printing and related support activities	49	599	12	9,974,563	1,270	0.8	1.0
NAICS 312 Beverage and tobacco product mfg.	44	517	12	5,969,828	914	0.8	0.7
NAICS 335 Electrical equipment, etc.	14	446	32	9,261,274	1,584	0.6	0.6
NAICS 331 Primary metal mfg.	8	257	32	4,103,898	1,240	0.4	0.3
NAICS 314 Textile product mills	14	119	9	1,153,908	732	0.6	0.5
Pierce County (including Tacoma)							
NAICS 336 Transportation equipment mfg.	46	2,528	55	52,407,459	1,592	0.7	0.7
NAICS 321 Wood product mfg.	45	1,971	44	32,806,098	1,278	2.1	2.6
NAICS 332 Fabricated metal product mfg.	102	1,795	18	27,058,286	1,149	0.6	0.6
NAICS 311 Food mfg.	82	1,704	21	23,367,389	1,048	0.5	0.5
NAICS 327 Nonmetallic mineral product mfg.	34	1,599	47	32,524,802	1,574	1.8	2.2
NAICS 337 Furniture and related product mfg.	40	1,122	28	15,511,861	1,066	1.4	1.5
NAICS 322 Paper mfg.	18	1,019	57	21,585,590	1,636	1.3	1.6
NAICS 326 Plastics and rubber products mfg.	25	926	37	14,285,206	1,166	0.6	0.6
NAICS 333 Machinery mfg.	44	702	16	12,302,349	1,349	0.3	0.3
NAICS 325 Chemical mfg.	21	638	30	14,600,796	1,764	0.3	0.3
NAICS 339 Miscellaneous mfg.	72	559	8	6,959,071	966	0.4	0.3
NAICS 312 Beverage and tobacco product mfg.	29	550	19	7,108,036	1,001	0.8	0.8
NAICS 324 Petroleum and coal products mfg.	8	542	68	14,729,573	2,119	2.4	2.2
NAICS 323 Printing and related support activities	46	432	9	5,210,646	879	0.5	0.5
NAICS 331 Primary metal mfg.	7	354	51	6,178,324	1,355	0.5	0.4
NAICS 314 Textile product mills	10	141	14	1,752,982	968	0.6	0.7
NAICS 334 Computer and electronic product mfg.	24	111	5	2,185,060	1,547	0.1	0.0
NAICS 335 Electrical equipment, etc.	7	82	12	1,773,562	1,677	0.1	0.1
NAICS 315 Apparel mfg.	8	64	8	724,306	857	0.3	0.3
Core region total	**4,052**	**158,513**	.	**3,803,406,584**	.	.	.

Source: BLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/

However, Boeing has its headquarters and a second concentration of activity in the city of Everett, north of downtown. This area, adjacent to the smaller Paine Field airport, includes the company's colossal final assembly complex, the Everett Production Facility. As a result, the industry was the largest manufacturing sector employer in Snohomish County (39,900) earning it a high employment LQ of 10.1. All told, the sector employed nearly 73,000 in the three-county core region.

After NAICS 336 Transportation Equipment and NAICS 311 Food processing, with 15,196 workers, the third largest export-oriented manufacturing employer in Seattle's core region is NAICS 334 Computer and electronic product mfg., which employed 11,595. However, the only other manufacturing sector in the Seattle core region with an employment LQ over 2.0, aside from NAICS 336 Transportation Equipment mfg., is NAICS 324 Petroleum and coal products mfg. in Pierce county, probably due to the Pierce County Terminal. This deep-water port includes petroleum storage facilities. Overall, the three-county core region had 4,052 manufacturing establishments with 158,513 employees and a wage bill of $3.8 billion in the second quarter of 2022.

Which manufacturing and non-manufacturing industries does Seattle specialize in?

The more detailed (4-digit) NAICS industries shown in Table 5.3 reveals the Seattle core region's specialties beyond manufacturing relative to other locations in the United States. The Table ranks all industries with an employment LQ of 2.0 or higher.

Several things stand out. First, aerospace (doubtless led by Boeing) is the largest manufacturing employer, by far. In King County, the more detailed classification of NAICS 3364 Aerospace product and parts mfg. (a subset of the broader NAICS 336 Transportation equipment mfg. mentioned earlier) has a much higher employment LQ of 7.0. Its 33,982 jobs accounted for 91% of the broader sector's employment. In Snohomish and Pierce Counties the employment LQ for Aerospace was also higher. The 32,199 jobs in Snohomish County, which represents 98% of the broader sector's employment there, yields an LQ of 33.7, and the 2,324 in Pierce Country yields an LQ of 2.1.

Second, the Seattle core region has very few manufacturing specializations beyond aerospace. The only other 4-digit manufacturing sectors in Seattle's core region with LQs above 2.0 aside from the port-dependent industries of fish processing, petroleum and cement, and the resource-connected NAICS 3211 Sawmills and wood preservation, is NAICS 3345 Electronic instruments mfg., which employs 3,267 in Snohomish County, and has an LQ of 4.0 there. This sector, which includes avionics, is also likely to be connected to the Boeing-led aerospace industry in the region.

What the Seattle core region does specialize in is easy to connect to the other two anchor firms discussed above: Microsoft and Amazon. In King County, which includes Microsoft's campus, NAICS 5132 Software publishers registered employment of 77,519 and an employment LQ of 12.6. The county is also home to the main Amazon campus in downtown Seattle, and the specializations in NAICS 5192 Web search portals etc., NAICS 5162 Media streaming distribution, and NAICS 5182 Computing infrastructure providers, all of which have LQs above 5.0. Employment in these three industries amounted to 48,661 in King County.

Table 5.3: Employment and wages by detailed industry, Seattle core region, NAICS 4-digit industries, 2nd quarter 2022, with employment LOQ >2.0, ranked (manufacturing in shaded rows)

	Number of establishments	Employment (June 2022)	Avg. employees / establishment	Total wages paid	Average weekly wages	Emp. location quotient	Wages location quotient
King County (Including Seattle and Bellevue)							
NAICS 5132 Software publishers	1,565	77,519	50	5,122,563,674	5,206	12.6	11.2
NAICS 1141 Fishing	78	520	7	29,781,479	3,715	8.1	13.3
NAICS 3364 Aerospace product and parts mfg.	91	33,982	373	1,013,986,778	2,332	7.0	4.8
NAICS 5192 Web search portals etc.	186	11,090	60	561,810,796	4,052	6.2	3.1
NAICS 4831 Water transportation	29	2,270	78	53,998,479	1,855	6.1	3.5
NAICS 5162 Media streaming distribution	179	14,372	80	1,300,493,780	7,317	6.1	6.8
NAICS 5182 Computing infrastructure providers	581	23,199	40	1,212,544,732	4,131	5.1	4.3
NAICS 3117 Seafood product preparation	23	1,648	72	60,443,651	2,431	4.7	8.4
NAICS 4855 Charter bus industry	11	817	74	10,827,183	1,025	4.1	2.7
NAICS 5615 Travel and reservation services	204	6,441	32	276,640,276	3,367	3.8	4.9

NAICS 5511 Management of companies	338	92,381	273	5,077,040,511	4,286	3.8	3.8
NAICS 4811 Scheduled air transportation	44	15,567	354	358,462,089	1,793	3.5	2.2
NAICS 5415 Computer systems design	6,740	57,657	9	2,678,381,677	3,609	2.4	2.0
NAICS 8131 Religious organizations	100	4,007	40	45,698,153	871	2.2	1.7
NAICS 8141 Private households	4,470	4,572	1	45,306,197	782	2.2	1.5
NAICS 7111 Performing arts companies	122	2,420	20	27,374,387	871	2.0	1.2
Snohomish County (including Everett)							
NAICS 3364 Aerospace product & parts mfg.	60	32,199	537	917,410,405	2,213	33.7	35.0
NAICS 1141 Fishing	14	56	4	1,209,613	1,559	4.5	4.4
NAICS 3345 Electronic instruments mfg.	27	3,267	121	103,426,165	2,421	4.0	4.5
NAICS 4922 Local messengers and local delivery	41	1,027	25	9,551,760	763	3.3	2.3
NAICS 2381 Building contractors	653	5,810	9	97,887,899	1,329	3.1	3.4
NAICS 2383 Building finishing contractors	778	4,873	6	72,038,991	1,141	3.0	3.0
NAICS 3211 Sawmills and wood preservation	8	431	54	7,734,133	1,384	2.5	2.9
NAICS 1114 Greenhouse, nurseries	69	896	13	10,200,367	870	2.4	2.5
NAICS 4233 Construction materials wholesalers	73	1,056	14	20,911,776	1,539	2.2	2.2
NAICS 3327 Machine shop mfg.	74	1,335	18	21,329,576	1,245	2.1	2.1
NAICS 5629 Remediation & waste services	56	664	12	11,763,141	1,386	2.0	2.1
Pierce County (including Tacoma)							
NAICS 1124 Sheep and goat farming	5	25	5	200,500	652	6.7	6.8
NAICS 4922 Local messengers and local delivery	65	1,427	22	14,049,533	753	4.0	3.3
NAICS 3211 Sawmills and wood preservation	13	698	54	13,674,348	1,506	3.5	4.8
NAICS 3117 Seafood products	7	271	39	3,715,877	1,046	3.5	4.0
NAICS 7132 Gambling industries	6	732	122	9,960,178	1,041	3.2	4.0
NAICS 5629 Remediation & waste services	51	1,179	23	20,511,777	1,361	3.1	3.5
NAICS 4233 Construction materials wholesalers	95	1,707	18	31,485,658	1,432	3.1	3.1
NAICS 5612 Facilities support services	14	1,026	73	18,967,424	1,445	3.0	4.1
NAICS 3212 Wood products manufacturing	4	552	138	8,870,632	1,244	3.0	3.3
NAICS 3273 Cement and concrete product mfg.	24	1,274	53	25,422,772	1,551	2.9	3.5
NAICS 4831 Water transportation	4	227	57	4,917,935	1,694	2.7	2.5
NAICS 1141 Fishing	9	35	4	657,660	1,786	2.4	2.3
NAICS 5611 Office administrative services	111	3,022	27	83,268,987	2,115	2.4	2.9
NAICS 3241 Petroleum products manufacturing	8	542	68	14,729,573	2,119	2.4	2.2
NAICS 6241 Individual and family services	4,328	13,704	3	90,972,293	519	2.3	2.1
NAICS 4412 Other motor vehicle dealers	40	879	22	21,510,751	1,891	2.2	3.5
NAICS 4883 Support activities for water transport	25	465	19	27,030,128	3,199	2.2	5.7
NAICS 3364 Aerospace product and parts mfg.	22	2,324	106	48,918,395	1,615	2.1	1.8
NAICS 2383 Building finishing contractors	614	3,828	6	55,768,968	1,138	2.1	2.2
NAICS 4931 Warehousing and storage	89	8,436	95	135,461,147	1,241	2.1	2.9
NAICS 2381 Building contractors	532	4,385	8	72,352,921	1,297	2.1	2.4
Core region total	**22,680**	**446,814**	**.**	**19,851,265,125**	**.**	**.**	**.**

Source: BLS, Quarterly Census of Employment and Wages, https://data.bls.gov/cew/. To sum up, the impact of the major anchor firms on employment in Seattle's core region is immense.

6. Policy institutions and practices

This section focuses on the City of Seattle's industrial policies and some of its main actors in the realm of economic and land development. The principal industrial area in the city of Seattle is called SoDo (for South of the Dome), an area located between the traditionally industrialized area adjacent to the Port of Seattle and the associated rail terminal and the former sports stadium, the Kingdome, which was demolished in 2000 and replaced two years later by what is now called the Lumen Field, located downtown.[18] SoDo has long been home to various industrial uses related to the maritime industries, such as welding, engine rebuilding, and warehousing. There is also a cluster of machine shops and contract manufacturers in South Park, south of downtown, near the international airport and a major complex of Boeing manufacturing facilities.

Overall, there is a long-standing belief in Seattle that manufacturing within the city limits is needed to help promote innovation and sustainability, and that manufacturing can provide equitable and sustainable economic opportunity for local businesses and communities. But how to achieve these goals has been a protracted and contentious process.

Concern about converting industrial land for residential, retail, and office space use is long-standing. For example, in 2007, then-Mayor Greg Nickels proposed a plan to quell land speculation in industrial areas and preserve manufacturing jobs by setting aside land for industrial use to ensure that "industrial land is safeguarded for industrial and manufacturing uses by putting strict new limits on the amounts of office and retail space allowed in industrially zoned areas." Nickels' plan was motivated, in part, by a local developer's purchase of 40 acres in SoDo in anticipation that the area's manufacturing activities would eventually be replaced by office space for software engineering and high-end retail, driving up land values and rents. At the time, Nickels mentioned that the city hosted 120,000 industrial jobs paying about $55,500 a year and that twelve percent of the city, or 5,142 acres, was zoned for industrial use. The plan, which was eventually adopted by the City Council, dramatically reduced the amount of office and retail space that could be included in projects built within the City's main industrial zones from 100,000 square feet for office space and 75,000 square feet for retail to just 10,000 square feet each. At the time, the Chair of the City Council's land-use committee said, "The mayor's proposal is very much a move in the right direction. … The council has long been concerned about industrial land and erosion of the industrial base in Seattle". A separate plan restricted to research and development in industrial areas to work that requires a laboratory setting rather than work that can be done in a regular office. The plan scuttled several projects, including the Port of Seattle's plan to build an office and industrial complex next to the port. The city's powerful maritime and port unions, the Sailors' Union of the Pacific and the International Longshore and Warehouse Union (ILWU), supported restrictive industrial zoning. The executive secretary-treasurer for the King County Labor Council at the time pointed to the "…need to maintain our industrial base, to maintain our family-wage jobs — that has been threatened by commercial speculation that could lead us to a point that this isn't the Seattle we grew up with." At the City Council, the idea was to develop a fuller set of economic development strategies to

[18] https://en.wikipedia.org/wiki/Kingdome

protect industrial areas from encroachment for inclusion in the city's comprehensive plan (Pan, 2007).

While these zoning requirements have been in force in some form since, a "fuller plan" has remained elusive. In 2016, the City of Seattle adopted a new industrial land use policy to preserve industrial land. Nevertheless, conflicts between industrial and non-industrial businesses remain over noise, traffic, parking, air, and water pollution. The City has sought to mitigate these conflicts by creating buffer zones between industrial and non-industrial areas. Other tensions have been mounting from extraordinary pressures from increasing land values, shortages of affordable residential properties, homelessness, and the dilapidation of old and outmoded industrial buildings.

There have been efforts to update what is considered "industrial use" to include multi-story structures to house many smaller manufacturers and include residential units for owners and workers on upper floors. As part of this program, the City's Office of Economic Development (OED) provided funding to support the development of a manufacturing incubator in South Park known as Industry Space Seattle, which consists of up to 12 individual suites in a single 47,500-square-foot warehouse. The idea is to provide opportunities for smaller spaces desirable for early-stage manufacturing. The facility offers overhead cranes and other shared equipment and tries to recruit women- and minority-owned businesses. Currently, the facility houses a tool and diemaker, structural steel fabricator, metal 3D laser printing and metal printing machine manufacturer, and rebuilder of ship propulsion systems. Many of these businesses collaborate on projects and employ each other's services. In 2017, Prologis, a global developer of industrial properties, broke ground on the Georgetown Crossroads project, a 3-story, 589,000-square-foot urban industrial facility supporting more than 800 direct jobs. The project includes two levels of warehouse/fulfillment space and a third floor for lab, production, and light industrial users. [19]

This development, and others like it, are indicative of the "new" types of industrial space needed to support urban manufacturing: smaller, more flexible, often with multiple tenants and mixed use to support a range of small and medium-sized manufacturing businesses with customizable space and shared services.

Lessons from policy interviews

According to the project interviews, including similar projects in SoDo has been contentious. The approach has been staunchly opposed by the unions, which view any inclusion of residential units in industrial development as a "camel's nose under the tent" of the current limits on industrial usage. Material from the interviews is in italics.

- *A city official said that the City has yet to fully support manufacturers, who have been left on their own, but that they are trying to correct this. The City has drafted a new Industrial and Maritime Strategy with consultation from labor, companies, and the port. This has included conversations about the routing of light rail, routing connections from the freight network to the port, and changes to some streets, so it is including these industrial uses in*

[19] https://www.seattle.gov/office-of-economic-development/stories-and-successes

the city's transportation planning, which has mainly been focused on how to move people before. So, it is a complex plan that includes both land use and transportation. Things have been done in silos in the past, and the City is trying to use a more comprehensive approach. It has not yet been put to a vote. Everything is in a holding pattern until the environmental impact statement is completed next September. In the meantime, the City is working with a consultant on a SWOT analysis to help promote industry in the city. There is the idea that technology has dominated the City's economy, but there is now a shift back toward manufacturing and maritime activity because it creates jobs for workers with less education.

- *According to one advocate for urban manufacturing in Seattle mentioned that the draft Industrial and Maritime Strategy has been very contentious. On one side are people who say manufacturing is important. On the other are people who say Seattle needs to convert industrial land to retail and condominiums, as has already happened in South Lake Union, located north of downtown. There has been a mass exodus of manufacturers to Kent, south of the city, in Pierce County, and some of the leading proponents of this are descendants of earlier industrialists who want to develop the land they own closer to downtown. They are leaving because of crime related to a homelessness crisis and fentanyl epidemic. Regional economic development bodies are happy enough to see this happen. But housing will not come to all of SoDo, which has no public resources such as schools or libraries. What it does have is more than 100 years of pollution. The area includes a "superfund" toxic clean-up site: an industrial plating facility closed in 1985, and the clean-up and a demolition permit so the site can be re-used is still pending.*
- *An official at a small business network said that the City's new Industrial and Maritime Strategy has been hard to get off the ground, in part because of opposition from the Maritime unions. The pandemic led to the failure of many small businesses, and a partnership between the nonprofits Seattle Good Business Network and Shunpike along with Seattle's Office of Economic Development launched the "Seattle Restored" program was launched to try to convert empty storefronts into maker spaces. The idea is to create more maker and small manufacturing spaces near transit hubs with housing above to revitalize the area, but the inclusion of housing was a non-starter for the unions. The unions feared that mixing housing with industrial would generate complaints from residents (noise, odor, congestion) and that housing would crowd out industrial uses. At the same time, developers want these mixed-use light industry campuses. The city has tremendous wealth from the successful big companies in the area but nevertheless city planning has been underfunded. Historically, there has been so much growth in the City that it has been easy for policy-makers to feel insulated from the need for economic development policies. Nevertheless, Seattle Restarted is successfully matchmaking entrepreneurs, makers, and artists with empty storefronts. It is a downtown revitalization effort and will be expanding to other neighborhoods (equity districts).*
- *A city official mentioned that workers could come from certificate programs or the Maritime Academy. They believed that the opportunities are there, but people don't know about them, and there are barriers even for short-term certification programs, such as a lack of child care for students. The Seattle Public Schools have some maritime classes and*

have been able to connect students with welding skills. Most demand for space in industrially zoned areas like SoDo is from technology companies for R&D. Projects include R&D for hydrogen power and carbon sequestration in cement production for the construction industry (circular economy). But there is not a holistic vision at the city-level. For example, the port is a regional hub; it exports grain from the Midwest.

- *There has been progress in warehousing with a project by Prologis for a multi-level container storage facility. Amazon and Home Depot are leaseholders.*
- *Industrial zoning is changing to include a certain percentage of where Industry and Innovation Centers can be developed for R&D and maker spaces and offices in urban industrial zones with 4–5 levels. There is a need to replace old wooden industrial buildings that are aging out. But there is tension with other uses and a workforce shortage across the board. Buffer zones are needed between industrial and non-industrial uses. Planning for various uses is still siloed and will take time to resolve.*
- *The SoDo Business Improvement District, located just south of downtown, is the industrial heart of Seattle. It is connected to the deep-water port, is close to Interstate Highways 5 and 90, and is the northwest terminal for several national railways, including BNSF, Amtrak, and Union Pacific. Amtrak [the U.S. passenger rail service] has invested $3 billion over 10 years to maintain long-haul trains and commuter rail equipment. Historically, the position of Seattle in this rail network supported 'your grandfather's manufacturing': iron, steel, copper, and cement, some of which are still active but have moved outside of the city; for example, Alaska Copper moved to Kent. But most have closed as production moved to China over the past 20 years. Shared kitchens, wineries, brewing, and distilleries want to be near downtown because they have tasting rooms. And there is small-scale production like sign making. Building material companies also want to be in SoDo because they have showrooms and need outdoor storage. Zoning in SoDo is 75% industrial and 25% 'other', including showrooms. Other activities compatible with the area that got here through variances to the code include auto dealerships and auto and truck repair shops. Historically, services to the logistics industry, like truck repair, have been big activities. Development pressure has been very high.*
- *According to one advocate for urban manufacturing in Seattle, the redevelopment process in Seattle's old industrial areas has been fraught. Mayors have served only one-term mayors for decades. The City Council is focused on social issues. The breach between the mayor and City Council is improving, but many city agencies are not functioning well. For example, city lists of businesses have been very inaccurate. The Office of Economic Development lost 60% of its personnel during the pandemic. Many of the city workers that remain have been working from home since the pandemic started, and getting people to come out for inspections and on-site consultation has been very difficult. All this has allowed the city to drag its feet [move slowly] on infrastructure improvements. The new Mayor recently gave a speech where he mentioned that urban manufacturing was a priority, he said we need a strong manufacturing and maritime sector and the jobs that they create. But this goes against the progressive orthodoxy that more affordable housing is the most urgent change that's needed. While these goals might seem compatible, homelessness crisis is perceived by many as more important that supporting manufacturing.*

7. Lessons from industry interviews

This section focuses on lessons from the research, including standard policy and business challenges urban manufacturing faces and a discussion of ten business models that might justify and sustain manufacturing in high-cost, congested urban settings. We illustrate these points with material collected during interviews with local companies and policy-oriented organizations. These challenges and workable business models used to structure the following sections appear to us to be common. We inserted comments from the interviews where appropriate when our interviews touched on these subjects. If there are no comments, it only means that the interviewees did not discuss these topics at particular length. We do not intend this to signal that such challenges are not present. Also, in many cases the material from the interviews outlines solutions to the identified challenges, not examples of the problems. Material from the interviews is in italics.

Common policy and business challenges for urban manufacturing

In our research, seven main challenges for urban manufacturing emerged:

1. High costs (rent, taxes, wages, services, logistics)
2. Lack of suitable industrial space in both zoning regulation and existing building stock. This was sometimes alleviated by zoning plans that purposefully carved out space for urban manufacturing. Still, these plans were under constant pressure from developers seeking the use of properties for higher-value uses, such as residential and retail.
    a. *A machine shop owner near SoDo said his building is a cruddy former fish processing plant.*
    b. *A city official mentioned that workers could come from certificate programs or the Maritime Academy. The focus is on higher-paying jobs, but also on the 'missing middle.' Low-wage workers live outside the city and have to commute in. The unionization rate in the city is higher than outside it (and higher than many other U.S. cities), so companies have moved out to areas like Kent [south of the City in Pierce County]. Housing has been a real problem. There is a real affordability crisis. This is a substantial political issue, with the flash point being land use zoning. Sixty-five percent of the residential housing in Seattle is single-family homes or duplexes, so there is high pressure to increase density, and neighbors resist this. The median income in Seattle is $106,00, which is not enough to pay rent on a single-family home. Public schools are losing students because young families cannot afford to live in the city. Some zoning will have to change to accommodate multi-family dwellings, but it is very contentious.*

3. Lack of support from government agencies.
   a. *A machine shop owner near SoDo mentioned that they need more help and are pretty much on our own. The have a hard time with local politics. The City Council is very far to the left politically. They are very idealistic and will not compromise on common sense solutions. The homelessness situation here is shocking. It is difficult to park on the street. People are defecating in the entryway. The homeless gravitate to industrial areas because they get kicked out of residential areas. There is lots of theft, and lots of garbage gets piled up. There is no one to call about this in the City.*
   b. *The company received two federal loans totaling $135,000 during the pandemic to cover salaries. This allowed them to stay in operation during the pandemic. It took a lot of effort. The owner felt responsible.*
   c. *The same owner said that their impression is that the Seattle Made business network is mainly for cottage industries. He is in included in the network, but mentioned that the company has received a few requests for quotations (RFQs) from the network, mainly from people who don't know what they are doing. [Note: Seattle Made comments that about 40% of businesses in their network manufacture specialty foods and beverages. The network also includes many textiles and apparel companies and contract manufacturers, personal care products, bicycle manufacturers, so there may be a mismatch between the services and connection provided by the network and this metalworking company.]*
   d. *The same owner said that he feels that the City would like to see manufacturing take place somewhere else. They have received support from the Federal Government [during the pandemic] and used a training grant from Washington State, but the city does not appear to be interested. The owner chooses to run their business, not engage in politics. They are thinking of developing their own product and then doing side jobs. They say they have ideas, but are not good at marketing, and that it's hard to have time to develop a new business on top of everything else they are doing.*
   e. *The owner of a contract electronics design and manufacturing firm located north of downtown Seattle said the City Council is politically very far left. Homelessness is the big pain point. They set the minimum wage at $18 per hour, which suits our employees, and they are growing, so can afford it. They feel that taxes are not very forgiving, however.*
   f. *They know about the Seattle Made business network, but they are not a member because they feel it is not relevant for their type of business. Customers come from word of mouth (1/4), repeat customers (1/4), walk-ins (1/4), and from the Internet. The State of Washington offers a lot of services (e.g., for training), but it all comes with a fee. Small companies are not on their radar.*

4. Lack of suitable workers.
    a. *A machine shop owner near SoDo said that workers need a lot of training and experience but that the pay is low, so there is little demand by potential hires for manufacturing jobs. their highest-paid worker earns $33.50 per hour. However, retention is high, not because of the pay, but because the work is not boring. It is interesting because the company is always doing something different. Management invites input from workers. People who can pay attention to detail are preferred. The company has three highly skilled workers that have been trained in-house. One had prior manufacturing experience, and another was entry-level but mechanically inclined. New hires are chosen based on the basic qualities needed with the expectation that training will be needed. New hires want to be a CNC (computer-controlled machining) programmer, but either the owner does that or it is outsourced. There is a community college program to train aerospace workers, but it is mainly for high-volume production environments [like Boeing]. The company only works on test and ground equipment for Boeing, since they are not FAA certified.*
    b. *The owner of a contract electronics design and manufacturing firm in a Seattle suburb said they do a lot of training and internal promotion. There will always be a need for manual assembly. New hires undergo aptitude testing to see if they can read and write and are intelligent, then they are trained. One employee is a self-taught engineer who does machine programming and helps with product design. He was able to contribute to the design of some medical equipment, working with customer Ph.D. engineers.*
    c. *An official at the Seattle Made small business network said that they are working to create a youth pipeline for manufacturing workers through outreach at public schools and through social media to youth-serving groups. The King County Waterworks Grant program has funded training youth in sustainability consulting for small-scale manufacturers, who received funding to pay for interns. They try to convey that manufacturing jobs are not all in big, dirty factories. This is all a big lift, but it is essential.*
5. Pollution and congestion. There is a perception, often deserved, that manufacturing uses create noise, fumes, traffic, and other issues. The surging popularity of bike lanes has come with a constituency opposed to the curb cuts needed to service the loading docks familiar at industrial facilities.
    a. *A machine shop owner near SoDo said his facility is nice, bright, and clean.*
    b. *The owner of a contract electronics design and manufacturing firm located north of downtown Seattle said that his facility is in a nice area, that the customer base is good, that everything is close by, that they like city life, and that their location is where they want to be*

c. *A respondent from the SoDo Business Improvement District said there is not enough parking in SoDo. Big companies here, like Costco, Amazon, and Starbucks, have "commute trip reduction" requirements and provide vans to get people from transit hubs to work.*

6. Environmental justice critiques, where manufacturing's poor environmental record provides ammunition for project critics since urban spaces with available structures and land suitable for industrial zoning tend to be located in or near low-income and communities of color.
7. The need for more affordable housing for production workers necessitates long commutes. Interviewees report many challenges in recruiting workers from close-in neighborhoods, given steeply rising housing and other costs associated with living in our near urban downtowns. Several respondents noted that manufacturing workers tended to travel from lower-cost outer suburbs and complained that public transportation did not run at hours suitable for workers traveling to and from work on early morning or night shifts.

Business model discussions

As we can see, manufacturing persists in the United States, even in high-cost urban environments. Our research asks, why is this the case? To get answers from the small sample investigated by our team (of four city regions with only six interviews in each), we have asked the question in the extreme: *Which business models appear to be viable and potentially sustainable in very high-cost and congested urban settings?* We found that urban manufacturing close in to the urban core is necessarily smaller in scale, more agile, and in some cases, more closely linked to innovation, and while it does provide employment opportunities for less educated workers and pathways for entrepreneurship, these opportunities are limited in scale. Nevertheless, urban manufacturing persists. This is true even when industrial space is hard to find, energy costs are high, logistics difficult, and housing unaffordable for production workers. Our research points to ten business models that motivated the interview subjects in the four city regions studied (and, presumably, elsewhere) to continue to engage in urban manufacturing:

- The first relates to innovation, where production is co-located with R&D and new product development to support the iteration needed for prototyping and initial scale-up. We also note that dynamic innovation systems are usually linked to industries and scientific fields deeply rooted in an urban area. In Seattle, it is aerospace, software, electronics, logistics, and retail, including e-commerce. In some situations, long delays between product iterations necessitated by the tremendous geographical separation between innovation and production are impractical, since manufacturing and product design engineers often need close contact. In some cases, new manufacturing techniques may need to be invented as part of the innovation process.

    - *The owner of a contract electronics design and manufacturing firm located north of downtown Seattle said that some of their business comes from larger-scale R&D projects from nearby labs and Microsoft, Google, and Amazon test facilities. For example, the company has built multiple iterations of Amazon's package delivery drones (including aerial and ground-based versions) and warehouse automation equipment, which are being developed and tested nearby. Some of these prototypes are produced in substantial volumes, and there is lots of repeat business as these prototypes are refined. Prototypes can go through 15–60 revisions, even if the plan is to eventually send production offshore. The customer may want to install 100 robots and then change a circuit board or cable assembly, which adds up to a lot of work. The company has been able to handle weekly changes to Amazon's drone designs; helping with design for manufacturability (DFM) and fixing bad documentation.*
    - *This same company has two additional groups of customers: start-ups and old-school companies. Many start-ups come from the University of Washington, located 1.3 miles away. These small companies need help in product development and prototyping. They have also helped food manufacturers develop a clean bill of materials (BOM) for new products. The company has worked on circuit boards, wiring harnesses, precision parts and controls for wind generators, flashing beer signs, biofuel boilers, wood-cutting machines, etc. If and when production expands, many of these companies move production to China.*
    - *The SoDo Business Improvement District is trying to help develop "flex space" that can accommodate R&D and advanced manufacturing; there are several "stealth" drone manufacturers in the area that do not have marketable products yet. There are also 79 permits for cannabis production, and these tenants have money and can pay top dollar. A popular expanding restaurant chain wants to build a food processing facility, but the project is behind because of slow permitting and inadequate electrical infrastructure.*
- The second relates to companies that need to be close to specialized or skilled labor.
- The third is for products mainly produced in low-cost locations but need to be rapidly replenished during unexpected demand surges, such as air conditioners during a heat wave, snow shovels during a winter storm, or apparel and other fashion or seasonal items for which demand exceeds forecasts.
    - *A respondent from the SoDo Business Improvement District said that the industrial activities in SoDo were key during the pandemic, since manufacturers could pivot to the production of hand sanitizer and PPE, and this raised awareness of the importance of urban manufacturing, not that this eliminated arguments and disagreements over land use.*

  - *An official at the Seattle Made small business network said manufacturing businesses in the City proved very resilient during the pandemic. Smaller apparel manufacturers could pivot to producing PPE, hospital scrubs (clothing), masks, and face shields. There has been a supply-chain storm, so it has been good to have local manufacturing. Manufacturers were able to adjust their business model faster than many restaurants. The question being asked is: now that global supply chains are recovering, will things go back to low-cost business models?*
- The fourth is for low-volume items with standardized production processes but high unit prices that do not justify the challenges inherent in distant production, such as repairing and maintaining machinery and producing luxury goods.
  - *A machine shop owner near SoDo mentioned that he gets business from local companies that want local manufacturing, but that they tend to be poorly organized and have bad drawings. They help with standardization, quality procedures, and training to help them scale production. The company is not interested in making parts for the aerospace industry, and is not FAA certified to produce parts used in flight. It is expensive to obtain certification and easy to overspend on tooling, which becomes obsolete when aircraft programs end. However, space flight parts are not regulated by the FAA. The company also provides maintenance and repair services for items as diverse as marine generators and espresso machines. They make parts for the light rail system, architectural parts, and furniture and stairways for expensive homes. A lot of quick turn-around work needs to be done locally.*
  - *There is a project in SoDo to develop hydrogen-powered mining truck engines. According to one respondent, the company invested $25 million to retrofit and build a manufacturing facility. But this is an exception. The area had a 3% industrial vacancy rate before the pandemic. Now it is 8%. It is hard to retrofit manufacturing space because a lot of customization is needed and the existing stock is dilapidated. Existing buildings may be the wrong size or on an inappropriately shaped located, in a logistically difficult location, or be heavily contaminated from prior activities. There are good reasons companies seek greenfield locations.*
- The fifth is custom-made products, such as one-off prototypes or unique crafts or art objects.
- The sixth is "non-tradable" goods and processing activities, for which production and consumption are best co-located and localized. One example that has come up in our research is the development and processing of fresh and specialty food items, either for retail or institutional markets, such as local "farm-to-table" food supply chains, breweries, and small distilleries. In Seattle, we encountered some producers that provided quick-turn around manufacturing services for prototypes and early product runs, produced parts for the maintenance of building equipment (elevators), and another that produced custom metal fittings for architects and builders. It is conceivable that these skills can be translated to larger scale production (although we found no evidence of this in our limited interviews). So, there might be a path for manufacturing growth be from non-tradable to tradable

products. This emphasizes the importance of business development, branding, scale-up, and distribution.

    - *There is interest in urban farming to increase the quality of food. An official at the Seattle Made small business network said that 40% of the manufacturers in their network are in the food and beverage sector. Some have their own brand, and the city has a shortage of co-packing facilities, cold storage, and other key infrastructure for the growing food and beverage manufacture sector. The network has helped connect local food producers and restaurants to nearby local farms as well.*

- The seventh is for highly regulated products or products with regulatory requirements for domestic sourcing. This has historically been the case, especially for products for the military and other government purchases. However, in recent years, domestic production requirements have been extended to a broader range of materials and products, such as those used for infrastructure projects. While there are many reasons to locate these new investments outside of existing high-cost industrial regions, such as those listed in the previous section, there may be reasons to do so, such as those listed here. In addition, the availability of funds from the Federal Government to support domestic manufacturing can provide opportunities for local actors (states, counties, cities, universities, and industry groups) to gain access to new funding to support local industrial ecosystems, especially if there are viable industries or even the remnants of dying industries present in the region.
    - *The owner of a contract electronics design and manufacturing firm located north of downtown Seattle said they work on medical equipment and for aerospace companies with products that the FAA and FDA tightly regulate. Good documentation is essential for these markets. Testing is often done by customers, but nevertheless the company tests 100% of what they produce.*
    - *An official at the Seattle Made small business network said many outdoor apparel companies had been founded in Seattle. When they got big, they offshored production, but some still produce locally for military contracts. Many large retailers say they don't know where to get samples made, so the network is trying to help them get connected to small cut-and-sew shops in the city.*
- The eighth is legacy manufacturing plants that have operated for many decades. The company often owns the real estate, processes are stable, and older machinery is fully amortized. Such activities can be characterized as "hanging on," however. Unless industrial zoning is explicitly protected, they are under constant pressure for redevelopment for higher-value land uses, such as housing or offices.
    - *The owner of a contract electronics design and manufacturing firm located north of downtown Seattle said that part of his product mix is old products that need repair or replacement parts. An example is work for a local elevator company that needs thousands of parts to replace annually.*

  - *A respondent from the SoDo Business Improvement District said there is constant pressure from technology companies to expand in SoDo. Workers want to be near downtown for the nightlife and sports stadiums. Every project now includes an event space. There is almost no residential use in SoDo.*
- The ninth is for products where there is an imperative to shrink the geography of supply chains to reduce their carbon footprint.
    - *Note: this reason was only mentioned in one of our Boston interviews.*
- The tenth is for companies seeking to avoid offshoring costs beyond unit prices: tariffs, shipping delays, hidden management costs, and quality problems that increase scrap and rework costs can be expected when manufacturing is sourced internationally. Unexpected supply chain disruptions have been especially pronounced in recent years, leading buyers to look for manufacturers closer to end use (nearshoring and reshoring).
    - *20 years ago, when a respondent from an electronics contract manufacturer (EMS) near south of the city was an outsourcing manager for data storage firm Adaptec, they decided to set up their own local EMS firm to offset the "hidden costs" of offshoring (Adaptec had production in Singapore), They felt there was a need for local manufacturing. The company has been in business ever since, and recently merged with a second company. It has 10 employees. The typical order is to assemble about 10,000 circuit boards*

Low volume, high mix, and shared production

The general (non-scientific) impression from across the four case studies conducted by our team is that the most viable form of manufacturing in high-cost urban areas tends to be low-volume, small-scale, and with modest employment benefits. The norm is lower productivity and less effective utilization of equipment. A possible exception uncovered in the research is medium-volume facilities which produce a high mix of items. Such facilities can support all of the roles outlined above except for legacy manufacturing, which is, by definition, non-replicable. In high-mix production environments, manufacturing output can be substantial, but production runs for any one product will tend to be relatively short. The challenge is to keep capacity utilization high in the face of varying requirements. This is more than just a matter of equipment utilization. For example, materials managers in high-mix environments must coordinate the flow of various inputs (materials, parts, and components), and machinery must have fast set-up times and flexible tooling. High variability means that high-mix manufacturing resists automation. While there is a range of newer technologies aimed at increasing the productivity of high-mix production, such as cobots, 3D printing, manufacturing resource planning, and other business process software aimed at streamlining high-mix production, they remain expensive and unproven, and adoption rates are low in smaller manufacturing companies (Waldman-Brown, 2020). Advanced manufacturing can also elevate the importance of a high-quality workforce, but with better-trained workers comes the additional challenges of availability and high costs. It is common for only a few business functions to be carried out within the urban area, such as final assembly and last-minute configuration, and those functions that benefit from proximity to R&D (e.g., prototyping).

- *A machine shop owner near SoDo said he has a cornucopia of different machines in his shop, 2 CNC lathes, 2 2-axis CNC lathes, and 2 CNC mills that allow him to do high or low volume production runs and that it is his job it to keep all that running. The biggest problem is having enough work to keep the machines running enough to make money, given that their monthly machinery payment is more than $10,000. They would love to add a second shift, but the labor force is not flexible enough since setups need to be changed with each new run. It takes six hours to change a setup, leaving only 2 hours running before the 3 hours needed to undo the setup. It would be risky to double the workforce when there is no assurance of consistent work. The biggest challenge with a high mix production is administrative. There is a lot of paperwork and documentation required for each job. The company recently acquired an enterprise resource planning system (ERP), which has helped, but there are a lot of technical features and tasks in the ERP and computer-aided design (CAD) and CNC programming. The owner plans to hire someone for this eventually.*

The general impression from our research highlights two types of manufacturing that persist in high-cost urban environments that are both beneficial and sustainable: manufacturing related to innovation and production of non-tradable, particularly specialty foods. This is because these types of manufacturing are less cost-sensitive than higher-volume production and because there are social benefits beyond manufacturing employment to be garnered, such as supporting innovation and a diverse population of entrepreneurs. One promising avenue for scaling suitable diverse products and pathways for entrepreneurship is shared facilities, either in not-for-profit accelerators or for-profit contract manufacturers. These facilities can offer certifications, share the cost of plant and equipment, and offer various ancillary services, such as business consulting, design assistance, pooled purchasing, and help to find customers and marketing. When shared facilities work as they should, the next challenge comes when successful products need to scale past the high-mix setting to dedicated medium-volume facilities.

- *A machine shop owner near SoDo said he has thought of joining forces with other machine shop owners in the area to share information. He envisions it as a roving party that hosts speakers at various shops. There is a lot of unused capacity in the area. There are shared problems and expenses and a need for R&D and testing services, but have no common "water cooler" to hang out at and chat with peers.*

Again, a general (non-scientific) impression from the four case studies conducted by our team is that in high-cost-urban settings, industrial property and workforce shortages often force these firms to relocate outside the urban core. Nevertheless, reliance on R&D and start-ups can be sustainable if there is a steady flow of new products, new entrepreneurs, and small businesses focused on scaling the production of manufactured goods. However, fostering a robust pipeline of new companies and products requires specialized financial and educational resources focused on manufacturing entrepreneurship. If manufacturing is to be captured in the region, city and state-level policy-makers will need a sustained focus on urban manufacturing, which is often lacking as political regimes change and the demands of industries better suited to high-cost urban settings take precedence.

8. Concluding remarks

The City of Seattle has a long history of promoting manufacturing within city limits. The aerospace factory complex of Boeing in South Park remains the largest contributor to Seattle's manufacturing profile. The demand for manufacturing and repair services to support the Port of Seattle and ancillary activities in the rail terminus and warehouses also remains viable. However, promoting and preserving manufacturing within city limits has been contentious, and pressure to transform industrial space to higher value purposes more in tune with the industries driving the regional economy: software and IT services, is constant and rising. While the technology sector does require manufacturing for R&D, prototyping, and the low volume, high-mix production of higher-cost items, an adaptation of existing industrial properties to serve these purposes has been challenging and not smooth.

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