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The Global Value Chains of CERN Procurement

A Time Series Analysis for 1999 to 2024

Gerhard Streicher, Fabian Gabelberger

Research assistance: Birgit Schuster

December 2025
Austrian Institute of Economic Research

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Commissioned by CERN, Directorate Office for Accelerators and Technologies

Internal review: Mark Sommer
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This analysis identifies the global value chains associated with CERN procurement. By analysing the period 1999-2024 it also highlights the changes in these value chains, caused by a deepening global integration, especially during the first decade of the 21st century (followed by flattening in the following decade). Although contracts are awarded overwhelmingly to firms from member countries (as well as associates and observers; Ø 1999-2024: 98 percent), we find that a sizable and increasing share of the value added associated with these contracts benefits non-member countries (on average, 13 percent of value added are generated in these countries, with China as the most important one). Together with the global impact of CERN's scientific results, this bolsters the case for attempts to widen the net of CERN member countries.

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1. Introduction

The European Organization for Nuclear Research, CERN, is an intergovernmental organisation focused on fundamental physics research located in the Swiss-French border region around Geneva. Established in 1953, it hosts a complex of interconnected particle accelerators to uncover what the universe is made of and how it works; its current flagship particle accelerator, the Large Hadron Collider, is the largest and highest-energy particle accelerator in the world. It is highly successful in scientific terms. Apart from its primary scientific mission, CERN has also been instrumental in major technological innovations, most prominent the "invention" of the World Wide Web.

To achieve this impact, the running of this institution entails substantial expenditures, in the form of personnel, investment, maintenance and operating costs. Apart from enabling CERN to achieve its mission, however, these costs are linked to substantial economic benefits, as they give rise to opportunities for additional sales and the associated value added at the suppliers of CERN's inputs (and the suppliers of these suppliers…).

The aim of the present report is to analyse the global value chains with which CERN's expenditures are associated. The analysis estimates and summarises the economic value added linked to the operating expenditures of CERN in the period between 1999 and 2024. The focus will be the disaggregation of the total effects in the sectoral and regional dimension – which sectors in which countries have benefited from CERN's procurement. Furthermore, a major aspect will be the evolution of these sectoral and regional linkages: during the observation period 1999-2024, global trade has undergone substantial shifts in volume, but even more importantly in its structure, following the rise of new players – with China as the biggest and most important of them.

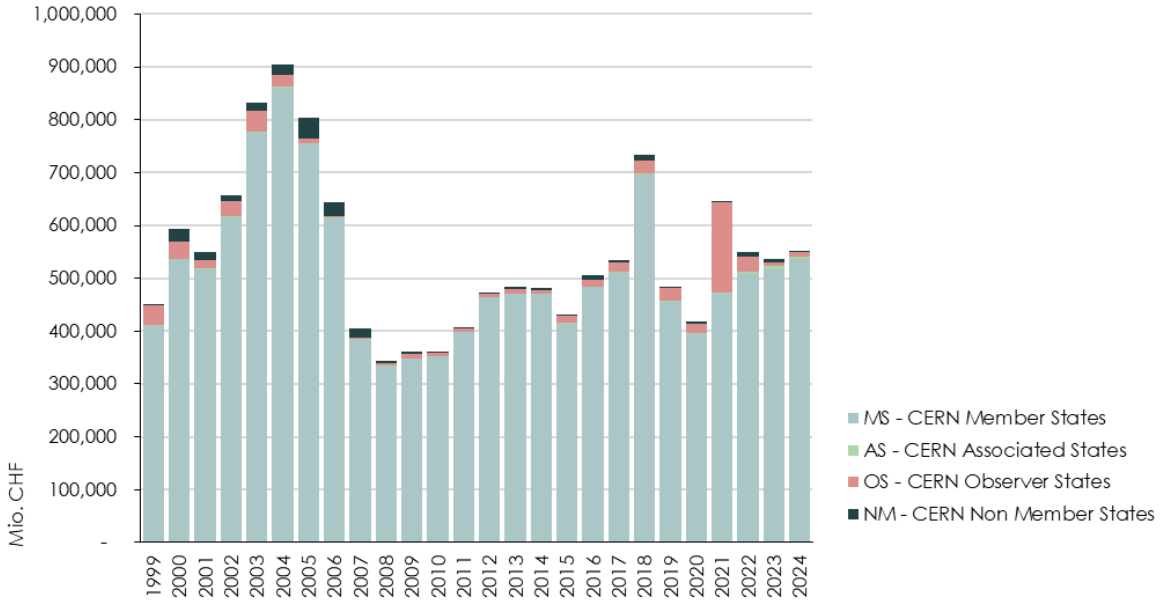
2. The Data

The analysis is based on detailed procurement data provided by CERN, spanning the period 1999-2024, which include:

- Both supplies and services orders;
- All orders of the past 25 years irrespective of the funding channels (both CERN budget and team accounts are included);
- In-kind contributions for projects/activities managed by CERN (excluding in-kind contributions of experiments)

The results of this analysis in terms of share of contracts per country are therefore not directly comparable to the CERN Procurement Reports. Per year, some 40-90 thousand individual orders were issued, with a total contract volume of 350 to more than 900 Mio. CHF (Figure 1).

Figure 1: **CERN procurement orders in Mio. CHF by member status of recipient, 1999-2024**

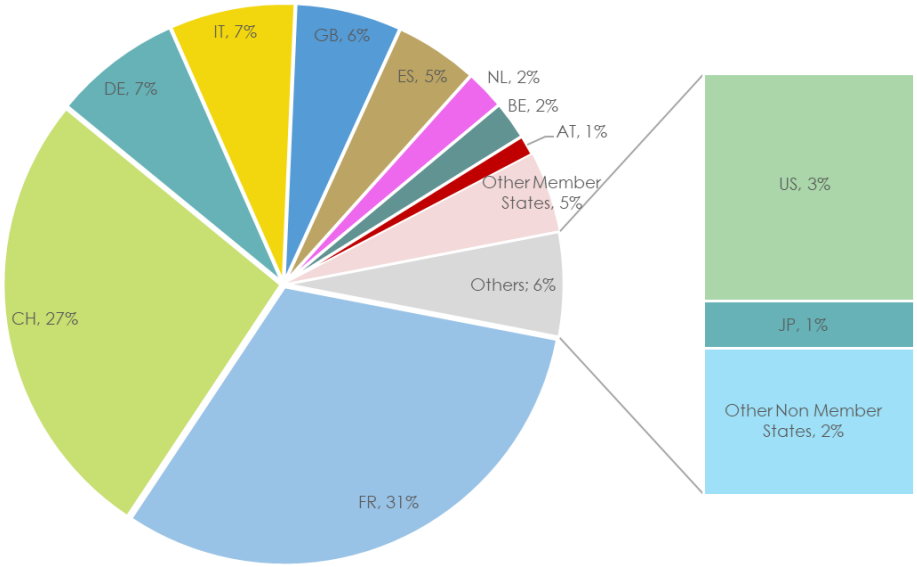


Source: CERN; WIFO calculations.

On average, 94% of contracts were awarded to firms from CERN Member States (MS), a further 4% to firms from the CERN Associated Member States (AS), as well as the two Observer States USA and Japan[1](see Figure 2). Only around 2% of orders by volume were sourced from other, Non Member (NM) States.

[1] Japan and the United States of America hold Observer status with respect to the LHC; the United States of America also holds Observer status with respect to the HL-LHC; see https://home.cern/about/who-we-are/our-governance/member-states

Figure 2: **CERN procurement orders by nationality of recipient, Ø 1999-2024**



Source: CERN; WIFO calculations.

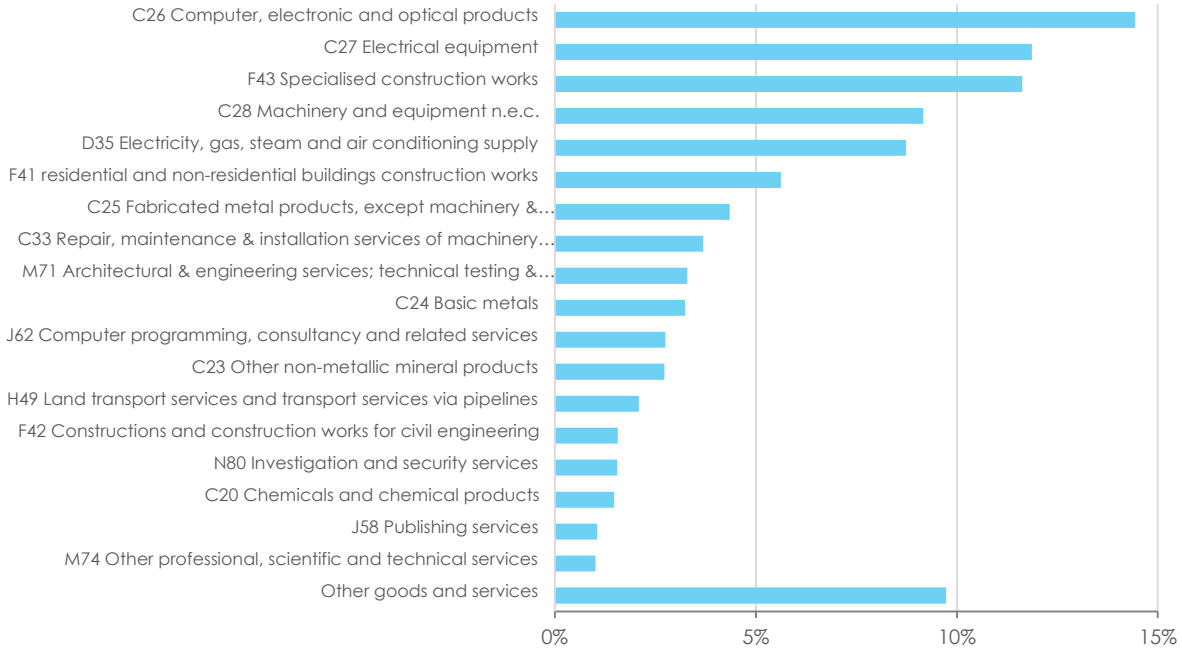
Apart from name and nationality of the supplier, order description, contracted and charged amount (plus a host of accounting items), a CERN-specific code for the contracted good or service was included. However, this code was changed during the observation period 1999-2025: Until 2015, a 3-digit alphanumeric code was used, whereas from 2018 onwards, it was replaced by a hierarchical 8-digit code (in 2016 and 2017, some overlap exists between the two systems). In all, the older 3-digit code distinguished between around 620 types of contracts, whereas the new one is much more detailed, with more than 2,400 types organized in 14 "families" (plus a distinction in "material" and "service").

To convert the codes into the economic NACE (or, rather, CPA) classification[2] necessary for estimating the associated value chains, we took a two-step approach: in the first step, we used AI (ChatGPT) to produce a correspondence based on the description of the classes, the result of which was manually checked and (if necessary) corrected in the second step. For the new 8-digit codes, we additionally distinguished between "material" and "service" contracts[3]. About 1% of items could not be classified, they constituted accounting entries (like advance payments to contractors etc.). The result is shown in Figure 3:

[2] NACE is the acronym for "Nomenclature statistique des activités économiques dans la Communauté européenne". It is the statistical classification of economic activities in the European Community; CPA, the statistical classification of products by activity (CPA), is the corresponding classification of products (goods and services) in the European Union. ADAGIO, the model used to estimate the global value chains, is based on NACE and CPA, respectively.

[3] for example: code 04090300, Access Control Systems, was identified as commodity C26 – *computer, electronic and optical products* – as a material, but was classified as C33 – *repair and installation of machinery and equipment* as a service.

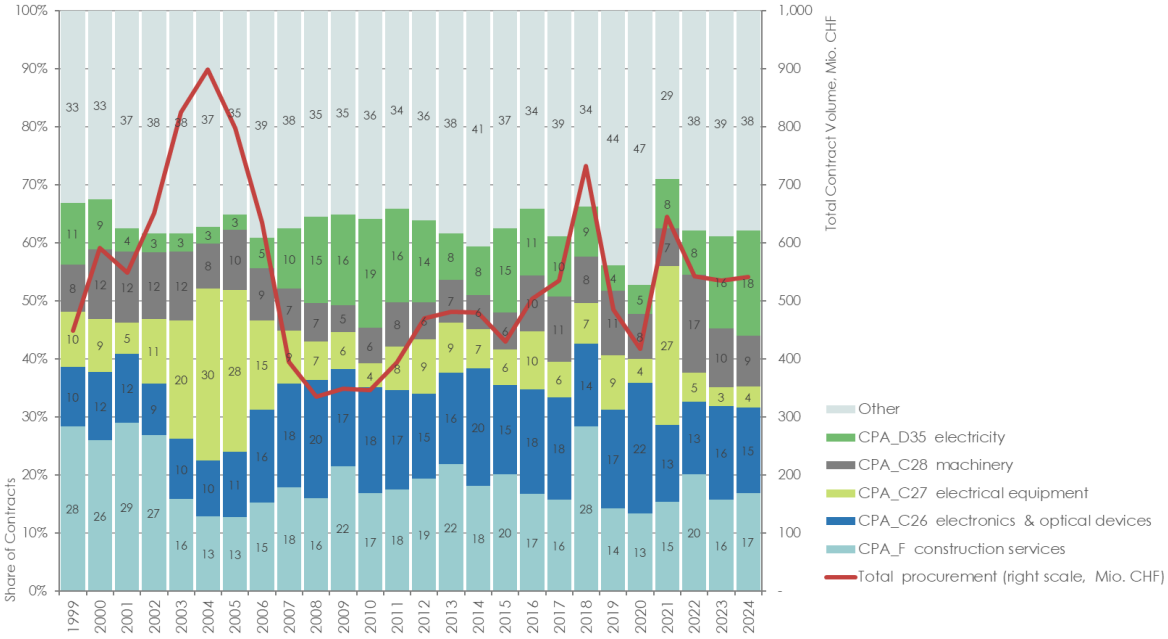
Figure 3: **Share of CERN procurement orders by CPA2-digit classification of contract, Ø 1999-2024**



Source: CERN; WIFO calculations.

On average, most contracts covered Hi-tech hardware (computers, electronics, optics; 14%), followed by specialized construction and electrical equipment (12% each). The commodity structure of procurements was quite volatile, with electrical equipment reaching 30% during 2003-2005 and 2021, periods which were preceded by higher-than-usual construction activity (with a share of 13-30%), reflecting the chronology of investment activities. Electricity demand (3-19%) was complementary – its share was lowest when investment activity was highest – in other words, electricity demand was highest during experiment periods.

Figure 4: **Total volume and main commodity structure of CERN procurement orders, 1999-2024**



Source: CERN; WIFO calculations.

The CERN Host States (HS), France and Switzerland, have the highest shares of direct contracts, with 31 and 27% respectively. Their share is especially high in contracts for "regional" or "local" services, as Figure 5 shows: Electricity (D35) and construction services (F41-43) in particular but also repair and installation of machinery (C33) or security services (N80) are rarely sourced from outside these two regions.

Figure 5: **Share of CERN procurement orders by nationality and CPA-2digit, Ø 1999-2024**[4]

			C26	C27	F43	C28	D35	F41	C25	C33	M71	C24	J62	C23	H49	F42	N80	other	**Total**
MS	FR	France	2.1	2.6	5.4	2.0	7.7	0.9	1.9	1.6	1.0	0.5	0.4	1.0	0.4	0.1	0.8	3.1	**31.3**
	CH	Switzerland	5.5	0.7	1.2	2.2	1.0	1.0	0.8	1.4	0.6	0.4	1.0	0.3	1.2	1.5	0.6	7.2	**26.6**
	DE	Germany	1.3	2.2	0.3	0.8	-	0.0	0.3	0.1	0.6	0.5	0.1	0.3	0.1	-0.0	0.0	0.7	**7.5**
	IT	Italy	0.7	2.1	0.9	1.4	-	0.8	0.3	0.1	0.1	0.2	0.0	0.3	0.1	0.0	0.0	0.3	**7.3**
	GB	United Kingdo	1.1	0.5	1.1	0.5	-	0.9	0.2	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.7	**6.1**
	ES	Spain	0.3	0.4	0.9	0.7	-	1.3	0.3	0.3	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.2	**4.8**
	NL	Netherlands	0.5	0.2	0.7	0.2	-	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.4	**2.3**
	BE	Belgium	0.4	0.0	0.7	0.3	-	0.0	0.1	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.2	**2.2**
	AT	Austria	0.1	0.1	0.0	0.0	-	0.6	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-	0.0	0.2	**1.2**
	PL	Poland	0.4	0.0	0.0	0.1	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	**0.8**
	FI	Finland	0.1	0.1	0.0	0.1	-	-	0.0	0.0	0.0	0.2	0.0	0.2	0.0	-	-	0.0	**0.7**
	DK	Denmark	0.1	0.4	0.1	0.1	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.7**
	SE	Sweden	0.1	0.1	0.0	0.1	-	-	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-	0.0	0.0	**0.5**
	PT	Portugal	0.0	0.1	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	**0.4**
	NO	Norway	0.1	0.0	0.0	0.1	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	**0.3**
	HU	Hungary	0.0	0.1	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-	0.0	0.0	**0.2**
	GR	Greece	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	**0.2**
	CZ	Czech Republi	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	**0.2**
	SK	Slovakia	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-	-	0.0	**0.2**
	RO	Romania	0.1	0.1	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.2**
	IL	Israel	0.1	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.1**
	BG	Bulgaria	0.1	0.0	-	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	**0.1**
	SI	Slovenia	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.0**
	EE	Estonia	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.0**
	RS	Serbia	0.0	0.0	-	0.0	-	-	0.0	-	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.0**
AS	IN	India	0.0	0.1	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.2**
	TR	Turkey	0.0	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	0.0	-	0.0	-	-	0.0	**0.1**
	PK	Pakistan	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	-	-	0.0	**0.0**
	LT	Lithuania	0.0	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	0.0	0.0	0.0	-	-	0.0	**0.0**
	HR	Croatia	0.0	0.0	-	0.0	-	-	0.0	-	0.0	0.0	0.0	-	0.0	-	-	0.0	**0.0**
	UA	Ukraine	0.0	-	-	0.0	-	-	0.0	0.0	-	-	-	-	0.0	-	-	0.0	**0.0**
	CY	Cyprus	0.0	0.0	-	0.0	-	-	0.0	0.0	-	0.0	-	0.0	0.0	-	-	0.0	**0.0**
	LV	Latvia	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	**0.0**
	BR	Brazil	-	0.0	-	-	-	-	-	-	0.0	0.0	-	-	0.0	-	-	0.0	**0.0**
OS	US	United States	0.6	1.3	0.0	0.0	-	-	0.1	0.0	0.0	0.6	0.1	0.2	0.0	-	0.0	0.4	**3.3**
	JP	Japan	0.1	0.3	0.0	0.2	-	-	0.0	0.0	0.0	0.1	-	0.0	0.0	-	-	0.1	**0.7**
NM	ROW	Other countrie	0.5	0.4	0.0	0.1	-	-	0.1	0.0	0.1	0.1	0.1	0.1	0.1	-	0.0	0.2	**1.7**
	World Total		**14.3**	**11.8**	**11.5**	**9.1**	**8.7**	**5.6**	**4.3**	**3.7**	**3.3**	**3.2**	**2.7**	**2.7**	**2.1**	**1.6**	**1.5**	**14.1**	**100.0**

Source: CERN; WIFO calculations. – MS - CERN Member States, AS - CERN Associated Member States, OS - CERN Observer States, NM - CERN Non Member States.

In the following chapter, the global linkages ("global value chains") of these procurement contracts will be investigated using ADAGIO, a multi-regional Input-Output model.

[4] Cells with zero value are marked "-", 0.0% values are the result of rounding. See Appendix for NACE/CPA codes.

3. The Model

The global value chains associated with CERN procurement were estimated using a time-series variant of ADAGIO, a multi-regional Input-Output model which was already used to estimate the indirect value added effects from constructing the Future Circular Collider (FCC) (Streicher, 2024)[5]. ADAGIO uses 2019 as its base year; to capture the evolution of world trade during the observation period 1999-2004, we replaced the IO core of ADAGIO with a series of multiregional IO tables[6]. The source for these tables was WIOD, which pioneered the compilation of multiregional SUTs (and IOTs; see Timmer et al, 2015, 2012). WIOD, however was discontinued; instead, FIGARO (a cooperative endeavour by EUROSTAT and the EU's Joint Research Center JRC in Seville, Spain; see Remond-Tiedrez and Rueda-Cantuche, 2019) was set up to succeed WIOD. As a result, FIGARO covers 2010-2023, significantly expanding WIOD's 2000-2014 coverage. Regional coverage is similar: WIOD has 43 countries, FIGARO 45[7] (plus a Rest-of-the-World). Both data bases do not include the CERN Member States Israel and Serbia; therefore, their individual performance with respect to indirect and induced effects from CERN procurement could not be assessed in this analysis.

For 2010-2023, FIGARO was used for the SUT core of ADAGIO; previous years were based on WIOD. In the overlap period (2010 to 2014), we observed some differences to FIGARO when using WIOD data. As the FIGARO data base is much more recent, we decided on using FIGARO results for 2010-2014. WIOD results for 2010 were scaled to FIGARO, and the results for 2000 to 2009 were anchored to this "WIOD-FIGARO-base year". Results for 1999 were obtained using the WIOD structures for 2000, and FIGARO's 2023 structure was used to estimate the 2024 value chains. This can be defended as arguably only a slight inaccuracy, as Input-Output structures tend to be quite persistent with only modest year-on-year changes.

Along the global value chains, 3 types of effects can be distinguished:

- The **direct** effects occur at the level of CERN contractors: if a firm gets a contract, then the contract volume constitutes additional turnover for this firm. Part of this turnover will be used to buy material and services to fulfil the order (these are the intermediate inputs); the difference between intermediate inputs and turnover constitutes value added – it is used to pay the employees[8] and cover depreciation[9]. Anything left over after all these expenses have been paid for constitutes net operating profits.

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[5] for a more detailed model description, see the Appendix.

[6] or, rather, Supply-Use tables (SUTs), which distinguish between sectors that produce and use commodities (IO tables, on the other, are derived from SUTs; instead of sectors x commodities, they are defined for sectors x sectors resp. commodities x commodities. In the first case, it is output from other sectors which goes into each sector's production; in the latter, it is commodities which are produced using other commodities. In both cases, information is lost by transforming SUTs into the respective IO table. For this reason, ADAGIO uses SUTs, but also – and even more importantly – because the SUT environment makes it easier to "dynamize" the static SUT or IO tables.

[7] FIGARO lacks Taiwan, but includes Argentina, South Africa and Saudi Arabia.

[8] Compensation of employees consists of wages and social security contributions

[9] as well as any net taxes on production, which is only of marginal importance in most sectors.

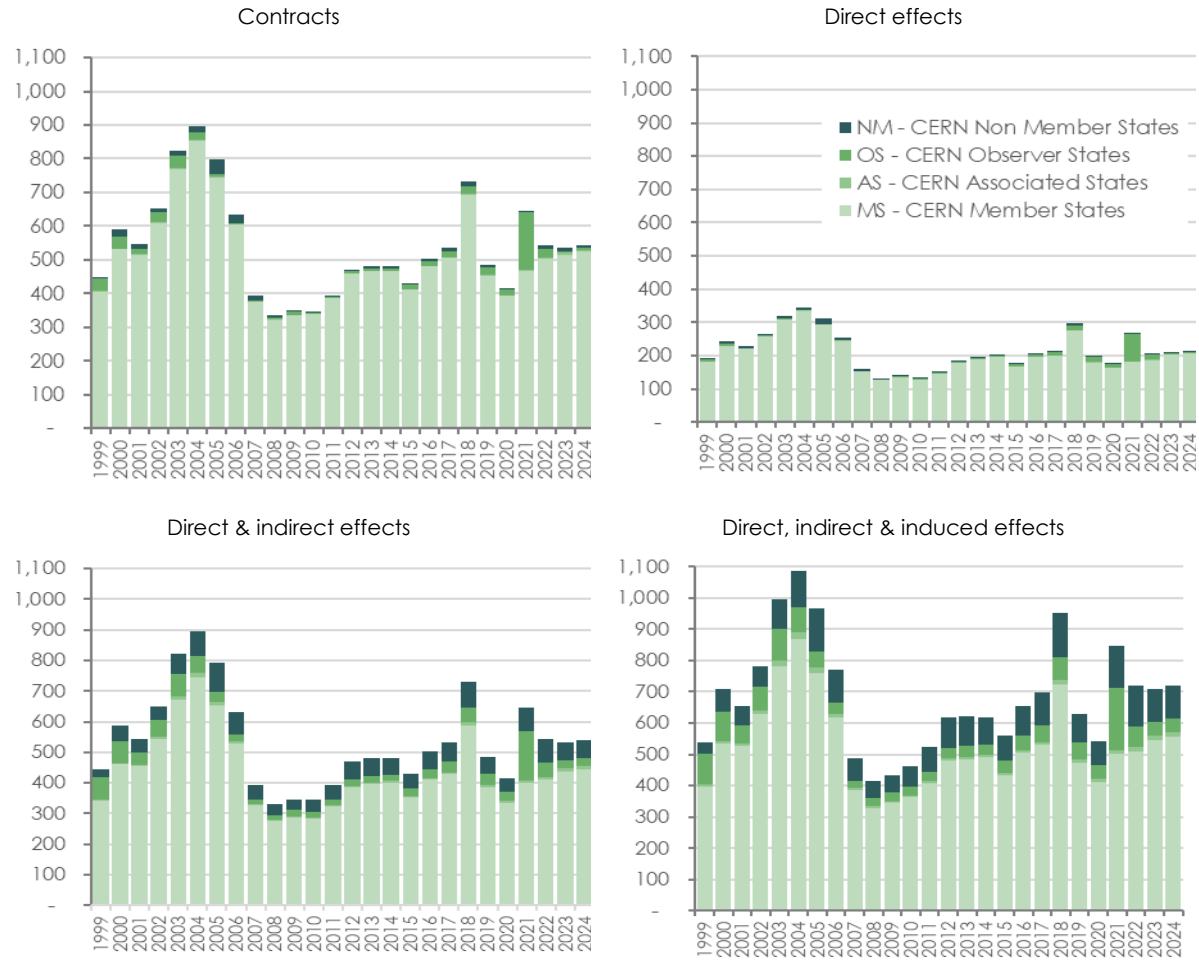
- **Indirect** effects follow from intermediate inputs: if a firm buys intermediates, then this constitutes turnover for the firm's suppliers, who themselves generate value added and even more intermediate demand (which again generates indirect effects etc.).
- Direct and indirect effects constitute the production-related effects. If the economic system under investigation is expanded, value added-related **induced** effects occur: wages paid are spent on private consumption or depreciated capital stock is replaced. In this analysis, we will include replacement investments, as these are closely linked to the production process.

4. The Results

Procurement demand by type of commodity and nationality of contractor was fed into ADAGIO to estimate the direct, indirect and induced effects connected to these purchases.

Figure 6 shows the volume and distribution of direct, indirect and induced effects between CERN members and non-members.

Figure 6: **Contract volumes and economic effects by member status, 1999-2024[10], in Mio. CHF**

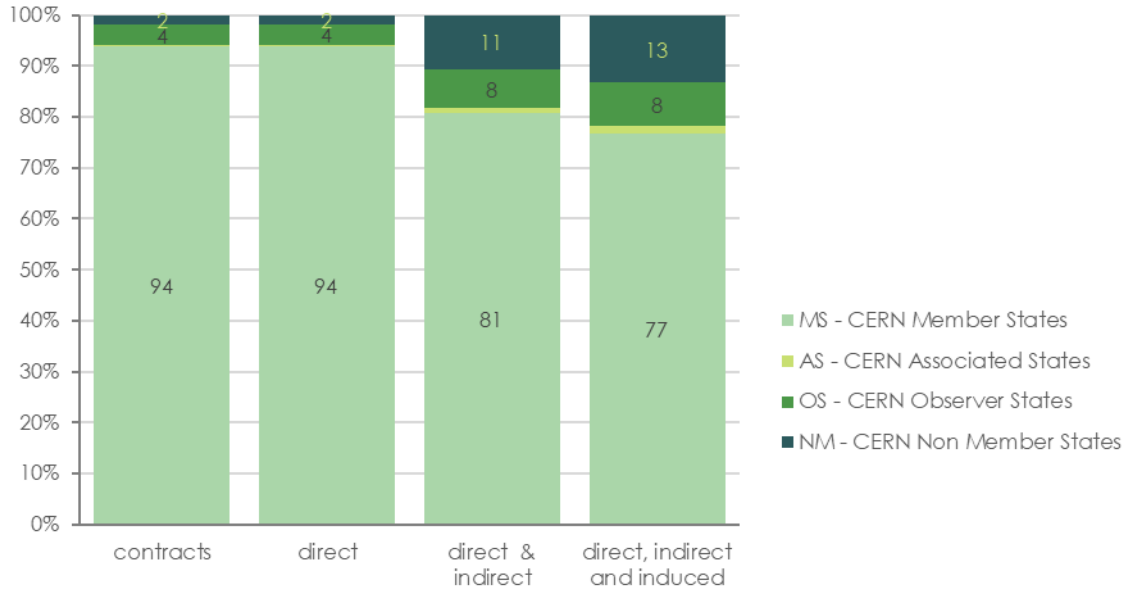


Source: CERN; WIFO calculations.

[10] Some countries became members only during the observation period. The "member status" reflects the status as of 2025. Of the member states, Israel and Serbia could not be analysed separately due to lack of country coverage in the multiregional IO tables.

The results show a broadening of effects along the geographical dimension: while non-members' share of contracts was only around 2% on average (the share of direct effects is very similar), its share of indirect and induced effects is much larger, with 11% resp. 13% on average during the observation period. Conversely, member states' 94% of direct contracts diminished to 77% after taking account of global value chains.

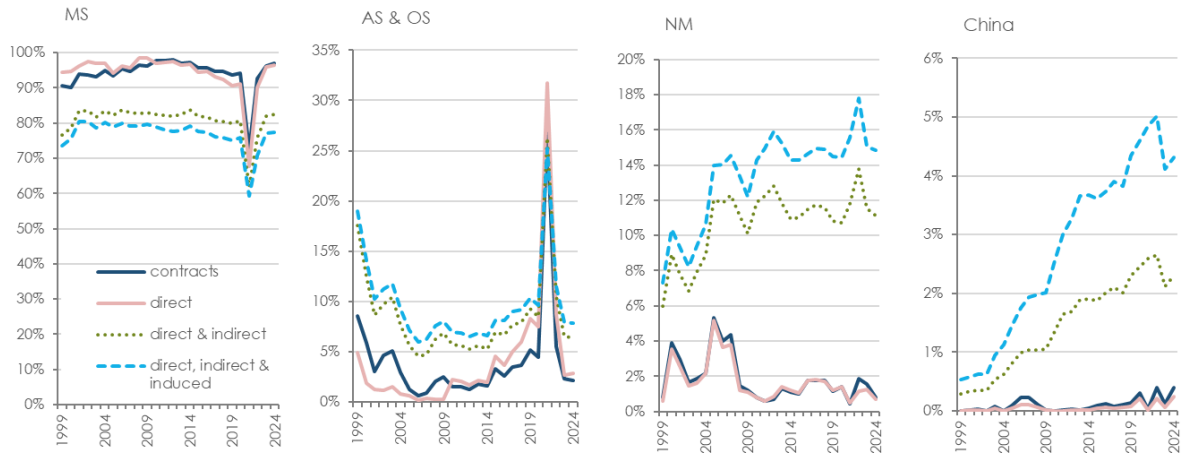
Figure 7: **Average share of contract volumes and economic effects by member status, Ø 1999-2024**



Source: CERN; WIFO calculations.

During the observation period, this disproportionately high value-added effect for non-members (as well as observers and associates) became even more pronounced, reflecting the enormous increase in global trade linkages. "Globalization" peaked around 2008, which is reflected in an almost flat non-member share in the second half of the observation period, as shown in Figure 8. However, China continued to expand its position in international manufacturing, as also shown in this figure: despite negligible direct contracts, China's share of indirect and induced effects continued to climb almost to the end, reaching 5% when induced effects are included.

Figure 8: **Share of contract volumes and economic effects by member status and China, 1999-2024**



Source: CERN; WIFO calculations.

Table 1 gives the estimated shares of contracts and value added effects (as well as their share of regular contributions) for all model regions. As mentioned above, Israel and Serbia are not part of the data bases (WIOD, FIGARO) used in this analysis, a separate analysis of their share in the value added effects is therefore not possible.

A well-known imbalance shown in the table is the rather large share of procurement contracts and economic effects enjoyed by the host states, France and Switzerland. This effect is due to the fact that many goods and services linked to the operation are typically sourced regionally or locally.

Table 1: **Percent share of contributions, contracts and VA effects by model regions and member status[11], Ø 1999-2024**

		In %	contributions	contracts	direct effects	direct & indirect effects	direct, indirect & induced effects
MS	AT	Austria	2.2	1.7	1.4	1.3	1.3
	BE	Belgium	2.7	2.3	2.0	2.1	2.0
	BG	Bulgaria	0.3	0.2	0.1	0.1	0.1
	CH	Switzerland	3.6	25.3	27.9	18.6	16.5
	CZ	Czech Republic	0.9	0.3	0.1	0.3	0.4
	DE	Germany	20.5	7.0	8.0	9.2	9.3
	DK	Denmark	1.8	0.9	0.7	0.7	0.7
	ES	Spain	7.5	4.9	4.8	4.5	4.3
	EE	Estonia	0.0	0.1	0.0	0.0	0.0
	FI	Finland	1.3	1.0	0.7	0.6	0.6
	FR	France	14.7	28.9	30.1	23.5	22.5
	UK	United Kingdom	15.4	6.2	7.3	6.7	6.2
	EL	Greece	1.3	0.3	0.2	0.2	0.2
	HU	Hungary	0.7	0.4	0.3	0.3	0.3
	IT	Italy	11.1	6.7	6.0	6.7	6.5
	NL	Netherlands	4.5	2.3	2.3	2.5	2.4
	NO	Norway	2.3	0.4	0.3	0.8	0.8
	PL	Poland	2.5	0.8	0.6	0.9	0.9
	PT	Portugal	1.1	0.7	0.4	0.4	0.4
	RO	Romania	0.6	0.4	0.1	0.2	0.2
	SK	Slovakia	0.4	0.4	0.1	0.2	0.2
	SI	Slovenia	0.1	0.1	0.0	0.1	0.1
	SE	Sweden	2.5	0.7	0.5	0.7	0.8
	IL	Israel	0.9	NA	NA	NA	NA
	RS	Serbia	0.1	NA	NA	NA	NA
AS	BR	Brazil	0.1	0.0	0.0	0.2	0.3
	CY	Cyprus	0.0	0.0	0.0	0.0	0.0
	HR	Croatia	0.0	0.1	0.0	0.0	0.0
	IN	India	0.5	0.4	0.2	0.5	0.8
	LT	Lithuania	0.0	0.1	0.0	0.0	0.0
	LV	Latvia	0.0	0.0	0.0	0.0	0.0
	TR	Turkey	0.2	0.2	0.1	0.3	0.3
	PK	Pakistan	0.1	NA	NA	NA	NA
	UA	Ukraine	0.0	NA	NA	NA	NA
OS	JP	Japan	0.0	0.8	0.6	2.0	2.3
	US	United States	0.0	3.1	3.3	5.5	6.0
NM	AU	Australia	0.0	0.0	0.0	0.2	0.3
	CA	Canada	0.0	0.1	0.0	0.4	0.5
	CN	China	0.0	0.2	0.1	1.4	2.7
	ID	Indonesia	0.0	0.0	0.0	0.1	0.2
	IE	Ireland	0.0	0.3	0.2	0.4	0.5
	KR	Korea	0.0	0.2	0.0	0.3	0.5
	LU	Luxembourg	0.0	0.1	0.0	0.1	0.1
	MX	Mexico	0.0	0.0	0.0	0.2	0.3
	MT	Malta	0.0	0.0	0.0	0.0	0.0
	RU	Russia	0.0	1.8	1.2	1.8	1.9
	ROW	Rest-of-World	1.1	0.4	0.3	5.6	6.4
World	Total	In %	100	100	100	100	100
World	*Total*	*In Mio. CHF*	*1.089*	*573*	*217*	*537*	*681*

Source: CERN; WIFO calculations.

For example: firms from Austria (the first row in the table), which contributes 2.2% of CERN's member fees[12], are awarded 1.7% of CERN's procurement contracts[13]. In terms of value added,

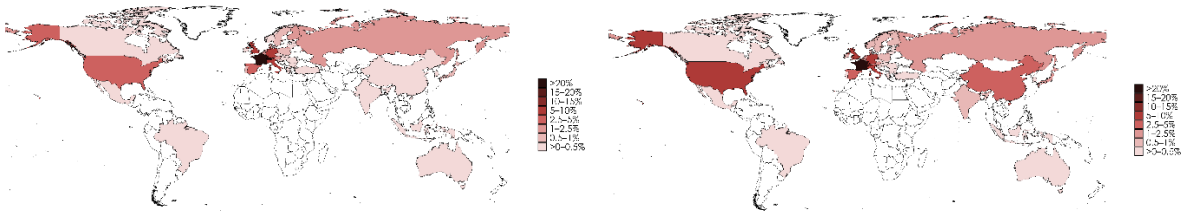
[11] Some countries became members only during the observation period. The "member status" reflects the status as of 2025. Of the member states, Israel and Serbia could not be analysed separately due to lack of country coverage in the multiregional IO tables.

[12] During 1999-2024, this amounted to an average of 23.6 Mio. CHF, out of a total of 1,080 Mio. CHF.

[13] On average, CERN'S annual procurement volume was 570 Mio. CHF, of which Austrian firms received 10 Mio. CHF.

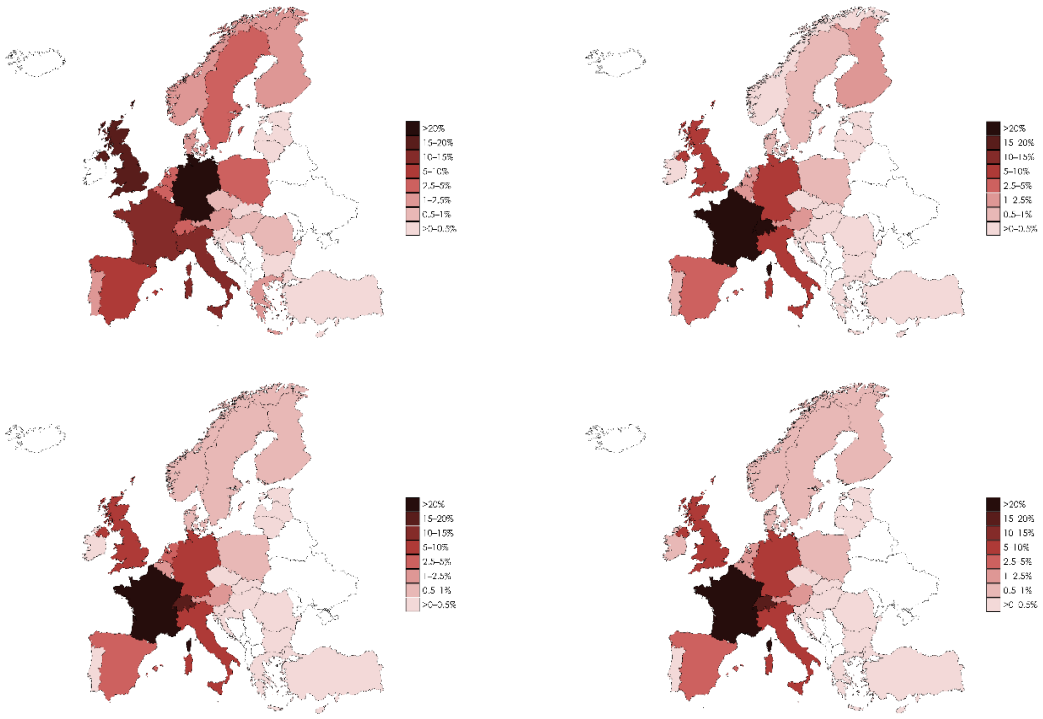
these contracts are associated with 1.4% of all direct effects[14]. If indirect and induced effects are included, the Austrian economy receives 1.3% of world-wide value added associated with CERN's procurement[15].

Figure 9: **Share of contracts resp. total effects, World Ø 1999-2024**



Source: CERN; WIFO calculations.

Figure 10: **Share of regular contributions, contracts, indirect and total effects, Europe Ø 1999-2024**



Source: CERN; WIFO calculations.

[14] World-wide direct effects amounted to 217 Mio. CHF, Austria's share came to 3 Mio CHF.

[15] Total direct & indirect value added effects are estimated at 540 Mio. CHF, which rises to 680 Mio. CHF when induced effects are included as well. The contribution to Austria's economy amounts to 7 resp. 8.5 Mio. CHF.

5. Discussion

The aim of this analysis was to track the global value chains associated with CERN procurement, highlighting the global linkages and their development during the years 1999-2024, a period of rapid developments in international trade. The most important observations include:

- Contract volumes roughly follow participants' (i.e. CERN Member States, MS, and Associated Member States, AS) annual budget contributions to CERN, even if some contracts are awarded to firms from CERN Non-Member States (around 7%, of which 4 percentage points are contracted to firms from the two CERN Observer States, Japan and USA).
- The economic effects (i.e. those associated directly with contracts, without any knowledge or technological spillovers) are more widely distributed: including depreciation-related induced effects, less than 80% are estimated to accrue to MS and AS (plus a further 8% to OS).
- This "outflow" is especially pronounced in the case of China, whose share of value added effects – despite negligible direct contracts – rose from 0.5 to 5% during the observation period – testament to the rapid integration of (and rising dependence on) China into world manufacturing.
- A contentious though well-known result is the rather large share of economic effects enjoyed by the CERN Host States, France and Switzerland – together they account for almost 40% of estimated effects. This imbalance is due to the fact that many goods and services necessary for operation are best sourced regionally or even locally.

The results show that the costs of a scientific research organization like CERN are connected with tangible economic impacts in terms of value added and employment – not only for the staff and scientists involved, but also for the suppliers and their employees. However, the results also show that the connection between annual contributions to CERN, direct contracts and indirect benefits is not always clear-cut, crucially depending on the position of a region in the global value chain: for example, China and the United States, which are not member states of CERN, are estimated to have sizeable economic benefits due to their prominent roles in global value chains.

A more immediate recommendation pertains to the classification of procurement items which CERN has developed: especially in its new version, it has greatly aided the present analysis. Nevertheless, to use it in the present context, a mapping had to be devised to the EU's standard economic classification system NACE/CPA[16]. This rough-and-ready bridge has been provided to CERN to be used in future studies; however, the bridge was defined at the CPA2-digit level only, as the minimum requirement for the IO model ADAGIO. To facilitate future studies

[16] NACE is the acronym for "Nomenclature statistique des activités économiques dans la Communauté européenne". It is the statistical classification of economic activities in the European Community; CPA, the statistical classification of products by activity (CPA), is the corresponding classification of products (goods and services) in the European Union.

involving CERN procurement data, we suggest supplementing the CERN-specific classification system with a correspondence table to the economic CPA-classification system. This could be based on the mapping developed for the present analysis, but should go below the 2-digit level as many important qualities of goods and services (as for example technology content) become only apparent at a more detailed level: for example, at the 2-digit level, spacecraft and bicycles are both classified as product C30, "Other vehicles". Only at a deeper level does the classification diverge (C30.1 for spacecraft, C30.9 for bicycles). Therefore, we propose to aim for a 4-digit classification of procurement contracts.

6. Annex: ADAGIO - A DynAmic Global Input Output model

ADAGIO, A DynAmic Global Input Output model, is part of a family of regional models with a common modelling philosophy; a philosophy which might be described as "Dynamic New Keynesian": although not "General Equilibrium" in the usual sense, this model type (which might be called "EIO" – econometric Input Output modeling – or "DYNK" – Dynamic New Keynesian) shows important aspects of equilibrium behavior. The dynamic aspect differentiates "DYNK" from the static CGE long-term equilibrium. This feature is most developed in the consumption block, where a dynamic optimization model of households is applied. But it equally applies to the equilibrium in the capital market as well as to the macroeconomic closure via a well-defined path for the public deficit.

The "New Keynesian" aspect is represented by the existence of a log-run full employment equilibrium, which will not be reached in the short run, due to institutional rigidities. These rigidities include liquidity constraints for consumers (deviation from the Permanent Income hypothesis), wage bargaining (deviation from the competitive labor market) and imperfect competition.

The DYNK model is an input-output model in the sense that it is inherently a demand driven model. However, it is a much more powerful model for impact assessment than the static IO quantity and price models due to the following features:

1. The price and the quantity side of the input-output model are linked in different ways, demand reacts to prices and the price of labor reacts to demand.
2. Prices in the DYNK model are not identical for all users as in the IO price model, but user-specific due to its proper account of margins, taxes and subsidies, and import shares that are different for each user.
3. Consumption, investment and exports (i.e. the main categories of final demand) are endogenous and not exogenous as in the IO quantity model, explained by consumer behavior (demand system), regional import demand (differentiated by intermediate and final use) and producer behavior (K,L,E,M model with M split up into domestic and imported).
4. Aggregates of the column of IO coefficients (total intermediates, energy goods, value added components) are endogenous and explained in the K,L,E,M model, whereas in the IO price model they are taken as exogenous.

While the DYNK approach shows several similarities with computable general equilibrium (CGE) models, it also deviates from specifications in CGE models in some important aspects. Output is demand driven and the supply side is represented with the help of a cost function that also comprises total factor productivity (TFP). The growth of TFP is the most important long-term supply side force in that sense in the DYNK model. Contrary to some CGE applications, exports are also fully demand driven via foreign demand in the DYNK approach (demand for imports in one country corresponds to demand for exports in other countries).

Members of this family of regional models are ASCANIO (a model of the 9 Austrian provinces), FIDELIO (a model of the EU 27, developed for and with the IPTS, the Institute for Prospective

Technology Studies in Sevilla; see Kratena et al., 2013, 2017), and ADAGIO, a model based on the WIOD data base[17].

Prices are determined endogenously: based on output prices (which are determined in the production block), purchaser prices are derived by taking into account commodity taxes (and subsidies) as well as trade and transport margins. For international trade, the model takes account of the cif/fob correction by explicitly incorporating international trade and transport costs[18].

a. The production technology: for all sectors, we assume a $KLEM_mM_d$-technology, that is, we distinguish between 5 factors of production: Capital, labour, energy, domestically produced intermediates, and imported intermediates. Together, the capital and labour share make up value added; the aggregate of energy and intermediates (both domestically produced and imported) constitutes the use of intermediates. These factor shares, together with the Output Price, are modelled within a TRANSLOG framework.
b. Wages are set under a Wage bargaining assumption, taking into account sectoral productivity, the general price level, and the unemployment rate. In the wage and employment block, three skill levels – low, medium, high – are distinguished.
c. Consumption by households: based on the COICOP classification, we distinguish between 15 groups of consumption goods; 2 of them are treated as "durable consumption goods" (housing and vehicles), the rest as "non-durables" (food, clothing, furniture and equipment, health, communication, recreation and accomodation, financial services, electricity and heating, private transport, public transport, appliances, other consumption goods, as well as a category "durable depending", which captures the running and maintenance outlays for the durable consumption goods).
   Durables are modelled in a stock-flow-model, whereas the non-durables are dealt with in an AIDS-type model.
   The consumption block distinguishes between 5 types of households, based on their wealth (5 quintiles). Current consumption is determined by current income as well as the stock of wealth. Accumulation of wealth is modelled in an intertemporal framework.

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[17] The WIOD project compiled Supply and Use Tables for 40 countries (the EU 27 plus 13 major economies from outside Europe. WIOD was conducted within the 7th EU-framework project 'WIOD: World Input-Output Database: Construction and Applications' (www.wiod.org) under Theme 8: Socio-Economic Sciences and Humanities, Grant agreement no. 225 281. See Timmer et al. (2015).

In December 2016, an update became available, now covering 43 countries (Croatia as a new member state was added; also, Switzerland and Norway were taken in, now ensuring almost complete coverage of the European continent (excluding only the eastern states apart from Russia).

[18] For details on the estimation of consistent international trade and transport margins, see Streicher and Stehrer (2015).

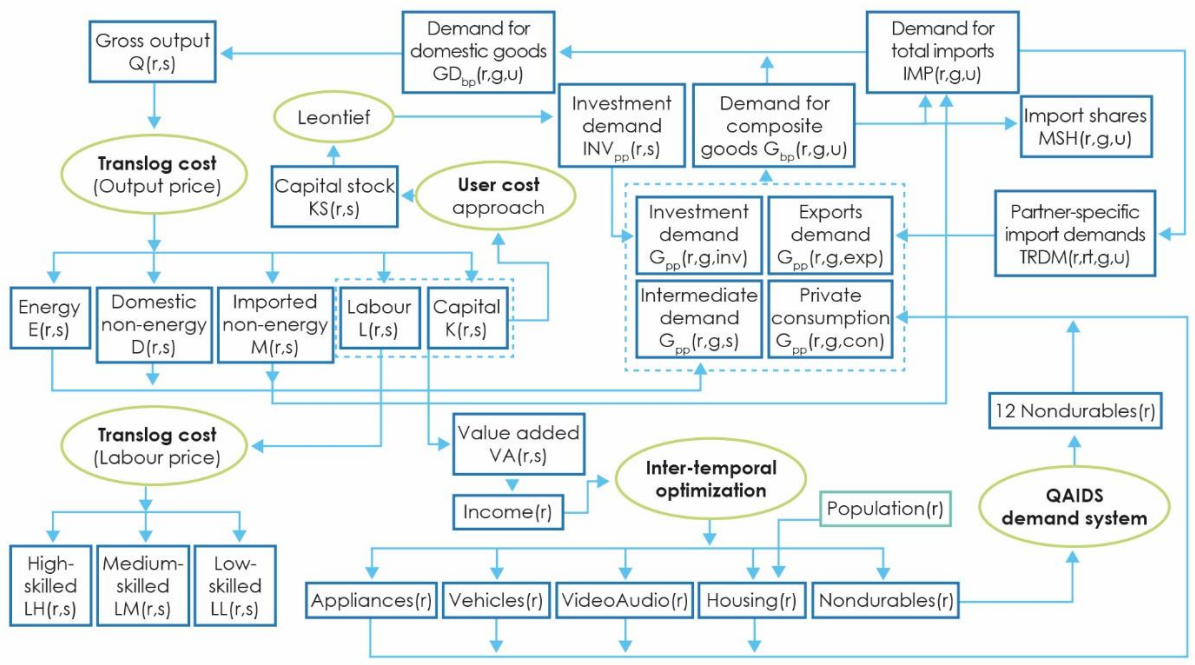
Basic energy prices (crude oil, coal) are exogenous. All other prices are endogenous, starting from output prices (as defined in the TRANSLOG specification of sectoral production technology; this is the price at the factory door), and adding trade and transport margins (national as well as international[19]) and commodity taxes (which, in the case of imports, can include import duties) to finally arrive at purchaser prices (the prices relevant for the respective users; even within the same region, different users can –an typically will – face different prices for the same commodity. The main reason for this is different commodity taxes (intermediate consumption mostly faces low or no commodity taxes, because these are typically defined as "value-added taxes": intermediate users can reclaim most input taxes that they have paid), but probably also different trade and transport margins.

For an extensive and in-depth treatment of all parts of the model, see Kratena et al. (2013, 2017) and Kratena and Streicher (2017).

ADAGIO is first and foremost a demand-driven model: demand will be satisfied immediately, excess (or inadequate) demand is not allowed. Supply-side constraints, however, enter the scene indirectly via the price model: if an economy becomes overly tight, wages will go up, taking with them output prices – and, consequently, all prices derived from them – which are all other prices. Demand for this sector's (or economy's) products will, therefore, be dampened. In fact, and unless forced (by, for example, overly devaluing the exogenous exchange rate, or an overly lax target path for the budget deficit), conditions for overheating will not arise in the first place. In other words, ADAGIO is not a business cycle model, but rather a tool for following medium- to long-term developments.

[19] Streicher and Stehrer (2015) demonstrate the consistent integration of international trade and transport margins into the IO framework.

Figure A 1: **ADAGIO's model structure**



Source: Kratena et al. (2013).

To sum up: ADAGIO is an Input-Output model with econometrically estimated behavioural equations. These include Translog specifications for the production side (where, based on input prices and technology, factor and investment demand as well as output prices are determined) and a (quadratic) AIDS specification for consumption demand (based on appropriate purchaser prices). Additional econometric equations determine wages and skill shares (the model distinguishes between 3 skill levels in labour demand).

ADAGIO builds on Supply-Use tables: these tables describe the economy in term of commodity flows: which sectors of the economy produce which commodities (Supply) resp. who consumes these commodities (Use. If the consumers are sectors, then this is called intermediate use: sectors need products from other sectors in their own production processes. Final consumption, on the other hand, is what might be called the "raison d'etre" of economic activity: it consists of consumption by private households and government, investment by sectors, changes in inventory, and exports. Supply-Use tables (SUTs for short) are the basis for Input-Output tables (IOTs): whereas SUTs distinguish between producers and consumers on the one hand and commodities on the other, IOTs show directly the flow between sectors and users (with only implicit distinction between commodities: in SUTs, a sector can (and usually will) produce more than one commodity, which can be "traded" separately. In IOTs, it is only total flows between economic agents, without distinction by type of commodity. IOTs are usually calculated from SUTs; however, going from SUTs to IOTs involves a loss of information – therefore, it is not possible to reverse this process).

The Supply-Use tables are based on the set of regions included in the WIOD project and encompasses 43 Countries plus a Rest-of-the-World. In the current version of ADAGIO, however, the data base itself is no longer taken from WIOD, as the update of this data base was discontinued in 2017 (the most recent year in WIOD is 2014). Instead, ADAGIO is based on Supply-Use-Tables adapted from EUROSTAT (for the EU 27/8) and OECD (for the remaining countries). The current base year of the model is 2017/18.

Table A 1: **ADAGIO country list**

EU member states		Non-EU countries	
AT	Austria	AU	Australia
BL	Belgium	BR	Brasil
BG	Bulgaria	CA	Canada
CY	Cyprus	CH	Switzerland
CZ	Czech Republic	CN	China People's Republic
DK	Denmark	ID	Indonesia
DE	Germany	IN	India
EL	Greece	JP	Japan
EE	Estonia	KO	South Korea
FI	Finland	MX	Mexico
FR	France	NO	Norway
HR	Croatia	RU	Russia
HU	Hungary	TR	Turkey
IR	Ireland	TW	Taiwan
IT	Italy	US	USA
LT	Lithuania		
LU	Luxembourg		
LV	Latvia		
MT	Malta		
NL	Netherlands		
UK	Great Britain		

Source: Eurostat, WIFO.

For the time-series version of ADAGIO, which was used in this paper to account for the changing trade linkages during the observation period from 1999-2024, we replaced the IO core of ADAGIO with a series of multiregional IO tables[20]. The source for these tables was WIOD, which pioneered the compilation of multiregional SUTs (and IOTs; see Timmer et al, 2015, 2012). WIOD, however was discontinued; instead, FIGARO (a cooperative endeavour by EUROSTAT and the EU's Joint Research Center JRC in Seville, Spain; see Remond-Tiedrez and Rueda-Cantuche, 2019) was set up to succeed WIOD. As a result, FIGARO covers 2010-2023, significantly expanding WIOD's 2000-2014 coverage. Regional coverage is similar: WIOD has 43 countries, FIGARO

[20] or, rather, Supply-Use tables (SUTs), which distinguish between sectors that produce and use commodities (IO tables, on the other, are derived from SUTs; instead of sectors x commodities, they are defined for sectors x sectors resp. commodities x commodities. In the first case, it is output from other sectors which goes into each sector's production; in the latter, it is commodities which are produced using other commodities. In both cases, information is lost by transforming SUTs into the respective IO table. For this reason, ADAGIO uses SUTs, but also – and even more importantly – because the SUT environment makes it easier to "dynamize" the static SUT or IO tables.

45[21] (plus a Rest-of-the-World). Both data bases do not include the CERN members Israel and Serbia; therefore, their individual performance with respect to indirect and induced effects from CERN procurement could not be assessed in this analysis.

For 2010-2023, FIGARO was used for the SUT core of ADAGIO; previous years were based on WIOD. In the overlap period (2010 to 2014), we observed some differences to FIGARO when using WIOD data. As the FIGARO data base is much more recent, we decided on using FIGARO results for 2010-2014. WIOD results for 2010 were scaled to FIGARO, and the results for 2000 to 2009 were anchored to this "WIOD-FIGARO-base year". Results for 1999 were obtained using the WIOD structures for 2000, as was FIAGRO's 2023 structure used to estimate the 2024 value chains. This can be defended as arguably only a slight inaccuracy, as IO structures tend to be quite persistent with only modest year-on-year changes.

The ADAGIO economies are disaggregated into 64 sectors; among them 4 basic sectors (Agriculture and Mining; A and B) and 19 manufacturing sectors (C).

[21] FIGARO lacks Taiwan, but includes Argentina, South Africa and Saudi Arabia.

Table A 2: **ADAGIO sectors**

NACE code	Industry	NACE code	Industry
A01	Crop and animal production, hunting	H50	Water transport
A02	Forestry and logging	H51	Air transport
A03	Fishing and aquaculture	H52	Warehousing and support activities for transportation
B05-07	Mining of coal and lignite	H53	Postal and courier activities
B08-09	Other mining and quarrying	I55-56	Accommodation
C10	Manufacture of food products	J58	Publishing activities
C11-12	Manufacture of beverages	J59	Audio and video production
C13	Manufacture of textiles	J60	Programming and broadcasting activities
C14	Manufacture of wearing apparel	J61	Telecommunications
C15	Manufacture of leather and related products	J62-63	Computer programming and consultancy
C16	Manufacture of wood and of products of wood	K64	Financial service activities, except insurance
C17	Manufacture of paper and paper products	K65	Insurance, reinsurance and pension funding
C18	Printing and reproduction of recorded media	K66	Activities auxiliary to financial and insurance services
C19	Manufacture of coke a. refined petroleum products	L68	Real estate activities
C20	Manufacture of chemicals and chemical products	M69	Legal and accounting activities
C21	Manufacture of pharmaceutical products	M70	Activities of head offices; management consultancy
C22	Manufacture of rubber and plastic products	M71	Architectural, technical and engineering activities
C23	Manufacture of other non-metallic mineral products	M72	Scientific research and development
C24	Manufacture of basic metals	M73	Advertising and market research
C25	Manufacture of fabricated metal products	M74-75	Other professional, scientific and technical activivities
C26	Manufacture of computer, electronic a. optical prod.	N77	Rental and leasing activities
C27	Manufacture of electrical equipment	N78	Employment activities
C28	Manufacture of machinery and equipment n.e.c.	N79	Travel agency, tour operator and other reservation
C29	Manufacture of motor vehicles, trailers	N80-82	Security and investigation activities
C30	Manufacture of other transport equipment	O84	Public administration and defence; social insurance
C31	Manufacture of furniture	P85	Education
C32	Other manufacturing	Q86	Human health activities
C33	Repair and installation of machinery and equipment	Q87-88	Residential care activities
D35	Electricity, gas, steam and air conditioning supply	R90	Creative, arts and entertainment activities
E36	Water collection, treatment and supply	R91	Libraries, archives, museums a. other cultural activities
E37-39	Sewerage	R92	Gambling and betting activities
F41	Construction of buildings	R93	Sports, amusement and recreation activities
F42	Civil engineering	S94	Activities of membership organisations
F43	Specialised construction activities	S95	Repair of computers a. personal a. household goods
G45	Wholesale and retail trade a. repair of motor vehicles	S96	Other personal service activities
G46	Wholesale trade, except of motor vehicles	T97	Activities of households as employers
G47	Retail trade, except of motor vehicles		

Source: Eurostat.

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