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Vertical Intra-Industry Trade: An Empirical Examination of the Austria's Auto-Parts Industry

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Abstract

A distinctive feature of present globalization is the development of international production sharing activities i.e. production fragmentation. The increased importance of fragmentation in world trade has created an interest among trade economists in explaining the determinants of intra-industry trade (IIT) in intermediate goods. In this study the extent of IIT in Austria's auto-parts trade is analyzed by decomposing Austria's auto-parts trade into one-way trade, vertical IIT and horizontal intra-industry trade IIT. Then development of the vertical IIT in the auto-parts industry, as an indicator for international fragmentation of production process between Austria and its 29 trading partners, is examined and various country-specific factors suggested by fragmentation literature are tested using newly developed panel econometrics techniques and more recent data from 1996 to 2006. The results show that a substantial part of IIT in the Austrian auto-parts industry was vertical IIT and the econometric results mainly support the hypothesis drawn from the fragmentation results. In particular, the findings show that the extent of Austria's vertical IIT in auto-parts is positively correlated with average market size, differences in per capita GDP, and foreign direct investment while it is negatively correlated with distance.

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Keywords: Vertical intra-industry trade, Fragmentation, Austrian auto-parts industry, Panel data techniques;

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1 Introduction

A distinguishing feature of the present economic globalization is fragmentation of production.[1] As world markets have become increasingly integrated in the last few decades due to developments in transportation and communication technologies, the degree of product fragmentation (i.e. production sharing) increased across countries, leading to an increase in the trade of intermediate goods as goods are designed, produced and assembled in different locations.

Despite the increase in the intermediate goods trade, the empirical literature on the fragmentation has given only descriptive statistics on the importance of trade in intermediate goods induced by international fragmentation of the production process (Feenstra 1998; Hummels et al. 1999; Yeats 2001; Kimura and Ando 2005; Kaminski and Ng 2005; Ando 2006). In contrast, with the exceptions of Görg (2000), Jones et al. (2004), Egger and Egger (2005), and Kimura et al. (2007), there has been little empirical study into the shortcomings of fragmentation.

One of the problems mentioned in these studies has been how to measure the degree of fragmentation. Lloyd (2004) argues that vertical product differentiation can take place due to product stage separation. Ando (2006) argues that vertical intra-industry trade (IIT) in intermediate goods, resulting from production sharing activities, seems to be the best way to see the extent of fragmentation for a particular industry.[2] Hence, following Ando (2006) and Wakasugi (2007), the goal of this paper is to calculate the indices of vertical IIT in auto-industry between Austria and its 29 trading

[1] Product fragmentation can be defined as division of production process into different locations across different countries. There are different types and terms of fragmentation used in the fragmentation literature. These are "outsourcing" by Feenstra and Hanson (1997), "disintegration of production" by Feenstra (1998), "fragmentation" by Deardoff (1998) and Jones and Kierzkowski (2001), "vertical specialization" by Hummels et al. (1999), and "intra-product specialization" by Arndt (1997).

[2] IIT is defined as the simultaneous export and import of products, which belong to the same statistical product category. IIT of goods with a certain range of unit-price differentials between exports and imports is classified as horizontal IIT, while the rest is classified as vertical IIT.

partners and analyze the determinants of vertical IIT, which is used as a proxy for the extent of fragmentation in this study.[3]

The Austrian auto-parts industry is chosen for several reasons. First of all, the auto-industry is often regarded as one of the most fragmented industries. Due to fragmentation, Austria's import and export levels of auto-parts has continually increased. The nominal value of Austria's imported auto-parts more than doubled from $5.3 billion in 1996 to $12.7 billion in 2006 (see Figure 1.c). Likewise, Austria's auto-parts exports increased significantly from $5.3 billion in 1996 to $12.9 billion in 2006 (see Figure 1.c). This increase in the auto-parts trade implies that IIT has become more prevalent in the Austrian auto-parts industry.[4] Second, Austria is among the World's top-twenty in auto-parts imports and exports.[5] Historically, Austria is known as an auto-parts supplier, largely due to the fact that more than 10 automobile production facilities are located near Austria such as BMW, Skoda, Volskwagen, Audi, Fiat, Renault, etc. Furthermore, the automotive industry is Austria's most important manufacturing and export sector. The automotive industry represents ~11% of Austria's total industrial output and ~12% of total Austrian exports.[6]

Finally, there has been a major structural change in the Austrian automotive industry brought about by the accession of the Central and Eastern economies into the European Union (EU). This may impact the pattern and the determinants of Austria's

[3] Several empirical studies have analyzed the determinants of VIIT in motor vehicle and auto-parts industry (Becuwe and Mathieu, 1992; Ito and Umemoto, 2004; Umemoto, 2005; Montout et al. 2002). However, the shortcoming of these empirical studies is probably the fact that they do not incorporate the hypotheses stemming from newly developed fragmentation literature.

[4] In auto-industry, global production networks involve intra industry trades in both at levels of final products and intermediate goods.

[5] 2006 Survey by the Office Aerospace and Automotive Industries' Automotive Team ranks Austria among the top 20 countries in terms of auto-parts exports in the world in 2003.

[6] For a more detailed picture of the Austrian automotive industry, see Mosser and Bruner (2007).

auto-parts trade.[7] Given its crucial importance in the global automotive industry and in the Austrian economy, the Austrian auto-parts industry has become an appropriate case to study fragmentation.

Using finely disaggregated international trade data, this paper examines the recent change in trade patterns of the auto-parts industry in Austria, particularly by breaking down Austria's auto parts trade into inter-industry trade, vertical IIT and horizontal IIT. As there has not been any study that investigates the Austrian experience in this strategically important industry, this paper seeks to fill the void.

Fragmentation in the Austrian auto-parts industry was investigated over time by using vertical IIT as an indicator of fragmentation between Austria and its 29 trading partners for the period 1996 to 2006. In particular, various country-specific factors suggested by fragmentation literature initiated by Jones and Kierzkowski (1990) are tested, utilizing newly developed panel data techniques.[8] This study, unlike the previous literature, will provide valuable information about the structure and determinants of vertical IIT as an indicator of the fragmentation process in the Austrian auto-parts industry.

The major findings can be summarized as follows. First, between 1996 and 2006 there is a noticeable and important increase in vertical IIT in auto-parts, as it has come to dominate the trade flows of the industry. Second, hypotheses drawn from fragmentation literature help explain vertical IIT. In particular, the findings suggest that the extent of

[7] As shown in Bhattacharya (2007), Austria's trade links with Central and Eastern Europe have gathered momentum in recent years. In particular, Central and Eastern European countries' share of Austria's total exports rose from 12.5 % in 1991-1995 to 18 % in 2001-2005 while its share in total exports increased from 8 % in 1991-1995 to 14 % in 2001-2005. According to Bhattacharya (2007), the shift in the commodity composition of exports and imports as well as the enormous increase in manufacturing products implies that intra-industry trade resulting from outsourcing activities has become much more important than before in Austria's trade with the region. See also Egger et al. (2001).

[8] IIT in intermediate goods does not seem to be fully explained by the traditional trade models of IIT developed by Krugman (1980) and Helpman and Krugman (1985). On the other hand, fragmentation theory seems to be more appropriate for analyzing trade in intermediate goods.

Austria's vertical IIT in auto-parts is positively correlated with average market size, differences in per capita GDP, and outward FDI while it is negatively correlated with distance. These findings support the claim that IIT in the Austrian auto-parts industry is mainly the case of international fragmentation of vertical production chains.

This paper is organized as follows: Section 2 offers a brief explanation of the developments in Austria's auto-industry trade. Section 3 surveys empirical methodologies on the measurement of fragmentation and outlines the methodology for the measurement of IIT. Section 3 also analyzes the patterns of IIT in the Austrian auto-industry. Section 4 presents the economic model as well as the determinants of vertical IIT, while also addressing the key issue of estimation. Section 5 presents the empirical results. Finally, Section 6 contains concluding remarks.

2. Developments in the Austrian Auto-Industry Trade

In this section, we describe the extent, nature and dynamics of Austria's auto-industry trade with 29 OECD countries using data in the Harmonized System (HS). Table A1 provides the code list of auto-parts and Table A5 lists the countries used in the calculations.

The global automobile industry has been undergoing significant structural transformation in recent years.[9] First, automakers in the USA and Europe, such as General Motors (GM), Ford, Toyota, Honda, Volkswagen, Audi, and Daimler Chrysler, have outsourced an increasing proportion of automotive production to developing countries and emerging economies in order to reduce production costs. By outsourcing, automakers buy parts from outside suppliers rather than producing them within their own organization. Hence, reduced vertical integration allows auto manufacturers to buy parts

[9] For a more complete analysis of trends in automotive industry, see Sadler (1999), Diehl (2001), Corswant and Fredriksson (2002), Humphrey (2003), Lall et al. (2004), and Cooney and Yacobucci (2005).

from the best suppliers, a situation that typically results in lower unit costs. Another reason for reduction in the number of parts produced within the boundaries of the company is an attempt to benefit from economies of scale.

Second, most of the giant automotive manufacturers have recently merged with or acquired others to gain access to markets where a company did not have a significant presence. The merger between Chrysler Corporation and Daimler-Benz, Ford's acquisitions of Mazda, Jaguar, and Aston Martin, and GM's acquisition of Saab are just a few examples.

Finally, another trend is the increasing use of entire sub-assemblies ('modules') rather than individual components. For instance, rather than supplying only the fuel tank for a given model, a first-tier supplier may supply the entire fuel supply system.[10] Furthermore, car manufacturers have begun requiring their first-tier suppliers to provide modular components (standard) that can be used on several vehicle models worldwide. By using modules or preassembled units for several vehicle models, automakers are able to cut production costs and reduce their in-house parts operations.

These changes in the global auto industry have forever altered the relationship between motor vehicle manufacturers and auto-parts suppliers. First, motor vehicle manufacturers have forced their tier one manufacturers to become systems integrator-suppliers of modules or systems.

Second, tier one manufacturers are required to increase their role in the design, research and development of modules and systems. To meet these demands, auto-parts manufacturers have consolidated their operations worldwide since auto-parts

[10] Auto industry organized itself into several tiers. Tier 1 sells directly to automakers or original equipment manufacturers (OEM), which assemble final product. Tier 2 supply parts to Tier 1 and those that sell parts to Tier 2 are known as Tier 3, etc. moving down to the value chain. The term "tier" describes product rather than an entire firm so that some firms may be Tier 1 on one product and Tier 2 on another.

manufacturers will need to have adequate financial and managerial resources to comply with these new specific requirements of motor vehicle manufacturers. In preparation for the modules or systems, tier 1 suppliers are now required to form their own strategic partnerships with lower tier suppliers and manage the sourcing of auto-parts from tier 2 and tier 3 suppliers.

In an attempt to consolidate their activities, European and North American automakers have begun to shift their production bases to emerging markets, such as Latin America, China, and other markets in Southeast Asia. Auto-parts suppliers, then, have built component plants close to assembly plants or entered into joint ventures with local manufacturers because of the use of just-in-time delivery systems. This demand on proximity in module supply has led to the emergence of global mega auto-parts manufacturers, such as Delphi, Visteon, Bosch and Magna.

The subsequent detailed analysis will show that these changes have also had major effects on the structure of the Austrian auto industry.[11] The automotive industry is one of the Austria's most important manufacturing industries as well as Austria's most important export industry. The automotive industry represents around 11% of Austria's total industrial output and 12% of total Austrian exports. Historically, Austria is known as an automotive components supplier, largely due to the fact that more than 10 automobile production facilities are located near Austria such as BMW, Skoda, Volkswagen, Audi, Fiat, Renault, Hyundai Kia, and etc. Among various auto-parts, Austria has particularly specialized in the development and production of power trains, engines, and transmissions, which accounts for ~ 40% of the auto-parts production.[12]

[11] For a more detailed picture of the Austrian automotive industry, see ABA-Invest in Austria (2002) and Mosser and Bruner (2007).
[12] More than 300 auto-parts producers including General Motors Powertrain, BMW Motoren, Magna Steyr, and MAN Nutzfahrzeuge supply components for the motor vehicle industry in Austria.

In line with global trends, the Austrian motor vehicle and auto-parts industry has experienced major changes during the last few decades. First, there has been a shift from the production of auto-parts to assembly operations. The Austrian auto-parts industry has traditionally been linked to German automakers. However, the interdependence between the Austrian and German auto-industry is changing. Over the last decade, in response to increased competition, German auto-makers began to source more parts from cheaper production locations, especially Central and Eastern European countries.[13] In order to meet the increased price competition associated with the opening of Central and Eastern European countries, several auto-parts suppliers in Austria deployed some of their labor-intensive production and assembly operations to low-cost locations, particularly the Czech Republic, Slovakia, Slovenia, Hungary, and Poland. As a result, auto-parts production in Austria has been badly affected by rising German imports of auto-parts from these locations in recent years.

Austria, long represented in the auto-parts industry, has become a part of the auto assembly industry. This industry has become vital to Austria, with about 350.000 motor vehicles produced a year.[14] This fact, also evident from trade data, confirms the increased importance of final assembly relative to auto-parts production in Austria.

Further, given the new role of tier 1 suppliers in the research and development of modules and systems, the Austrian auto-parts manufacturers have no option but to sell their businesses or merge with existing multinational auto-parts manufacturers as many

[13] For details, see Nunnenkamp (2005).

[14] For instance, Magna Steyr, a subsidiary of Magna International and one of the leading auto-parts manufacturer in Austria, assemble a total of more than 200.000 vehicles for various automakers on a contract basis, such as Daimler-Chrysler (Chrysler Voyager, Grand Voyager, Jeep Grand Cherokee, Jeep Commander), BMW (X3 Sports Activity), Saab (9-3 Cabriolet), Mercedes-Benz (G-Class). Recently, Magna Steyr is agreed with BMW to manufacture Mini series beginning in the year 2010. Further, Aston Martin has agreed a deal with Magna Steyr for the production of its forthcoming Rapide sedan in Austria starting at the end of 2009.

historically independent auto-parts producers who sold directly to the German motor vehicle manufacturers lack the scale to be competitive in the global market.[15]

Outsourcing also leads to a change in the factor intensity of the auto-parts industry in Austria. In recent years, there has been a shift towards high-skill, intensive production in the Austrian auto-parts industry.[16] This implies that Austria, despite the outsourcing of low-skill production stages to neighboring countries, seems to have maintained its competitiveness. This is largely due to the fact that skilled-labor has been in relatively abundant supply in Austria. Hence, outsourcing has a significant positive impact on the demand for workers with high education while it has a negative impact on the demand for workers with low education.

These global trends that have shaped and are still shaping the Austrian automotive industry over the last two decades also have a major impact on the international pattern of the Austrian automotive industry trade. Austria's total trade (exports & imports) in the auto industry increased significantly from $20.9 billion in 1996 to $ 47.8 billion in 2006, a 228% increase during this period (Figure 1.a). Particularly, trade figures show that Austria shifted from being a net importer of motor vehicle products to being a net exporter in 2002 and it has remained a net exporter of motor vehicle products since.

In contrast, Austria was a large net exporter of auto-parts in 1996 whereas the trade in auto-parts was almost balanced in 2006. The export shares of motor vehicle products in total automotive exports has increased from 35% to 45% whereas the import shares of motor vehicle products dropped from 50% to 37% during the sample period

[15] Currently, there are around 80 international auto-parts manufacturers, such as Delphi Packard Austria, Bosch, Magna International, and Johnson Controls, that coordinate their Eastern European operations from their base in Austria.

[16] The employment effects of outsourcing originated from the accession of the new Member states to EU also present in other Austrian manufacturing sectors. See Bhattacharya (2007).

(see Figures 1.d and 1.e). However, the export share of auto-parts in total exports has fallen steadily from 65% in 1996 to 55% in 2006. In turn, the import share of auto-parts in total imports has grown substantially, from 50% in 1996 to 63% in 2006, as Fig.1.d and 1.e depicts. Moreover, imports of auto-parts have been the most rapidly growing component of the auto-parts trade. Over the period 1996-2006, Austria's auto-parts exports to OECD countries grew by 10% per annum on average while its total imports grew on average by 12% a year. As a consequence, Austria has become a net importer of auto-parts in 2006. This finding is definitely consistent with the frequently asserted opinion on globalization, particularly with respect to outsourcing.

The geographical pattern of Austria's trade in auto-parts has undergone a change mirroring the change in trade between 1996 and 2006. Table 1 presents data on Austria's auto-parts trade by partner country for 29 OECD member countries plus two groups of countries (core and peripheral) during the period analyzed. The geographical composition of Austria's auto-parts trade reveals a few important, empirical facts.

First, as seen in Table 1, almost 90% of Austria's auto-parts trade occurred with the 29 OECD member countries. Among them, Germany remained one of the top trading partners of Austria during the study period. In 2006, exports to Germany accounted for 45% of total Austrian auto exports and imports from Germany accounted for 50% of the total Austrian auto-parts imports. Germany is a very important trading partner of Austria.

However with new member states being added to the EU, it has been losing its position. The share of Germany in Austria's auto-parts exports declined from 57% in 1996 to 45% in 2006. In the meantime, Germany's role in Austria's auto-parts imports declined, from 52% in 1996 to 50% in 2006, as shown in Table 1. This result suggests that Austria appears to have slowly lost its comparative advantage in the auto-parts industry due to the establishments of assembly plants in Eastern and Central Europe by German auto-makers, such as Opel in Poland, Volkswagen in the Czech Republic and the Slovak Republic, and Audi in Hungary.

German automakers who established operations in these countries were followed by German auto-parts suppliers, such as Bosch in the Czech Republic.[17] As a result, suppliers in Central and Eastern Europe have gained a sizable market share in both German auto-parts exports and imports, which was at the expense of suppliers from Austria.

In 2006, Austria's major exporting destinations behind Germany are Spain (5.06%), Italy (4.74%), Poland (4.52%), and the United Kingdom (4.30%) (see Table 1). Interestingly, most of them are outside of the advanced OECD area, which has become an increasingly attractive host for German automakers over the past two decades. For instance, Spain and Poland have important shares in Austria's auto-parts exports mainly because of Volkswagen's engagement in these countries, such as Seat, a subsidiary of the Volkswagen Group in Spain.

However, in the case of imports, the other major suppliers of auto-parts to Austria in 2006 are USA (7%), Italy (6.20%), France (4%), and the Czech Republic (3.41%), as shown in Table 1. The rapid growth of America's exports to Austria is primarily a reflection of increased production at the Magna Steyr facility in Graz, where several vehicles are assembled for various USA automakers, as mentioned above.

Second, the share of the European periphery countries in Austria's auto-parts trade increased substantially at the expense of Western European (core) countries in recent years. As seen in Table 1, the patterns and dynamics of Austria's trade in auto-

[17] For details see Diehl (2001) and Nunnenkamp (2005).

parts differ for core and peripheral countries.[18] Examining core countries first, Table 1 shows the share of the core countries in Austria's auto-parts exports has dropped from 84% in 1996 to 78% in 2006, whereas the share in Austria's auto-parts imports has dropped from 90% to 83% during the same period. In contrast, the share of peripheral countries in Austria's auto-parts exports and imports has increased from around 8% in 1996 to 13% in 2006 and from 5% to 8%, respectively. It seems that for this industry, the entrance of new member states to the EU, which enabled both Austrian and European multinationals to set up production plants there, coupled with geographical proximity, may have had a decisive impact on the pattern of Austria's auto-parts trade over the past decade.[19]

In addition, we also investigate the structure of Austria's auto-parts trade to show the composition and relative importance of individual auto-parts systems or subgroups, which can be computed by disentangling auto-parts trade into six systems or subgroups: bodies and parts, chassis and drivetrain parts, electrical and electric components, engines and parts, tires and tubes, and miscellaneous parts.[20] Moreover, Austria's top 5 export and import partners in 2006 are identified for each one of the subgroups in this context, as shown in Table 3 and 4, respectively.

Overall, Table 2 shows that Austria was always a net exporter of the engines and parts group in the period under consideration. In 1996, this category accounted for over 50% of Austria's total auto-parts exports and 28% of total auto-parts imports in 1996. In 2006, Austria was still a net exporter of the engines and parts category even though the share of engines and parts in Austria's auto-parts exports and imports has dropped

[18] Table A.5 lists core/periphery categorizations of countries used in the analysis.
[19] The increased trade in auto-parts with Central and Eastern Europe is accompanied by substantial expansion of Austria's outward FDI stocks in the region. See, for example, Nunnenkamp (2005) and Bhattacharya (2007).
[20] A detailed description of each subgroup is provided in Table A1.

significantly from 50% in 1996 to 35% in 2006 and from 28% to 25%, respectively. This pattern is not unexpected since engines and parts production are skill-intensive in nature and Austria generally has a comparative advantage in this type of activity, primarily because of the existence of a skilled labor force and the availability of advanced technology in Austria. It should be noted that engines and parts production requires high technology and skilled labor.[21] This may be further explained by the long standing cooperation between Austrian auto-parts suppliers and German automakers. For instance, BMW Motors in Steyr produces around 600,000 gasoline and diesel engines annually, – with two out of every three BMWs sold around the world. Further, Opel Austria Powertrain engine and transmission facility produced around 460,000 three-cylinder and four-cylinder engines in 2007.

However, Table 2 reveals that Austria is gradually specializing in other subgroups at the expense of the engines and parts category, particularly chassis and drivetrain parts, electric and electrical components, and bodies and parts over the last decade. Specifically, Austria somehow remained a net importer of chassis and drivetrain parts during the period 1996-2006, although the share in both exports and imports increased considerably in recent years: its share in total auto-parts exports increased from around 19% in 1996 to 23% in 2006 and the share in imports raised from 28% to 31%. As a result, of the 5 major groups shown in Table 2, chassis and drivetrain parts category ranks number one in terms of import share. The high level of chassis and drivetrain parts imports is not surprising since manufacturing in this category tends to be

[21] Auto parts production needs a wide range of skills to manufacture. Some auto-parts involve a production process which is labor-intensive and that are not required on a just-in-time basis. These include parts such as seat belts (bodies and parts), tires (tires and tubes) and the final assembly of automotive electrical and electronics components-particularly electrical wiring- (electrical and electric components). In contrast, some parts, which are relatively hard to ship or required on a just-in-time basis, need high technology and skilled workmanship to manufacture. Such parts include parts for diesel and semi diesel engines (engines and parts), brake (chassis and drivetrain parts), and rear-view mirrors for vehicles (bodies and parts).

somewhat more labor-intensive in recent years, which causes Austrian auto-parts producers to specialize in more capital and skill-intensive production processes, while leaving the most labor-intensive activities to be done in neighboring countries.[22]

Likewise, the import market penetration for electrical and electric components, relatively labor-intensive and easy to ship, is quite high during the period of 1996-2006, but it has shown modest decline in recent years. Looking at table 2, we can see that Austria was always a net importer of electrical and electric components during the study period although exports have increased significantly in recent years: its share in Austria's exports rose from roughly 11% in 1996 to 18% in 2006, with its share in Austria's imports rising from 16% to 20%. Given Austria's competitive strengths in capital-intensive and skill-intensive parts, particularly those that are relatively labor-intensive and easy to ship, or those that are not required on a just-in-time basis, this is not surprising.

On the other hand, Table 2 shows that exports of the bodies and parts category have grown significantly faster than imports during the 1990s. The share of bodies and parts category increased from 12% in 1996 to 16% in 2006 while the share in imports dropped from 16% to 14%. Consequently, outside the engines and parts category, Austria has moved from the status of a net importer to that of a net exporter of the bodies and parts groups in 2006. Though some parts within the bodies and parts category are relatively labor-intensive and easy to ship, such as seat belts and seat covers, the trade pattern of the bodies and parts category is still consistent with the factor endowment of Austria due to the fact that some components, including the rear-view mirror and bodies

[22] Engineering advances caused transformation of chassis modules from high-cost production items requiring skilled labor to low-cost parts sensitive to labor cost savings. In addition, some of chassis and drivetrain components are large metal structures that have traditionally been built close to final assembly plants. See Klier and Rubenstein (2006).

for passenger carrying vehicles, are hard to ship and require capital and skilled workmanship to manufacture.

By contrast, Austria was always a net importer of the tires and tubes group during the period 1996-2006 (see Table 2). The share of tires and tubes in Austria's auto-parts exports went up from almost 0% in 1996 to 1% in 2006 whereas the corresponding import share decreased from 6% to below 5%, virtually the same percentages as a decade earlier. The insignificance of the tires and tubes group in Austria's auto-parts trade may suggest that vertical type fragmentation is less likely to be observed in tires and tubes because of the fact that it is quite costly to transport the processed tires and tubes across borders due to the bulkiness of these goods. In addition, this finding is not surprising because the construction of tires, particularly at the assembling stage of tire components, has always been seen as labor intensive and sensitive to labor costs, though robotics has begun to displace traditional tire building techniques on a large scale in recent years.

It was mentioned earlier that the top 5 exporting and importing markets' sources are also tabulated to analyze the regional structure of Austria's auto-parts trade for each subgroup. The regional structure of Austria's auto-parts trade reveals three significant facts.

First, Germany has occupied the first position among the top 5 export and import partners in all subgroups, as illustrated in Table 3 and 4. As mentioned earlier, it is clear that Austrian auto-parts producers are closely tied to German auto-makers. Aside from Germany, the USA has become the second most important trade partner of Austria for some auto-parts groups in recent years, particularly as a sourcing country for bodies and parts and chassis and drivetrain parts and as an export destination country for engines and parts and tires and tubes. The USA plays such an important role in Austria's auto-parts trade because of the assembly operations carried out by Austrian suppliers, mostly Magna Steyr facilities in Graz.

Second, Central and Eastern countries, such as the Slovak Republic, Poland, Hungary, and the Czech Republic have become major exporting destinations for Austria in recent years. In addition, the level of auto-parts imports from these countries has increased dramatically since the 1990s. The increase has been even faster than the rate from core European countries, clearly reflecting the increasing interdependence of outsourcing activities in the automotive industry between Austria and Eastern and Central European countries.

Third, Asia's contribution to Austria's auto-parts market was very small. As depicted in Table 3 and 4, no Asian country ranks among the top 5 export destinations of Austria. However, in the case of imports, Korea has occupied the fourth position among the sourcing countries in the electrical and electrical parts group and Japan has occupied the fifth position in the tires and tubes group. It seems that distance limits Asia's role as a supplier for some product groups, where timeliness of delivery is a key issue.

3 Measurement of Intra-Industry Trade in Austria's Auto-Industry

This section presents a brief survey of empirical methodologies on the measurement of fragmentation and outlines the methodology for the measurement of IIT.

3.1 Fragmentation

Fragmentation can be defined as division of production process into different locations across different countries. A number of studies attempt to measure the degree of fragmentation. These studies can be divided into four groups based on their methods as well as the data sources employed.[23]

The first group measures the degree of fragmentation by employing input-output (I-O) data tables, which provide information on the interrelationship among industries, including the use of imported intermediate goods and the export of each industry's output (see Feenstra and Hanson 1996 and 1997; Campa and Goldberg 1997; Hummels et al., 1998). It is difficult to capture the degree of fragmentation with the available I-O tables as these tables do not include information on whether the goods produced with the imported intermediate goods are exported to third countries.

The second group of studies such as Görg (2000), Graziani (2001), and Egger and Egger (2005) measure fragmentation by using outward processing trade (OPT) and inward processing trade (IPT) statistics.[24] Although this method definitely provides some insights about the level of fragmentation, it has one major shortcoming: that it covers only a few products. Thus, this method will underestimate the degree of fragmentation.

Another method used in the literature to measure the degree of fragmentation is intra-firm trade statistics (see Andersson and Fredriksson, 2000; Borga and Zeile, 2004; Chen et al., 2005; and Kimura and Ando, 2005). Fragmentation can lead to intra-firm trade between different production locations within the same organization of vertically organized Multinational Enterprises (MNEs) from advanced countries, which often establish an affiliate in a developing country to produce labor-intensive intermediate

[23] For a more detailed discussion on the empirical analysis of fragmentation see Egger et al. (2001).

[24] IPT is the duty relief procedure allowing goods to be imported into the country for processing and subsequent export outside the country without payment of duty while OPT involves intermediate goods exports for further processing in a foreign country which the goods are shipped back to home country under tariff exemption.

goods, which are then exported back to its home base for assembly.[25] Despite the fact that intra-firm trade statistics clearly establish the link between fragmentation and MNEs proving it better than the other two methods, it has two major shortcomings that make the employment of this method rare in the empirical literature. First, it is difficult to distinguish between horizontally integrated and vertical integrated MNEs with the available data. Second, detailed information on the intra-firm trade is available only for few countries such as the U.S. and Japan, which limits analysts to make international comparisons on the degree of fragmentation across different countries and industries.

Lastly, some analysts suggest using international trade statistics to estimate the degree of fragmentation by simply calculating the volume of trade in parts and components (see Yeats 2001; Kaminski and Ng 2005; Kimura et al. 2007) or the intra-industry trade index (Kol and Rayment 1989; Schüler 1995; Ando 2006) in intermediate goods. Yeats (2001) evaluates the magnitude and growing importance of global production sharing in international trade by looking at the items classified as components and parts within the machinery and transport equipment group of the Standard International Trade Classification System (SITC 7). The major disadvantage of this approach is that many parts related to the above groups come under different headings.[26] Hence, this method clearly fails to capture the degree of fragmentation for a particular industry.

As suggested by Jones et al. (2002), international fragmentation also generates IIT in intermediate goods between countries. Analysts suggest dividing IIT into

[25] For instance, Chen et al. (2005) found that a significant portion of the U.S. exports of manufactured goods carried out by the U.S. multinationals is sent to foreign manufacturing affiliates of the U.S. multinationals have mainly consisted of materials and components for further processing or assembly: the share of the U.S. exports to foreign affiliates for further manufacturing had increased from 15.6 % in 1977 to 22 % in 1999.

[26] For instance, transport equipment group of 78 does not include parts such as automotive tires, electronics, instruments, glass parts, or rubber parts, which are recorded under different headings.

horizontal and vertical components by comparing unit values of exports and imports of intermediates. Intermediate goods whose unit values do not fall within a certain range are considered vertical IIT, which may capture trade in intermediate goods with different quality. Vertical IIT can also reflect the trade as a result of back-and forth transactions in vertically fragmented production networks in the same commodity heading. Hence, vertical IIT could be used as an indicator of international fragmentation within the same product category. This empirical approach is clearly supported by the recent findings by Jones et al. (2002), Ando (2006), and Kimura et al. (2007) that the rapid increase in vertical IIT mainly originated from the vertical linkages in production rather than trade in quality differentiated goods.[27]

Overall, the brief review of fragmentation literature suggests that vertical IIT in intermediate goods seems to be an appropriate indicator to address the extent of fragmentation in a particular industry.[28] It should be kept in mind that vertical IIT in intermediate goods used as a proxy for the extent of fragmentation also captures certain portion of trade not related to a vertically fragmented production network. Unit values may differ across traded intermediate goods because of categorical aggregation, horizontal differentiation, and vertical specialization. The effects of aggregation on unit values will be limited in our empirical analysis since the commodity statistics at the six-digit level are employed in this study. Besides, quality differences in intermediate goods are not expected to be as large as in the case of final goods trade, and thereby their effects on imported and exported unit values could be negligible.

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[27] Horizontal IIT through fragmentation would also be present if imported parts and components are exported with small unit price differentials embodied in the local market. However, this kind of trade does not seem to be important in Austria's auto-parts trade.

[28] Despite the superiority of intra-firm trade statistics over the other methods, this study employs the intra-industry trade statistics to measure the extent of international fragmentation in Austria's auto-parts industry mainly due to data constraints.

Turning to the effects of vertical specialization, we expect that vertical specialization generates unit value differences across technologically related export and import intermediates. Thus, the unit value differences can be used as an indicator to determine whether IIT in particular intermediates is IIT in technologically linked intermediates. Hence, it can be concluded that vertical IIT is a good indicator of fragmentation in the Austrian auto-parts industry.

3.2. Methodology of Measuring IIT

IIT is defined as the simultaneous export and import of products, which belong to the same statistical product category. According to Fontagne and Freudenberg (1997), three types of bilateral trade flows occur between countries: inter-industry trade (i.e. one-way trade), vertical IIT and horizontal IIT. This section presents empirical methodology for measuring IIT and its components.

The most widely used method, known as the G-L index for computing the IIT, was developed by Grubel and Lloyd (1971).[29] In recent years, an alternative method has been suggested by Fontagne and Freudenberg (1997), Fontagne et al. (1997), and Fontagne et al. (2006). They seek to disentangle bilateral trade flows into one-way trade (OWT), two-way trade in vertically differentiated goods (TWTV), and two-way trade in horizontally differentiated goods (TWTH).[30] As Fontagne and Freudenberg (1997) point out, the G-L index gives us the problem of having two different explanations for the same majority trade flow (such as exports): the inter-industry part of the majority flow by traditional trade theory and intra-industry part of the majority flow by the new trade

[29] The traditional G-L index is negatively correlated with large overall trade imbalance. With national trade balances, the level of IIT in a country will be clearly underestimated. To avoid this problem, Grubel and Lloyd (1975) proposed another method to adjust the index by using the relative size of exports and imports of particular good within an industry as weights.

[30] Empirical studies using the Fontagne and Freudenberg´s (1997) method are Montout et al. (2002), Ito and Umemoto (2004), Umemoto (2005), and Ando (2006).

theories. To avoid this problem, Fontagne and Freudenberg (1997) proposed new criteria: that trade in a product is considered to be two-way trade when the value of the minority flow represents at least 10% of the majority flow. Otherwise, both exports and imports are regarded as inter-industry trade.[31]

Given the criticisms of Fontagne and Freudenberg (1997) over the measurement of intra-industry trade, we apply both the G-L and the Fontagne and Freudenberg's methods to the Austrian auto-parts industry trade in order to examine bilateral trade flows in its component parts of inter-industry trade, horizontal IIT and vertical IIT.[32] These two methods used to measure intra-industry trade are briefly described in the following subsections.

3.2.1 The Grubel-Lloyd Type Trade Decomposition

As indicated above over the problems of the unadjusted G-L index, this paper computes the extent of intra-industry trade between Austria and its trading partner by employing the adjusted G-L index, defined as:

$$IIT_{jkt} = \frac{\sum_{i=1}^{n}(X_{ijkt} + M_{ijkt}) - \sum_{i=1}^{n}|X_{ijkt} - M_{ijkt}|}{\sum_{i=1}^{n}(X_{ijkt} + M_{ijkt})} \tag{1}$$

where X_{ijkt} and M_{ijkt} are Austria's exports and imports of product i of industry j with country k at time t. Hence, IIT_{jkt} computes the export and import flows with country k in industry j, adjusted or weighted according to the relative share of the trade flows in

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[31] Fontagne et al. (2006) compare between the G-L index and the two-way trade index using regression analysis in a quadratic form for all country pairs in the world in 2000 and find the fit between two indices are good but the two-way index is considerably larger than G-L index. As pointed by Fontagne and Freudenberg (1997), a degree of caution must be used when comparing and interpreting the G-L index and the two-way trade index because these two methods are complementary rather than substitutes. The former method deals with the intensity of overlap while the later method calculates the relative importance of each type of trade in total trade.

[32] This method is called as "the decomposition-type threshold method" by Ando (2006).

the i products included in j. The G-L index is equal to one if all trade is IIT and is equal to zero if all trade is inter-industry trade.

The first step to compute the G-L index is to select auto-parts (intermediate products) in the bilateral trade data. Bilateral trade flows used in this paper are classified at the 6-digit level of Harmonized Tariff Schedule (HTS), which are used to construct the G-L index for each trading partner. In the end, 92 items are considered as auto-parts from the 6-digit level of HTS.[33]

Once the auto-parts products are selected for our study, we break total IIT into its two components of horizontal IIT and vertical IIT by using the method suggested by Abd-el-Rahman (1991), Greenaway et al. (1995).

Assuming that differences in prices reflect quality and unit value indexes are regarded as a proxy for prices, IIT is considered as horizontal if the export and import values differ by less than 25%, i.e. if they fulfill following condition;[34]

$$\frac{1}{1.25} \leq \frac{P^X_{ijkt}}{P^M_{ijkt}} \leq 1.25 \qquad (2)$$

where P^X_{ijkt} and P^M_{ijkt} represent the unit value of Austria's exports and imports, respectively while indices i referring the product, j the industry, k the partner country in year t.

Intra-industry trade is considered to be vertical when the ratio of unit values falls

[33] In order to select the motor vehicle products and auto parts from the trade data, we employ the list provided by the Office of Aerospace and Automotive Industries' Automotive Team, part of the U.S. Department of Commerce's International Trade Administration. That team's definition of motor vehicle products and auto parts can be found at http//www.ita.doc.gov/td/auto.html.

[34] The choice of 25 % is arbitrary. In trade literature, two common values are often employed, 15 % and 25 %. Greenaway et al. (1995), Fontagne and Freudenberg (1997)'s empirical analysis suggest that the results are not very sensitive to the range chosen. The 15 % threshold is generally used and considered to be appropriate when the unit value differences reflect only differences in quality. However, in case of production fragmentation the 15 % threshold could be too wide and 25 % threshold is considered to be more appropriate. Taking these considerations into account, this paper uses a rather narrower measure of vertical IIT in intermediates to more accurately measure the degree of international fragmentation.

outside this range:

$$1.25 \leq \frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \tag{3}$$

or

$$\frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \leq \frac{1}{1.25} \tag{4}$$

After goods satisfy equation (2) are determined, the amount of horizontal IIT, $HIIT_{ijkt}$, is calculated using equation (1). Similarly, when we determine a trade flow as being trade in vertically differentiated goods by using equations 3 and 4, the G-L index for those goods, $VIIT_{ijkt}$, is measured using equation (1). Note that there might be some products with IIT which cannot be classified either HIIT or VIIT due to missing unit value data. We labeled those as non-classified IIT. Following discussion made by Ando (2006), Fontagne et al. (2006), the products with no unit value should be included into calculation of the G-L index. Otherwise, the actual share of intra-industry trade may have been underestimated for countries where the unit values of a large number of products were not available. Thus, IIT in auto parts can divided into three components in this method; HIIT, VIIT, and non-classified IIT.

3.2.2 The Decomposition-Type Threshold Method

For the sake of comparison, an alternative method developed by Fontagne and Freudenberg (1997) and Fontagne et al. (1997) is also employed to break down total trade into three types: one-way trade (OWT), two-way trade in horizontally differentiated goods (TWTH), and two-way trade in vertically differentiated goods (TWTV). In this method, there are three steps to compute the share of each type of trade. In order to differentiate between OWT and two-way trade (TWT), the first step of our analysis is to determine the degree of trade overlap. Trade in a product is considered to be TWT when the value of minority flow of trade represents at least 10% of the majority flow of trade and as OWT otherwise:[35]

$$\frac{Min(X_{ijkt}, M_{ijkt})}{Max(X_{ijkt}, M_{ijkt})} \geq 0.1 \tag{5}$$

where X_{ijkt} and M_{ijkt} are Austria's exports and imports of product i of industry j with country k at period t.[36]

After determining trade flows as being TWT, the second step is to distinguish trade in horizontally differentiated goods from trade in vertically differentiated goods by following the method from Abd-el-Rahman (1991) and Greenaway (1995) as briefly outlined in the previous section. Therefore, TWT is classified as TWTH if the export and import unit values differ by less than 25%, i.e. if equation (2) holds and as TWTV otherwise.

Finally, the share of each type of trade is defined as follows:

$$S_{jkt}^{Z} = \frac{\sum_{i=1}^{N}\left(X_{ikt}^{Z} + M_{ikt}^{Z}\right)}{\sum_{i=1}^{N}\left(X_{ikt} + M_{ikt}\right)} \tag{6}$$

where S_{jkt}^{Z} stands for either one-way trade (OWT_{jkt}), horizontal two-way trade ($TWTH_{jkt}$), or vertical two-way trade ($TWTV_{jkt}$), while indices Z referring to one of three trade categories depending on the corresponding trade type, i referring to the product, j the industry, k the partner country in year t.

[35] Unfortunately, the G-L method still considers the minority flow below this 10 % threshold as two-way trade when the calculated G-L index is greater than zero.

[36] Most previous studies such as Umemoto (2005) used 10 % as a benchmark, though some studies use different benchmark values such as Montout et al. (2002). In our study, the 10 % benchmark is employed.

Using equation (6), the shares of the three trade types (OWT, TWTH, and TWTV) are calculated for trade in auto-parts. Note that some products have no information on quantities. Thus, it is not possible to determine whether two-way trade of such products is vertical or horizontal. These products in our data set are classified as "non-classified two-way trade". Consequently, TWT in and auto parts can be divided into three components in this method; TWTH, TWTV, and non-classified TWT.

3.3 Evidence of IIT in Austria Auto-Industry

Using the two approaches outlined in the previous section, we compute measures of IIT in the auto-industry as a whole as well as separately for the motor vehicle products, and auto-parts between Austria and OECD, for the period 1996 to 2006. At the more aggregated level, summary results are presented in Figure 2 for horizontal intra-industry trade (HIIT), vertical intra-industry trade (VIIT) and total intra-industry trade (IIT) along with measures for inter-industry trade, using the first approach; and in Figure 3 for horizontal two-way trade (TWTH), vertical two-way trade (TWTV), total two-way trade (TWT), and one-way trade, using the second approach.

Three points are worth noting. First, the auto-industry as a whole as well as the component parts of motor vehicle products and auto-parts shows a substantial level of inter-industry trade.[37] However, the overall Grubel-Lloyd measure of intra-industry trade (IIT) in the auto-industry, motor vehicle products, and the auto-parts industry has

[37] Similarly, Ando (2006) provided empirical evidence that auto-industry trade in East Asia is mainly one-way trade thanks to import substituting policies in these developing countries, although vertical IIT became important for auto-parts in recent years. On the other hand, Montout et al. (2002) demonstrated the importance of IIT in NAFTA's auto parts trade, which represents approximately 70 % of total trade in the 1990s. Similarly, Jones et al. (2002) also found that the degree of IIT between the USA and Mexico in auto-parts rose substantially, from 67 % in 1992 to 85 % in 1999. However, Lall et al. (2004) argue that in auto-industry fragmentation is more constrained than other sectors, such as electronic sector. While auto-industry has separable stages of production and parts with different scale, skill and technological needs whose production can be located in different countries, many components, such as body and chassis parts, are heavy thus making their processing suitable for relocation in closer areas rather than in distant areas, which in turn reduces the degree of intra-industry trade.

increased in recent years, respectively, from around 21% in 1996 to 24% in 2006, 19% to 20%, and 23% to 25%.

Second, the relative significance of vertical IIT on total IIT of the auto-industry product groups and auto-parts has increased marginally from 14% in 1996 to 15% in 2006, 17% to 19%, respectively, while the corresponding share in motor vehicle products has dropped from 12% to 10%. In other words, vertical IIT in auto-parts dominates trade flows in auto-parts during the period considered.

A high degree of vertical IIT in the auto-parts industry is suggestive of the substantial contribution of the fragmentation in trade between Austria and OECD countries. The increasing importance of the horizontal IIT, particularly in motor vehicle products, is closely linked with the ongoing structural change in the Austrian auto-industry where there has been a shift from the production of auto-parts to motor vehicle production. As mentioned earlier, IIT in finished goods (motor vehicle products) tend to reflect more exchange in horizontally differentiated goods based on varieties. The outcome is not surprising since trade in motor vehicle products accounts for a significant portion of the total auto-industry trade in recent years.

Finally, as is evident in Figure 2, the degree of intra-industry trade in auto-parts is much larger than in motor vehicle products. In addition, horizontal IIT is lower in the auto-parts trade compared with the motor vehicle trade. However, the Austrian auto-industry exhibits a high level of vertical IIT in some aspects while it has a relatively low level of vertical IIT in motor vehicle products. Both the recent developments in the auto-parts industry and the importance of vertical IIT in auto-parts suggest that the Austrian auto-parts suppliers are locating their production stages to take advantage of differences in labor costs across countries.

Furthermore, in almost all product groups (auto-industry products, motor vehicle products, and auto-parts), traditional G-L indices and two-way trade shares obtained from the decomposition method display a reasonably similar pattern. However, quantitatively the results of the decomposition type of threshold method measure for two-way trade are systematically higher than the G-L index results, consistent with the findings of Fontaigne et al. (2006).

The nature and dynamics of the Austrian intra-industry trade in auto-parts is further studied by breaking down the traditional G-L indices and two-way trade shares obtained from the decomposition method for each trading partner for the period 1996 to 2006.

Overall, two important findings emerge from the calculations of Austria's IIT indices for auto-industry. Our first finding is that there are wide variations of intra-industry trade indices and two-way trade shares across partner countries (see Table 5 and 6). As we can see in Table 5, in 2006 it was found that Germany had the highest values of IIT in auto-parts, 58%, followed by France, Italy, Sweden, and Hungary.[38] On the other hand, Table 5 reveals that the highest measure of horizontal IIT is seen in Germany (28% in 2006).

The United Kingdom, the Czech Republic, Ireland, and France are other important partner countries with a high degree of horizontal IIT. However, when looking at the vertical IIT in 2006, we see that Sweden has the highest degree of vertical IIT in auto-parts (36%), but there are other partner countries with rather high degrees of vertical IIT, such as France, Hungary, Germany, and Japan. From the measures in Table 5 and 6 we conclude that intra-industry trade indices are higher for developed countries,

[38] Likewise, Fontagne et al. (2005) showed that Germany and Austria are the two trading partners in the world having one of the highest shares of IIT in their manufacturing products trade: 77 % in 2000.

such as Germany, France, Italy, Sweden, and the United Kingdom, and also for Austria's neighbor countries such as Hungary, the Slovak Republic, and the Czech Republic.

The second important finding is that the degree of vertical IIT remained stable for periphery countries while it declined rapidly over the same period for core countries.[39] Our results presented in Table 5 indicate that the degree of vertical IIT, on average, declined marginally from 21% in 1996 to almost 20% in 2006 for periphery countries. As we mentioned previously, the importance of vertical IIT between Austria and periphery countries was largely due to high and increasing flows of German FDI into these countries over the period, which is directly related to the internationalization of production.

At the same time, core countries, on average, have experienced a sharp decline in the degree of vertical IIT during this period, from 15% to 13% (see Table 5).[40] These figures clearly show that the important pattern of intra-industry trade in Austria's auto-parts is still vertical IIT, not horizontal IIT, although the degree of horizontal IIT in auto-parts, on average, has doubled during the same period, from around 4% to 8%.

The importance of vertical IIT, particularly with periphery countries, confirms that Austria's trade in auto-parts mainly involves the exchange of technologically linked intermediates rather than involving the exchange of different varieties of the same intermediates.[41] Hence, the numbers obtained here clearly prove that low wages in periphery countries have a decisive impact on the pattern of Austria's trade in auto-parts,

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[39] Similarly, Umemoto (2005) illustrated that higher-income countries, such as the EU countries, experienced a sharp decline in the vertical IIT in auto parts whereas low-income countries, such as East Asian countries, experienced a sharp increase in vertical IIT during the late 1990s.

[40] For a similar results see Fidrmuc (2000), who showed that the level of IIT in EU trade with Austria dropped from 69 % in 1990 to 66 % in 1996.

[41] Gabrisch and Segnana (2003) also found that the shares of vertical IIT between Austria and candidate countries in 1993 and 2000 were 22 % and 42 %, respectively. The sharp increase in vertical IIT clearly indicate how rapidly vertical IIT became an essential element of trade between Austria and neighboring periphery countries.

in line with the predictions of the Heckscher-Ohlin theory that vertical IIT tends to be high among countries that are different in terms of their factor endowments.

Finally, Table 7 and 8 presents the results of the traditional G-L indices and two-way trade shares obtained from the decomposition method for each auto-parts group over the same period. We note several significant facts.

Using auto-parts groups' classification, first of all, Table 7 shows that the degree of G-L indices varies greatly across auto-parts groups. Of these auto-parts groups, chassis and drivetrain parts recorded the highest IIT index (68% in 2006), followed by electrical and electric components (65%) and bodies and parts (58%). With respect to vertical IIT, the engines and parts group has the highest vertical IIT index (46% in 2006).[42] The other auto-parts groups that recorded relatively high vertical IIT indices in 2006 include chassis and drivetrain parts (44%) and bodies and parts (30%). On the other hand, the highest measure of horizontal IIT is electrical and electric components (51% in 2006). The second largest product group, bodies and parts, also recorded a relatively high horizontal IIT index of 28% in 2006.

Second, as is shown in Table 7, of the six product groups (excluding chassis and drivetrain parts) we saw an increasing IIT index during this period: the total IIT index went up from 57% in 1996 to 58% in 2006 for the bodies and parts group, from 50% to 65% for electrical and electric components, from 50% to 53%, and from nothing to 24%.

In contrast, the relative importance of vertical IIT declined sharply in most of the groups, excluding engines and parts, in favor of horizontal IIT since 1996. For instance, electrical and electric components experienced the greatest drop of vertical IIT during this period: its index decreased from 39% in 1996 to 5% in 2006. The sharp increase in horizontal IIT suggests that the quality and price of Austria's auto-parts were

[42] Lall et al (2004) also find the evidence of rapid fragmentation of engine production in developing world.

approaching those of its trading partners. Nevertheless, auto-parts trade between Austria and OECD countries in 2006 demonstrated that vertical IIT still dominates horizontal IIT across all auto-parts groups, excluding the electrical and electric components group. These results support the claim that that intra-industry trade of Austria in auto-parts is mainly induced by international fragmentation of vertical production chains, in addition to intra-industry trade of auto-parts with different qualities.

4 Empirical Model, the Determinants of Vertical IIT and Estimation

4.1 Empirical Model

The following logit transformation model is proposed to explain the determinants of vertical IIT in the bilateral auto-parts trade between Austria and its 29 trading partners over the 1996-2006 period:

$$\ln\left(\frac{y_{kt}}{1-y_{kt}}\right) = \alpha_k + \mu_t + \beta_m Z_{kt} + \beta_d DIST_k + \beta_E EU15_k + \varepsilon_{kt} \qquad (7)$$

where y_{kt} stands for either $VIIT_{kt}$ or $TWTV_{kt}$ between Austria and its trading partner country (k), Z_{kt} is a set of m country-specific variables, $DIST_k$ represents the geographic distance and $EU15_{kt}$ indicates whether the trading partner are members of the European Union (EU), α_k is the country effect, $k = 1.....,K$, μ_t is the time effect, $t = 1.....,T$, and finally ε_{kt} is the white noise disturbance term distributed randomly and independently.

In the present study, two different concepts of the vertical IIT index between Austria and its trading partners (k) are used for purpose of comparison: the vertical intra-industry trade index ($VIIT_{kt}$) based on the Grubel-Lloyd type trade decomposition method and the share of two-way trade in vertically differentiated goods ($TWTV_{kt}$) based on the decomposition-type threshold method.

Because the dependent variables range between zero and one, the logit transformation of the dependent variables are employed as the dependent variable in the regressions. In analyzing the determinants of the IIT, many earlier studies apply either a linear function or log-linear function by ordinary least squares to the IIT index. However, estimation of a linear or log-linear function may predict values of the IIT that lie outside the theoretically feasible range. Thus, a number of studies such as Caves (1981) have used a logit transformation of the IIT index to overcome this problem. Logit transformation to the dependent variables is applied to analyze the determinants of vertical IIT in auto-parts industry.

4.2 The Determinants of Vertical IIT

In terms of the explanatory variables, several country-specific variables suggested by the fragmentation literature are considered to investigate the determinants of vertical IIT in auto-parts industry.[43]

Economic size (GDP): Jones and Kierzkowski (2004) claim that intra-industry trade in intermediate goods tends to increase as the bilateral market size of the two countries increase due to economies of scale in service link activities. In addition, larger markets also support more varieties and qualities to be traded (Lancaster, 1980). Thus, the larger the international market the larger the opportunities for production of differentiated intermediate goods and the larger the opportunities for trade in intermediate goods. As a result, vertical IIT in the auto-parts industry is expected to be positively related to the average market size of Austria and its trading partners, denoted as GDP_{kt}.

[43] The definitions and sources of explanatory variables are explained in Appendix and Table A.1.

Differences in market size ($DGDP_{kt}$): Grossman and Helpman (2005) show that a trading partner's market size encourages greater degrees of fragmentation between two countries. Firms are likely to find a trading partner in large host markets with the appropriate skills that match their needs. This suggests a negative relationship between the bilateral trade in intermediate goods and differences in market sizes. On the contrary, there are reasons to believe that large markets are the *most* likely to be served by local production due to the fact that the availability of local input producers in the host country should reduce the dependence on the imports of intermediate goods from the home country.[44] Consequently, the difference in market size ($DGDP_{kt}$), measured by the absolute difference of total GDP between Austria and its trading partners, could have uncertain effect on the vertical IIT.

Differences in per capita GDP ($DPGDP_{kt}$): Our empirical model also includes differences in per capita GDP as a measure of differences in factor endowments between Austria and its trading partners. Helpman (1984) shows that vertical type of trade increases with differences in relative factor endowments. Assuming that fragmentation typically occurs with vertical type of FDI, IIT in intermediate goods would be expected to be high when there are large differences in relative factor endowments across trading countries.

Likewise, Feenstra and Hanson's (1997) model of outsourcing predicts that fragmentation is more likely to take place between countries with dissimilar factor endowments. Previous studies such as Egger and Egger (2005) and Kimura et al. (2007) have used per capita income differences to measure the effect of the differences in factor endowments on fragmentation. Following the same logic, in the current study

[44] See Andersson and Fredriksson (2000) for a more detailed discussion on the relationship between host country's market size and intra-firm imports of imported intermediate goods.

differences in factor endowments is proxied by the absolute value of the difference in per capita GDP between Austria and its trading partners ($DPGDP_{kt}$), which is expected to be positively related to the share of vertical IIT. On the other hand, the differences in per capita GDP may also capture the differences in infrastructure endowment and worker skills between countries, which would be reflected in lower shares of vertical IIT. Therefore, the relationship between vertical IIT and the differences in per capita GDP could be either positive or negative depending on which effect dominates.

Foreign direct investment (FDI): FDI also influences the share of vertical IIT. Firms, through their FDI activities, have established extensive production and distribution networks to take advantage of differences among countries over the last two decades.[45] Recent evidence suggests that the establishment of such networks ultimately led to surge in intermediate goods trade. Vertical models by Helpman (1984) and Helpman and Krugman (1985) predict a complementary relationship between FDI and trade, given the fact that affiliates in the host country perform final assembly or processing stages using imported intermediate goods from the parent firms. Likewise, Feenstra and Hanson's (1997) model predicts that the growth of the capital stock in the host country encourages the flow of intermediate goods between two countries for further processing. Thus there is a positive relationship between vertical IIT and FDI. Austria's stocks of outward FDI into sample countries, FDI_{kt}, is used to test this hypothesis.

Geographical distance ($DIST_k$): The relevance of service-link costs for vertical IIT is also investigated. According to Jones and Kierzkowski (2000), reductions in

[45] Hummels (2007) shows that the decline in transportation costs, especially air shipping costs, and in costs of rapid delivery, and the use of air transportation as a means of transportation over ocean shipping, led to a significant rise in international trade, particularly in intermediate goods.

service-link costs should encourage the international fragmentation of production across countries. [46] However, measures of service-link costs are not widely available. Service-link costs consist of transport costs, telecommunication costs, coordination costs, and others. Among various components of service-link costs, transportation costs between production sites are the most visible portion of the service link costs and transportation costs, which are typically assumed to be a linear function of geographical distance. For instance, Kimura et al. (2007) claim that the geographical distance between countries can be viewed as indicative of service-link costs, particularly the transportation and telecommunication costs. Hence, geographical distance between the capital cities of Austria and its trading partners, $DIST_k$, is used as a proxy for service-link costs. Distance is interpreted as a direct measure of the service-link costs involved in connecting the different production plants located in different countries. The vertical IIT is expected to be negatively associated with distance ($DIST_k$) between Austria and its trading partner.[47]

The remaining variables that influence vertical IIT are the bilateral exchange rate and dummy variable for the countries belonging to the European Union (EU).

The bilateral exchange rate ($EXCH_{kt}$): The bilateral exchange rate ($EXCH_{kt}$) is included into our model to control the effects of exchange rate changes on trade patterns. We have no a priori expectation as to the direction of the impacts of the exchange rate changes on vertical IIT. However, a possible negative relationship in the empirical results implies that a depreciation of the domestic currency will increase the share of vertical IIT between Austria and its trading partners.

[46] In the same way, Krugman and Venables (1995), and Venables (1996) found that the volume of trade in intermediate goods is greater the lower the transportation costs between countries.

[47] The magnitude of this effect on vertical IIT could be different across different product groups: final and intermediate goods. Considering trade in intermediate goods, small changes in transportation costs have a major effect on fragmentation decisions because of multiple boarder-crossing involved in the value added chain. In contrast, distance is less likely to affect less the final goods trade in which goods pass the border only once.

EU dummy ($EU15_k$): It is generally accepted that economic integration will increase the share of vertical IIT due to specialization, division of labor, product differentiation, economies of scale, and reduction of trade barriers between member countries. In our case, we have used the dummy variable for the countries belonging to the European Union before the 2004 enlargement ($EU15_k$), which takes value 1 if both Austria and its trading partner are members of European Union and zero otherwise.[48] Regional integration is expected to have positive influence on the share of vertical IIT.

4.3 Estimation

In estimating the determinants of vertical IIT in the auto parts industry between Austria and its 29 trading partners, a number of estimation techniques are applied to equation (7) in order to ensure the robustness of the results. The results for two different concepts of vertical IIT index ($VIIT_{kt}$ and $TWTV_{kt}$) using these estimators are reported in Table 9 and 10.

First, equation (7) is estimated with the pooled Ordinary Least Squares (OLS), with a White heteroscedasticity correction. However, recently it has been shown that pooled OLS leads to biased results because it ignores unobserved cross-country heterogeneity. For example, there are good reasons to believe that unobserved individual factors such as legal, cultural, and institutional factors are difficult to observe and most likely affect bilateral trade flows between any pair of countries.

Using a panel data approach allows us to account for such effects. The most commonly employed panel models, which control for the existence of such effects, are the fixed effects model (FE) and random effects model (RE). The FE model is particularly appropriate in the presence of cross-country heterogeneity because it allows

[48] The EU-15 consists of Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

for unobserved factors that explain the bilateral trade flows between two countries and lead to unbiased and efficient results.

However, a shortcoming of the FE is that it is not able to compute coefficients for time-invariant variables such as distance or regional integration dummy variables because those variables are dropped within the transformation. In order to tackle this problem, most researchers advocate for the implementation of the RE model since it allows parameter estimation of time-invariant regressors within the panel data framework. However, as noted by Egger and Pfaffermayr (2004), the RE estimates are inconsistent when regressors are correlated with the error term.

In order to overcome the bias of the RE model, theoretical econometric and empirical studies recommend the use of the Hausman-Taylor procedure for panel data with time-invariant variables and correlated unit effects (such as Hausman and Taylor, 1981 and Egger and Pfaffermayr, 2004). Hausman and Taylor (1981) suggest an instrumental variable approach to estimate the coefficients of time-invariant variables by generalized least squares (GLS) to deal with the endogenity of some of regressors.[49]

In order to obtain efficient and consistent estimates for all parameters in (7), the Hausman-Taylor approach consists of four steps. In brief, the first step of the HT approach is to obtain an estimator of β which may not be efficient. Note that this procedure, however, eliminates the time-variant variables from the model. The second step is to form the within group residuals from the within regression at the first step and then regress them on the time-variant variables using a set of time-varying exogenous variables and time-variant exogenous variables as instruments. This provides a consistent estimator of time-invariant variables.

[49] For a detailed explanation of the estimation strategy, see Greene (2003).

In the third step, using residuals from both overall and within estimates, the components of variance of the dependent variable is estimated. The estimated variance components are then used to form the weight for feasible generalized least square (GLS) by forming the estimate of θ. In the final step, the estimate of θ is used to perform a GLS transformation on each of the variables at step 2. After transforming the variables by θ, the HT estimates of the coefficients of the model are then obtained by performing an instrumental regression on the GLS-transformed model using deviations of time-varying variables from their means as instruments.

The advantage of the HT approach is that it allows us to estimate the coefficients of time-invariant variables using instruments from inside the model. However, it is quite difficult to find appropriate internal instruments to estimate all model coefficients because the individual effects are unobserved. Following Egger and Pfaffermayr (2004), the explanatory variables are divided into two groups: the doubly exogenous (i.e. uncorrelated with the unobserved effects) and the singly exogenous ones (correlated with the unobserved effects). Hausman and Taylor (1981) suggest using economic intuition to decide which group a variable belongs to. In our case, it is appropriate to assume the distance and regional integration dummy as doubly exogenous and the remaining ones as singly exogenous variables. The doubly exogenous variables are then used as instruments for the singly exogenous variables such as GDP and FDI. The validity of the choice of instruments can be tested by performing a Hansen test of over-identifying restrictions, which is distributed as chi-squared. As shown in Table 9 and 10, the Hansen test for over-identifying restrictions does not reject the null hypothesis that our choice of instruments are valid for both concepts of the vertical IIT index.

To find the appropriateness of the HT approach, several statistical tests are performed.[50] First, we test whether we need to use panel data techniques in the first place, using the Chow test for fixed effects and the Breuch-Pagan (BP) test for random effects. As reported in Table 9 and 10, the Chow test confirms the appropriateness of the FE model over the pooled OLS whereas the Breusch-Pagan test advocates the use of the RE model over the pooled OLS. Consequently, the question of model selection arises. To decide whether the FE model or the RE model is appropriate, the Hausman specification test can be applied under the null hypothesis that individual effects are uncorrelated with the other regressors in the model. As evident in column 3 of Tables 9 and 10, the resulting Hausman test statistics in both regressions strongly indicate that the RE model should be preferred to the FE model.[51]

Finally, the Hausman specification test is applied to the FE and the HT method to determine if the instrumental variable technique eliminates the correlation between individual effects and other regressors in the model.[52] The reported values of 5.39 and 1.08 in Table 9 and 10 are much smaller than the critical value of 12.59, so the results suggest that, of the two alternatives considered here, the HT method is more efficient for both concepts of the vertical IIT index. Hence, in the remainder of analysis the

[50] As suggested by the tests for heteroscedasticity (the likelihood ratio test (LR) and serial correlation (the Wooldridge test) reported in Table 9 and 10, both pooled OLS and the FE model are conducted using the Newey-West method which generates robust standard errors in the presence of autocorrelation within panels and heteroscedasticity across panels. In addition, the RE model is estimated using feasible generalized least squares (FGLS) method in order to account for heteroscedasticity and autocorrelation. Besides addressing the problem of heteroscedasticity and autocorrelation, collinearity among independent variables are also examined and reported in Appendix, Table A4. After an examination of collinearity among explanatory variables in Table A4, it is found that none of the explanatory variables is strongly correlated with each other.

[51] Test statistics of 9.46 and 3.56 for both concepts of vertical IIT index are much smaller than the critical value of a chi-squared with six degrees of freedom (12.59).

[52] Someone might argue that if the hypothesis that individual effects are uncorrelated with the other regressors in the model can not be rejected, then there is no need to apply the HT model. However, Baltagi et al. (2003) show that there is a substantial bias in the RE estimators when there are time-invariant variables and also endogenity among the regressors. Hence, they concluded that inference based on the RE estimators can be seriously misleading even when there is no correlation between the explanatory variables and the individual effects.

discussions of the results for both concepts of vertical IIT will focus on those obtained using the HT method.

5 Estimation Results

The regression results from the HT method reported in Tables 9 and 10 generally support the hypothesis drawn from the theoretical literature models of fragmentation. In addition, as can be seen from the results in Tables 9 and 10, the estimated coefficients are qualitatively the same for $VIIT_{kt}$ and $TWTV_{kt}$, suggesting that the results are robust across both specifications of vertical IIT index.[53] In particular, the results show that the market size variable (GDP_{kt}) turn out to have a positive and significant association with vertical IIT, as predicted by the theory. As suggested by Jones and Kierzkowski (2001), a greater level of market size promotes a greater degree of fragmentation due to increasing returns to scale in service-link activities. This is in accord with the result of Jones et al. (2004), and Kimura et al. (2007).

The variable representing the difference in size between trading partners ($DGDP_{kt}$) exerts a negative but statistically insignificant impact on both $VIIT_{kt}$ and $TWTV_{kt}$, somehow consistent with the predictions of Grossman and Helpman (2005).[54] This implies that the rising number of intermediate goods producers in the trading partner countries seem to lead to an increasing supply of intermediate goods and thereby

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[53] Although we do not report the detailed results here, we also check the sensitivity of our results with respect to outliers. We consider a HTS product as an outlier if its unit value in any year is more than two standard deviations away from the population mean. Where outliers were obvious they were replaced by average values for that 6-digit category. Excluding these outliers from the dataset did not influence the key coefficients of interest relating vertical IIT. Overall, it is concluded that the results seem to be robust to extreme outliers.

[54] In contrast, Falvey and Kierzkowski (1987) have demonstrated that vertical IIT is positively associated with the differences in market size, reflecting differences in factor endowments. On first sight, the significant positive coefficient on the differences in market size appears to be contrary to expectations of the Falvey and Kierzkowski's (1987) model. However, in the present study, vertical IIT is used as proxy to measure the degree of fragmentation of production, instead of two-way exchanges of quality-differentiated products trade**.**

an increase in vertical IIT in the auto-parts industry. In addition, the result seems to be in line with the claim by Jones and Kierzkowski (2004) that agglomeration of intermediate goods producers in the host country ultimately leads to a surge in the intermediate goods trade because of the increasing returns in the service-link activities.[55]

The results illustrate that dissimilarities in GDP per capita as an indicator of differences in factor endowments have a positive and significant effect on $TWTV_{kt}$ but are insignificant for $VIIT_{kt}$, consistent with the predictions of both Helpman and Krugman's (1985) and Feenstra and Hanson's (1997) theoretical models that the volume of vertical trade or outsourcing tends to increase with greater differences in factor endowments between two countries.[56]

As noted earlier, however, differences in per capita GDP also capture the differences in location advantages such as the existence of supporting industries, public infrastructure, favorable policy environment, skilled labor, and industrial agglomeration, which would be reflected in lower shares of vertical IIT.[57] Given the fact that there are small differences in location advantages in the sample of countries included in the study, it is not surprising that the effect of location advantages on the vertical IIT becomes minimal, and consequently the findings of positive and significant impact of differences in per capita GDP implies that labor cost differences are most important in explaining the share of VIIT in the auto-parts industry than the location advantages.[58]

[55] This finding is similar to Klier (2005) who also find the importance of agglomeration in the auto-parts industry using detailed plant-level data on the U.S. auto supplier industry.
[56] This result about the positive relation between the trade induced by fragmentation and per capita income differences is similar to previous studies by Borga and Zeile (2004), Egger and Egger (2005), and Zeddies (2007).
[57] Cooney and Yacobucci (2005) suggest that key determinant for location choices of auto-parts firms would be the location of the assembly plant itself and the associated transportation infrastructure.
[58] For instance, Kimura et al. (2007) reports that machinery parts and components trade in Europe is discouraged by difference in GDP per capita, as a proxy for both differences in wages and location advantages while their influence on East Asia appears to be positive.

FDI variable (FDI_{kt}) has a significant positive effect on both $VIIT_{kt}$ and $TWTV_{kt}$, confirming our hypothesis that FDI stimulates the exchange of intermediates. This result is consistent with the theoretical expectation that vertical type FDI complements rather than substitutes for trade in intermediate goods. Similar findings also emerge in Görg (2000), Blonigen (2001), and Türkcan (2007). Thus, the results confirm the view that Austria started to engage in back-and-forth transactions in auto-parts with Eastern and Central European countries.[59] It has been mentioned earlier that since the opening of the Eastern European Economies at the beginning of the nineties FDI by the Austrian automobile industry, particularly auto-parts, in Central and Eastern Europe has increased significantly.[60] Egger et al. (2001) shows that the relocation of production stages from Austria to these countries (outsourcing) increased the level of intra-firm trade in intermediate goods over the period 1990-1998. At the industry level, they observed that outsourcing to Eastern countries is most pronounced in the transport equipment industry and the growth rate of intra-firm trade in this industry is substantially higher than the average growth of intra-firm trade in total manufacturing from these countries.

Moreover, our results indicate that the distance variable ($DIST_k$), a proxy for service-link costs, shows a negative and significant relationship with both concepts of the vertical IIT index, as expected. According to this result, transportation costs significantly hamper the fragmentation of production across countries, verifying the

[59] A number of MNEs in auto-industry such as Magna, Renault, or Volvo, have chosen Austria as the headquarters for their Eastern and Central European operations.
[60] See Bhattacharya (2007).

hypothesis developed by Jones and Kierzkowski (2001) that cross-border outsourcing is more favorable if service-link costs are lowered.[61]

Furthermore, the findings also suggest that many auto makers require auto-parts suppliers to locate near their plants because of the "just-in-time" manufacturing model. As seen in Table 2, a large portion of Austria's imports and exports of auto-parts are body and chassis parts categories that are heavy or bulky, causing their production location to be closer to the assembly plants. And so, the negative and significant coefficient of the distance variable points to the importance of the just-in-time production model in the Austrian auto-parts industry as well.[62]

Regarding the impact of regional integration on the vertical IIT in intermediate goods, the coefficients for $EU15_k$ are negative and statistically significant in both models. In other words, there is no statistical evidence to support the hypothesis that increasing regional integration between Austria and its trading partners has a positive impact on the auto-parts trade. This finding is consistent with Egger and Pfaffermayr (2002) who found that the last enlargement (Austria, Finland, and Sweden) does not lead to positive integration effects on the intra-core volume of trade. In this regard, Egger and Pfaffermayr (2002) point out that further enlargement of the EU should increase the intra-EU periphery trade volumes at the expense of the intra-EU core.

According to Egger and Pfaffermayr (2002), a prime example is Austria where companies have begun to locate the relatively labor intensive stages of auto-parts production to new member states from Central and Eastern Europe since 2004, thereby reducing the volume of trade in the auto-parts trade between Austria and Western

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[61] Jones et al. (2004) and Kimura et al. (2007) report similar findings for the relationship between service-link costs and trade in intermediate goods.

[62] Cooney and Yacobucci (2005) claim that distance may limit China's role in the U.S. auto-industry as a major supplier for auto-parts producers (particularly original equipment industry) using "just-in-time" production model.

European countries (see Table 1).[63] The rapid expansion of trade with the East and Central European countries, therefore, might partly explain the negative influence of the EU15 dummy on the vertical IIT in the auto-parts industry in the period considered.

Finally, the coefficient for bilateral exchange rate changes ($EXCH_{kt}$) appears to have a negative but statistically insignificant impact on $TWTV_{kt}$, a result similar to the previous studies by Arndt and Huemer (2005) and Thorbecke (2008) who also did not find any link between exchange rate changes and trade volumes induced by fragmentation.

6. Conclusions

The increased importance of fragmentation in world trade has created an interest among trade economists in explaining the determinants of intra-industry trade in intermediate goods. This study carries out a study on Austria's auto-parts industry IIT that represents improvements over previous studies as follows:

First, the pattern of the IIT and its components in the Austrian auto-parts industry is carefully examined with the applications of different methods to measure IIT between Austria and its 29 trading partners. Second, the development of Austria's vertical IIT in the auto-parts industry is analyzed, as an indicator for fragmentation and various country-specific factors suggested by fragmentation literature are tested using panel econometric techniques.

The results show that a substantial part of intra-industry trade in the auto-parts industry between Austria and its trading partner is vertical IIT. A high degree of vertical IIT in the auto-parts industry is suggestive of the substantial contribution of fragmentation to trade between Austria and OECD countries. The second important

[63] Before the last enlargement of the EU, Austrian auto-parts industry has traditionally been linked to the German automobile industry.

finding is that the degree of vertical IIT remained stable for periphery countries while it declined rapidly over the same period for core countries. The importance of vertical IIT between Austria and periphery countries was largely due to high and increasing flows of German FDI into these countries over the period, which is directly related to the internationalization of production.

Using the HT method, the econometric results obtained here generally support the hypotheses drawn from the fragmentation literature. The estimated coefficients are outstandingly similar and robust across the various estimation methods for both concepts of the vertical IIT index. In particular, the extent of Austria's vertical IIT in auto-parts is positively correlated with average market size and outward FDI while it is negatively correlated with the distance between markets. Furthermore, the negative relationship between the magnitude of vertical IIT and the EU dummy needs further investigation, as this result is contrary to the expectation of a positive relationship between the two variables.

The results in this paper leave several issues for further research. First of all, we have employed the unit values technique to separate vertical trade from horizontal trade at the commodity level. This method has one drawback: it is difficult to track an intermediate good once it is imported with the currently available trade data. Trade data used in this paper provide information only on the export and import values and quantities of a given input. The imported input could be used primarily for the production of a final good that is later consumed by local consumers or it could be used in the production of other intermediate goods or final goods that are later exported back to the original country or to the other countries.

It may be worthwhile to investigate this link in more detail in a future study to confirm whether 25% differences between unit values of exports and imports truly reflect value-added activities. Furthermore, it may be beneficial to separate countries under study into two groups based on their GDPs because selected trading partner countries have enormous differences in factor endowments, production technologies, and incomes.

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Appendix

Definition of Auto-Parts Industry Trade

The bilateral trade flows data at the 6-digit HS (Harmonized System, 1996) used in this study were obtained from OECD's International Trade Commodity Statistics (ITCS). There are about 6784 items at the 6-digit level of the HS. For the measurement of IIT in automobile industry, we choose to identify 18 items as motor vehicle products and 82 items as auto parts from the 6-digit level of HS. Moreover, auto-parts codes are divided into 6 subgroups: Bodies and parts, Chassis and Drivetrain parts, Electrical and Electrical components, Engines and parts, Tires and Tubes, and Miscellaneous parts. The 6-digit HS codes classified as motor vehicle products and auto-parts products are listed in Table A1.

This database provides detailed annual bilateral trade data for commodity exports and imports in value ($US at current prices) and quantities at the 6-digit level of the HS. Unit values at the 6-digit product level of the HS are then constructed as the value of imports and exports of the product divided by the corresponding quantities. In this source, export values are recorded on a f.o.b. basis while import values are recorded on a c.i.f. basis. Following Ando (2006), we multiplied the export values by 1.05 in order to adjust the discrepancy between export and import values. Thus, calculated unit price differentials do capture a trade in automotive industry that is entirely due to differences in quality or international fragmentation.

Country-Level Variables

Country-level variables on Austria and its 29 OECD countries are mainly retrieved from OECD database that can be downloaded from http://www.sourceoecd.org. The size of market size (GDP_{kt}) is proxied by the log of the average GDP of Austria and its trading partner, expressed in current US dollars. In addition, $DGDP_{kt}$ is the log of the absolute difference in market size, expressed in current US dollars. In line with Balassa and Bauwens (1987), we calculate the difference in market size as:

$$DGDP_{kt} = 1 + \frac{[w \ln w + (1-w)\ln(1-w)]}{\ln 2}$$

where $w = \frac{GDP_{ht}}{GDP_{ht} + GDP_{kt}}$, h and k are Austria and its trading partners, respectively. This index obtains the value between 0 and 1, and increases as the relative inequality between two countries increases.

The log of the absolute difference in per capita GDPs of Austria and its trading partner k is defined as $DPGDP_{kt} = |PGDP_{ht} - PGDP_{kt}|$, expressed in current US dollars. Moreover, FDI_{kt} is the log of the Austria's outward FDI stock into its trading partner k, measured in current US dollars. As a measure of multinational activity in the host countries, outward FDI stock data is chosen rather than outward FDI flows since stock data is more complete than the flows data. Some researchers argue that outward FDI stock is an imperfect proxy for multinational activity because multinational companies may also engage in many activities in the host countries that one would not expect to have any relationship with fragmentation of production, such as real estate investment. Nonetheless, considering the limited availability of the data, outward FDI stock data may be best available proxy.

$DIST_k$ is the log of direct distance between Austria's capital and its trading partner's capital and taken from the CEPII's Distance Database that can be downloaded from http://www.cepii.fr. At last, the bilateral exchange rate in this study is defined as the number of foreign currency unit per unit of domestic currency so that $EXCH_{kt}$ falls with a depreciation of the domestic currency, namely the Euro. The explanatory variables, their predicted signs, and their sources are summarized in Table A2. Table A3 provides the summary statistics for different concepts of the IIT index and explanatory variables while Table A4 present the correlation matrix between explanatory variables.

Following twenty-nine Austria's trading partners are included in the regression analysis: Australia, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Switzerland, Sweden, Turkey, the United Kingdom, and USA.[64] In addition, we divide our sample of countries into core and peripheral countries using the categorization drawn up by the World Bank. Table A.5 provides core/periphery categorizations of countries included into regressions.

[64] The purpose of this choice to minimize the number of missing observations considering the fact that the construction of unit values at the six-digit level of HS requires not only trade values but quantity information.

Table A.1 HS-6 Codes Relevant to Auto-Industry

Product Groups	HS Code	Descriptions
Motor Vehicle	870120	Road tractors for semi-trailers (truck tractors)
	870210	Diesel powered buses with a seating capacity of > nine persons
	870290	Buses with a seating capacity of more than nine persons nes
	870321	Automobiles w reciprocatg piston engine displacg not more than 1000 c
	870322	Automobiles w reciprocatg piston engine displacg > 1000 cc to 1500 cc
	870323	Automobiles w reciprocatg piston engine displacg > 1500 cc to 3000 cc
	870324	Automobiles with reciprocating piston engine displacing > 3000 cc
	870331	Automobiles with diesel engine displacing not more than 1500 cc
	870332	Automobiles with diesel engine displacing more than 1500 cc to 2500 c
	870333	Automobiles with diesel engine displacing more than 2500 cc
	870390	Automobiles nes including gas turbine powered
	870421	Diesel powered trucks with a GVW not exceeding five tonnes
	870422	Diesel powerd trucks w a GVW exc five tonnes but not exc twenty tonne
	870423	Diesel powered trucks with a GVW exceeding twenty tonnes
	870431	Gas powered trucks with a GVW not exceeding five tonnes
	870432	Gas powered trucks with a GVW exceeding five tonnes
	870490	Trucks nes
	870600	Chassis fittd w engines for the vehicles of headg Nos 87.01 to 87.05
Bodies and Parts	700711	Safety glass toughend (tempered) f vehicles, aircraft, spacecraft/ves
	700721	Safety glass laminated for vehicles, aircraft, spacecraft or vessels
	700910	Rear-view mirrors for vehicles
	830210	Hinges of base metal
	830230	Mountings, fittings & similar articles of base metal f motor vehicles
	870710	Bodies for passenger carrying vehicles
	870790	Bodies for tractors, buses, trucks and special purpose vehicles
	870810	Bumpers and parts for motor vehicles
	870821	Safety seat belts for motor vehicles
	870829	Parts and accessories of bodies nes for motor vehicles
	940120	Seats, motor vehicles
	940190	Parts of seats other than those of heading No 94.02
	940390	Furniture parts nes
Chassis and Drivetrain Parts	400950	Tubes, pipes & hoses vulcanised rubber reinforced or not, with fittin
	681310	Asbestos brake linings and pads
	681390	Asbestos friction material and articles nes
	731816	Nuts, iron or steel, nes
	732010	Springs, leaf and leaves therefor, iron or steel
	732020	Springs, helical, iron or steel
	842139	Filtering or purifying machinery and apparatus for gases nes
	848210	Bearings, ball"
	848220	Bearings, tapered roller, including cone and tapered roller assemblie"
	848240	Bearings, needle roller"
	848250	Bearings, cylindrical roller, nes"
	870831	Mounted brake linings for motor vehicles
	870839	Brake system parts nes for motor vehicles
	870840	Tansmissions for motor vehicles
	870850	Drive axles with differential for motor vehicles
	870860	Non-driving axles and parts for motor vehicles
	870870	Wheels including parts and accessories for motor vehicles
	870880	Shock absorbers for motor vehicles
	870893	Clutches and parts for motor vehicles
	870894	Steering wheels, steering columns and steering boxes for motor vehicl"
	870899	Motor vehicle parts nes
	871690	Trailer and other vehicle parts nes
Electrical and Electric Components	841520	Air Conditioning Machines of A Kind Used For Persons In Motor Vehicles
	841583	Air cond mach nes, not incorporating refrigerating unit"
	841590	Parts of air conditioning machines

	850132	DC motors, DC generators, of an output exceedg 750 W but nt exceedg 7"
	850710	Lead-acid electric accumulators of a kind usd f startg piston engines
	850730	Nickel-cadmium electric accumulators
	850790	Parts of electric accumulators, including separators therefor"
	851110	Spark plugs
	851120	Ignition magnetos, magneto-generators and magnetic flywheels"
	851130	Distributors and ignition coils
	851140	Starter motors
	851150	Generators and alternators
	851180	Glow plugs and other ignition or starting equipment nes
	851190	Parts of electrical ignition or starting equipment
	851220	Lighting or visual signalling equipment nes
	851230	Sound signalling equipment
	851240	Windscreen wipes, defrosters and demisters"
	851290	Parts of electrical lighting, signalling and defrosting equipment"
	851993	Cassette Players Play only (Excl. Pocket-Size And Dictating Machines)
	852520	Transmission apparatus, for radioteleph incorporatg reception apparat"
	852721	Radio rece nt capabl of op w/o ext source of power f motor veh, combi"
	852729	Radio rece nt capable of op w/o ext source of power f motor vehicl, n"
	853180	Electric sound or visual signalling apparatus, nes"
	853641	Electrical relays for a voltage not exceeding 60 volts
	853910	Sealed beam lamp units
	853921	Filament lamps, tungsten halogen"
	854430	Ignition wirg sets & oth wirg sets usd in vehicles, aircraft etc"
	902910	Revolution counters, prodion counters taximeters, mileometers & the l"
	902920	Speed indicators and tachometers; stroboscopes
	902990	Parts & access of revolution counters, production counters, taximeter"
	910400	Instrument panel clocks & clocks of a sim type for vehicles, aircraft"
Engines and Parts	401693	Gaskets, washers and other seals of vulcanised rubber"
	840734	Engines, spark-ignition reciprocating displacing more than 1000 cc"
	840820	Engines, diesel, for the vehicles of Chapter 87"
	840991	Parts for spark-ignition type engines nes
	840999	Parts for diesel and semi-diesel engines
	841330	Fuel, lubricating or cooling medium pumps for int comb piston engines"
	841391	Parts of pumps for liquid whether or not fitted with a measurg device
	841430	Compressors of a kind used in refrigerating equipment
	841459	Fans nes
	842123	oil or petrol-filters for internal combustion engines
	842131	Intake air filters for internal combustion engines
	848310	Transmission shafts and cranks, including cam shafts and crank shafts"
Tires and Tubes	401110	Pneumatic tire new of rubber f motor car incl station wagons & racg c
	401120	Pneumatic tires new of rubber for buses or lorries
	401210	Retreaded tires
	401220	Pneumatic tires used
	401310	Inner tubes of rubber for motor cars etc buses or lorries
Miscellaneous Parts	381900	Hydraulic brake & transmis fluids not cntg o cntg <70% of petroleum o
	382000	Anti-freezing preparations and prepared de-icing fluids
	401699	Articles of vulcanised rubber nes, other than hard rubber"
	830120	Locks of a kind used for motor vehicles of base metal
	842549	Jacks & hoists nes
	842691	Cranes designed for mounting on road vehicles
	843110	Parts of machinery of heading No 84.25
	870891	Radiators for motor vehicles
	870892	Mufflers and exhaust pipes for motor vehicles

Note: To select the automotive products from the trade data, we employ the list provided by the Office of Aerospace and Automotive Industries' Automotive Team, part of the U.S Department of Commerce's International Trade Administration. Their definition of auto-parts products can be found at http://www.ita.doc.gov/td/auto.html.

Table A.2 Variable Definitions, Expected Signs, and Sources

Variable Definition	Expected Signs	Sources
GDP_{kt} = Average GDP between Austria and its trading partner	+	Source OECD Annual National Accounts
$DGDP_{kt}$ = Absolute difference of GDP between Austria and its trading partner	+/-	Source OECD Annual National Accounts
$DPGDP_{kt}$ = Absolute difference of per capita GDP between Austria and its trading partner	+/-	Source OECD Annual National Accounts
FDI_{kt} = Outward FDI stocks from Austria into its trading partner	+	Source OECD International Direct Investment Yearbook Statistics
$DIST_{k}$ = The distance between Austria and its trading partner	-	CEPII's Distance Database: http//www.cepii.fr/anglaisfraph/bdd/distances.htm.
$EXCH_{kt}$ = Bilateral exchange rate between the Austria and its trading partner	+/-	Source OECD OECD.Stat Beta Version
$EU15_{k}$ =Regional integration dummy, 1 if the trading partner belongs to European Union, else 0	+	

Table A.3. Summary Statistics of Different Concepts of Intra-Industry Trade Index and Explanatory Variables

Variable	Mean	St. Deviation	Minimum	Maximum	Observations
$VIIT_{kt}$	0.19	0.13	0.00	0.89	319
$TWTV_{kt}$	0.32	0.22	0.01	0.99	319
GDP_{kt}	26.60	0.86	25.39	29.38	319
$DGDP_{kt}$	0.23	0.24	0.00	0.84	319
$DPGDP_{kt}$	10.86	0.18	10.43	11.45	319
FDI_{kt}	5.37	2.22	-0.23	9.22	220
$DIST_{k}$	7.35	1.29	4.08	9.81	319
$EXCH_{kt}$	1.39	2.00	-2.24	7.35	319

Note: [a] 'C' refers to correction of outliers for the intra-industry index. All variables are in natural logarithmic form.

Table A.4. Correlation Matrix Between Explanatory Variables

Variables	GDP_{kt}	$DGDP_{kt}$	$DPGDP_{kt}$	FDI_{kt}	$DIST_{k}$	$EXCH_{kt}$	$EU15_{k}$
GDP_{kt}	1.000						
$DGDP_{kt}$	0.578 (0.000)	1.000					
$DPGDP_{kt}$	0.072 (0.198)	0.292 (0.000)	1.000				
FDI_{kt}	0.172 (0.010)	0.189 (0.004)	0.144 (0.031)	1.000			
$DIST_{k}$	0.355 (0.000)	0.257 (0.000)	0.143 (0.010)	-0.468 (0.000)	1.000		
$EXCH_{kt}$	-0.128 (0.021)	0.074 (0.184)	-0.273 (0.000)	-0.097 (0.149)	-0.025 (0.656)	1.000	
$EU15_{k}$	-0.044 (0.433)	-0.099 (0.075)	0.315 (0.000)	0.130 (0.053)	-0.233 (0.000)	-0.542 (0.000)	1.000

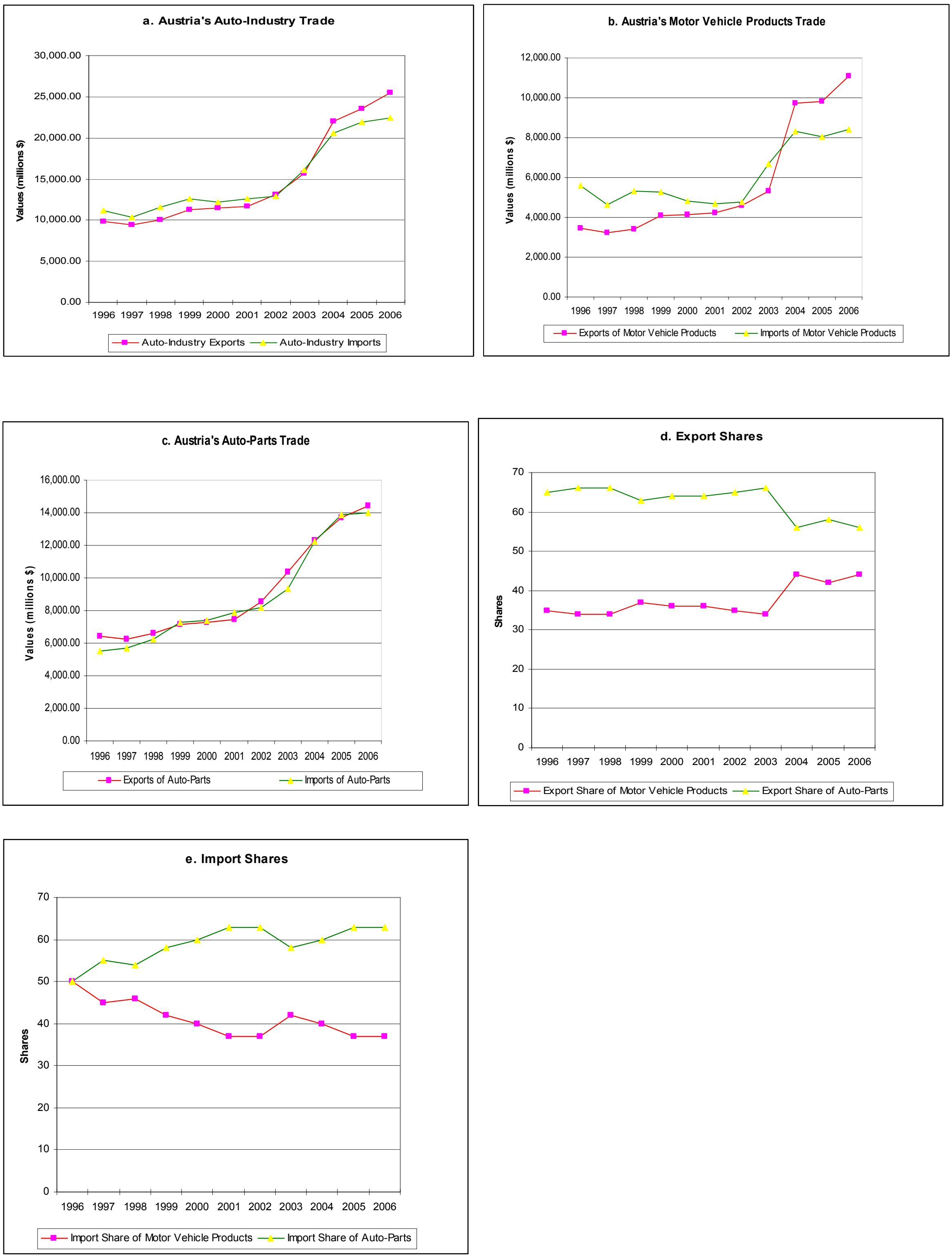
Note: p-values are reported in parentheses.

Table A.5. Countries Included in Regression Analysis

Australia^{C}	Luxembourg^{C}
Belgium^{C}	Mexico^{P}
Canada^{C}	Netherlands^{C}
Czech Republic^{P}	New Zealand^{C}
Denmark^{C}	Norway^{C}
Finland^{C}	Poland^{P}
France^{C}	Portugal^{C}
Germany^{C}	Slovak Republic^{P}
Greece^{C}	Spain^{C}
Hungary^{P}	Switzerland^{C}
Iceland^{C}	Sweden^{C}
Ireland^{C}	Turkey^{P}
Italy^{C}	United Kingdom^{C}
Japan^{C}	USA^{C}
Korea^{C}	

Note: Countries that we consider in this study account for roughly 90% of the US automotive trade. ^{C} and ^{P} indicate the countries that are classified as core countries and periphery countries, respectively.

Figure 1. Austria's Auto Industry Trade with World, 1996-2006



Source: Authors' own calculations

Table 1. Austria's Auto-Parts Trade by Countries (Values is in Millions of $ and Share is in%)

Countries	1996				2006			
	Exports		Imports		Exports		Imports	
	Value	Share	Value	Share	Value	Share	Value	Share
Australia	18.40	0.29	0.37	0.01	220.95	1.53	77.46	0.55
Belgium	0.00	0.00	0.00	0.00	260.99	1.81	67.34	0.48
Canada	53.88	0.84	74.10	1.34	206.39	1.43	196.73	1.41
Czech Republic	73.91	1.15	62.06	1.12	379.86	2.64	476.85	3.41
Denmark	26.53	0.41	16.81	0.30	70.00	0.49	35.71	0.26
Finland	29.25	0.46	50.67	0.92	44.09	0.31	319.67	2.28
France	117.39	1.83	285.86	5.16	385.92	2.68	490.15	3.50
Germany	3,663.97	57.16	2,923.58	52.81	6,589.95	45.77	7,035.48	50.25
Greece	8.51	0.13	0.74	0.01	176.52	1.23	0.76	0.01
Hungary	351.77	5.49	194.32	3.51	539.68	3.75	280.14	2.00
Iceland	1.07	0.02	0.00	0.00	2.40	0.02	1.27	0.01
Ireland	3.59	0.06	12.19	0.22	21.54	0.15	13.32	0.10
Italy	153.54	2.40	443.20	8.01	682.54	4.74	867.56	6.20
Japan	54.46	0.85	67.53	1.22	138.63	0.96	282.98	2.02
Korea	12.59	0.20	10.20	0.18	51.73	0.36	195.48	1.40
Luxembourg	0.00	0.00	0.00	0.00	3.98	0.03	30.32	0.22
Mexico	24.30	0.38	12.51	0.23	37.42	0.26	52.04	0.37
Netherlands	66.18	1.03	97.94	1.77	107.63	0.75	259.70	1.85
New Zealand	2.45	0.04	1.29	0.02	8.39	0.06	0.56	0.00
Norway	12.03	0.19	0.99	0.02	29.42	0.20	13.15	0.09
Poland	29.47	0.46	6.23	0.11	651.27	4.52	139.91	1.00
Portugal	41.03	0.64	22.83	0.41	109.93	0.76	61.23	0.44
Slovak Republic	33.38	0.52	10.69	0.19	301.24	2.09	122.63	0.88
Spain	478.13	7.46	43.16	0.78	728.74	5.06	218.05	1.56
Switzerland	68.11	1.06	50.90	0.92	184.92	1.28	178.49	1.27
Sweden	76.25	1.19	44.58	0.81	167.53	1.16	101.05	0.72
Turkey	9.50	0.15	22.40	0.40	49.69	0.35	72.23	0.52
United Kingdom	242.15	3.78	130.54	2.36	618.52	4.30	209.36	1.50
USA	303.85	4.74	743.95	13.44	510.58	3.55	979.56	7.00
Core	5,433.36	84.78	5,021.43	90.71	11,321.29	78.63	11,635.38	83.12
Periphery	522.33	8.15	308.21	5.56	1,959.16	13.61	1,143.8	8.18
OECD	5,955.69	92.92	5,329.66	96.28	12,992.10	90.23	12,715.30	90.81

Source: Authors' own calculations based on OECD's ITCS International Trade by Commodity Database-Harmonized System, 1996.

Table 2. Auto-Parts Trade by Product Groups (Values is in Millions of $ and Share is in%), 1989-2006.

Product Groups	1989				2006			
	Exports		Imports		Exports		Imports	
	Value	Share	Value	Share	Value	Share	Value	Share
Bodies and Parts	815.20	12.72	883.68	15.96	2,321.73	16.13	2,010.25	14.36
Chassis and Drivetrain Parts	1,276.11	19.91	1,551.30	28.02	3,453.44	23.99	4,354.27	31.10
Electrical and Electric Components	718.72	11.21	935.02	16.89	2,726.73	18.94	2,930.40	20.93
Engines and Parts	3,217.54	50.20	1,579.21	28.53	5,082.19	35.30	3,543.47	25.31
Tires and Tubes	0.00	0.00	363.66	6.57	13.05	0.09	602.26	4.30
Miscellaneous Parts	382.05	5.96	222.95	4.03	801.07	5.56	560.73	4.00

Source: Authors' own calculations.

Table 3. Top 5 Export Destinations of the Austrian Auto-Parts Industry in 2006 (Values is in Millions of $ and Share is in%)

Product Groups	Country-I	Country-II	Country-III	Country-IV	Country-V	World
Bodies and Parts	**Germany**	**Italy**	**USA**	**United Kingdom**	**Slovak Republic**	
	869.63	141.62	112.10	109.75	92.72	2,321.73
Chassis and Drivetrain Parts	**Germany**	**Spain**	**United Kingdom**	**Italy**	**Australia**	
	1,685.57	203.91	201.07	200.12	166.76	3,453.44
Electrical and Electric Components	**Germany**	**Poland**	**Italy**	**Hungary**	**Greece**	
	504.52	296.82	175.01	163.91	162.92	2,726.73
Engines and Parts	**Germany**	**USA**	**Spain**	**United Kingdom**	**Hungary**	
	3,260.06	317.83	256.91	193.78	137.07	5,082.19
Tires and Tubes	**Germany**	**USA**	**Spain**	**United Kingdom**	**Hungary**	
	5.31	1.43	0.96	0.83	0.66	13.05
Miscellaneous Parts	**Germany**	**Spain**	**France**	**Italy**	**Czech Republic**	
	264.86	102.35	56.34	35.38	32.91	801.07

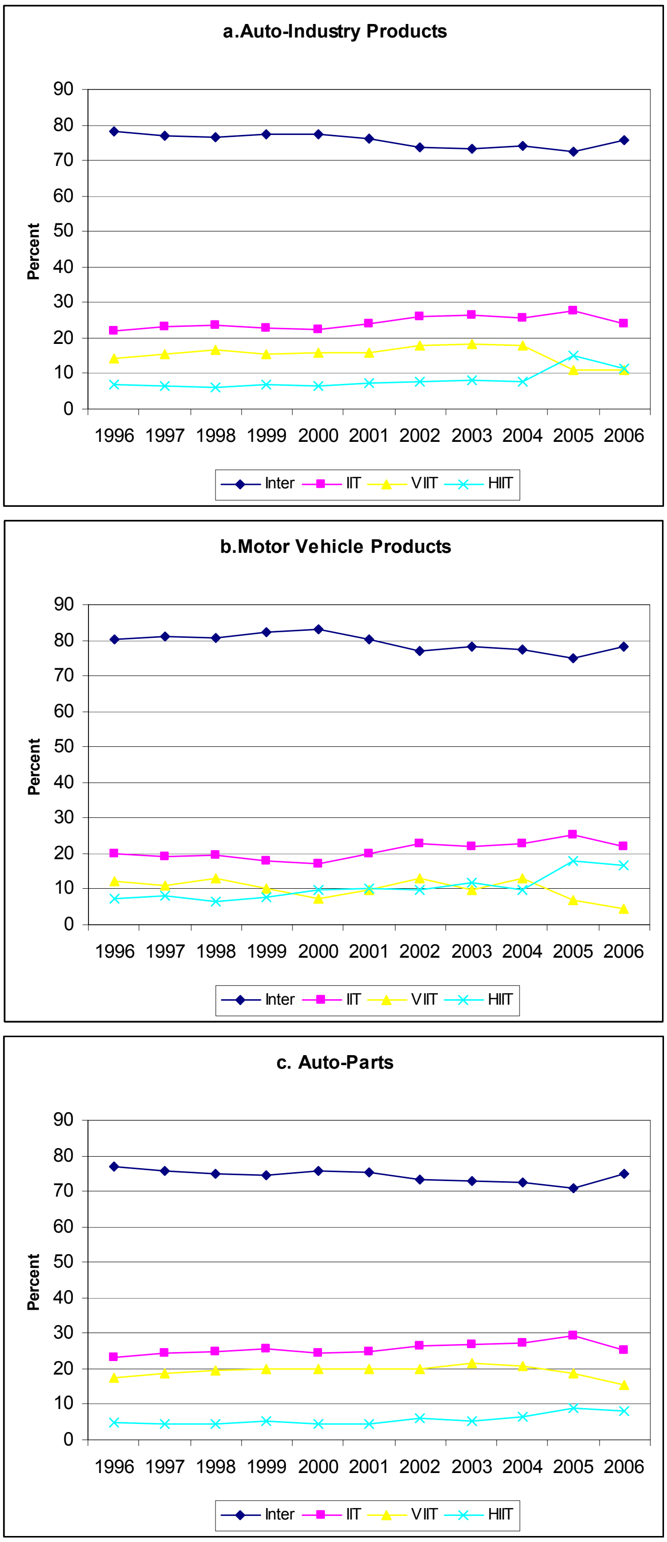
Source: Authors' own calculations.

Table 4. Top 5 Import Sources of the Austrian Auto-Parts Industry in 2006 (Values is in Millions of $ and Share is in%)

Product Groups	Country-I	Country-II	Country-III	Country-IV	Country-V	World
Bodies and Parts	**Germany**	**USA**	**Czech Republic**	**Canada**	**Italy**	
	995.52	159.26	132.09	100.10	74.97	2,010.25
Chassis and	**Germany**	**USA**	**Italy**	**France**	**Hungary**	
Drivetrain Parts	2,386.42	554.10	291.44	178.13	93.85	4,354.27
Electrical and	**Germany**	**Finland**	**Italy**	**Korea**	**USA**	
Electric Components	615.45	280.02	164.59	150.63	120.55	2,930.40
Engines and Parts	**Germany**	**Italy**	**Czech Republic**	**France**	**USA**	
	2,533.84	281.41	96.13	83.31	76.88	3,543.47
Tires and Tubes	**Germany**	**France**	**Australia**	**Spain**	**Japan**	
	211.94	45.95	43.30	43.27	40.45	602.26
Miscellaneous Parts	**Germany**	**USA**	**France**	**Italy**	**Czech Republic**	
	292.31	38.37	28.31	24.13	22.43	560.73

Source: Authors' own calculations.

Figure 2. Development of Intra-Industry Trade in the Austrian Auto-Industry-G-L Index, 1996-2006



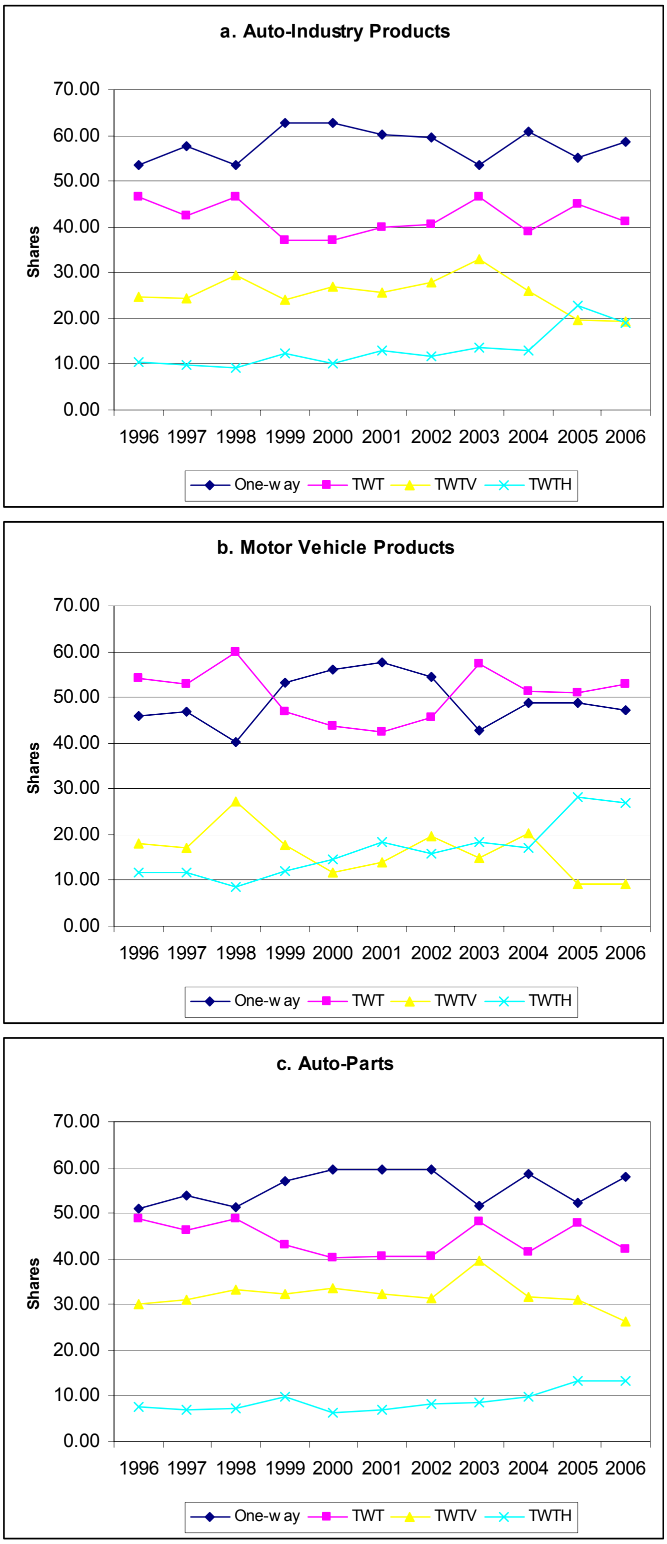
Source: Authors' own calculations

Table 5: Development of Intra-Industry Trade in the Austrian Auto-Parts Industry-G-L Index, 1996-2006

Countries	1996				2006			
	Inter	IIT	VIIT	HIIT	Inter	IIT	VIIT	HIIT
Australia	94.75	5.25	2.33	0.00	96.26	3.74	1.63	0.23
Belgium	100.00	0.00	0.00	0.00	81.22	18.78	10.69	7.01
Canada	65.54	34.46	25.91	8.09	83.08	16.92	13.15	2.58
Czech Republic	49.82	50.18	41.59	8.37	57.85	42.15	16.22	24.56
Denmark	66.64	33.36	23.52	8.09	71.48	28.52	17.05	4.35
Finland	85.57	14.43	12.63	1.14	93.22	6.78	3.68	2.68
France	67.25	32.75	25.69	6.69	47.48	52.52	31.63	19.03
Germany	44.73	55.27	37.70	17.57	41.30	58.70	27.73	28.88
Greece	79.63	20.37	16.97	2.34	99.11	0.89	0.42	0.32
Hungary	79.96	20.04	19.34	0.62	57.78	42.22	30.96	9.42
Iceland	100.00	0.00	0.00	0.00	91.63	8.37	5.44	0.11
Ireland	90.98	9.02	6.94	0.00	66.63	33.37	9.21	23.56
Italy	62.68	37.32	20.77	16.41	54.62	45.38	23.41	20.78
Japan	81.74	18.26	12.63	4.95	71.24	28.76	27.59	0.31
Korea	84.99	15.01	11.08	1.07	95.24	4.76	3.95	0.53
Luxembourg	100.00	0.00	0.00	0.00	97.25	2.75	1.98	0.64
Mexico	97.01	2.99	2.47	0.20	84.49	15.51	6.03	9.27
Netherlands	60.00	40.00	33.53	5.97	64.47	35.53	22.44	11.27
New Zealand	77.23	22.77	21.53	0.00	92.07	7.93	0.97	0.03
Norway	88.03	11.97	8.72	0.85	79.10	20.90	18.98	1.64
Poland	79.40	20.60	12.67	6.95	78.31	21.69	13.96	7.28
Portugal	90.01	9.99	8.66	0.99	90.43	9.57	7.56	1.62
Slovak Republic	62.37	37.63	37.11	0.00	66.12	33.88	31.58	1.27
Spain	95.51	4.49	2.89	1.49	76.49	23.51	13.42	8.50
Switzerland	65.86	34.14	22.75	10.66	69.84	30.16	20.57	7.89
Sweden	49.32	50.68	33.79	15.94	56.65	43.35	36.67	3.66
Turkey	77.78	22.22	16.49	5.26	65.27	34.73	25.71	7.44
United Kingdom	73.35	26.65	24.01	2.15	62.01	37.99	10.62	25.67
USA	62.20	37.80	21.43	16.15	78.18	21.82	16.82	3.62
Core	78.46	21.54	15.66	5.03	76.81	23.19	13.82	7.67
Periphery	74.39	25.61	21.61	3.57	68.30	31.70	20.74	9.87
Mean	76.98	23.02	17.35	4.89	74.79	25.21	15.52	8.07

Sources: Author's calculation based on OECD's ITCS International Trade by Commodity Database-Harmonized System 1996.

Figure 3. Development of Intra-Industry Trade in the Austrian Auto-Industry - Decomposition Method, 1996-2006



Source: Authors' own calculations

Table 6: Development of Intra-Industry Trade in the Austrian Auto-Parts Industry-Decomposition Method, 1996-2006

Countries	**1996**				**2006**			
	One-Way	**TWT**	**TWTV**	**TWTH**	**One-Way**	**TWT**	**TWTV**	**TWTH**
Australia	90.41	9.59	6.05	0.00	93.11	6.89	1.55	0.55
Belgium	0.00	100.00	0.00	0.00	69.28	30.72	16.95	13.29
Canada	59.33	40.67	29.35	11.00	70.37	29.63	23.67	5.92
Czech Republic	22.12	77.88	64.31	13.34	35.03	64.97	30.77	30.06
Denmark	48.76	51.24	34.64	14.44	54.49	45.51	25.47	9.19
Finland	76.02	23.98	18.99	4.59	89.34	10.66	6.57	3.23
France	38.86	61.14	48.24	12.63	27.06	72.94	45.10	24.94
Germany	21.45	78.55	53.78	24.76	7.95	92.05	48.48	38.98
Greece	60.54	39.46	36.59	2.42	99.03	0.97	0.78	0.00
Hungary	47.95	52.05	51.17	0.77	20.10	79.90	48.90	28.24
Iceland	0.00	100.00	0.00	0.00	86.92	13.08	10.30	0.00
Ireland	87.45	12.55	10.54	0.00	39.14	60.86	11.63	48.55
Italy	29.31	70.69	42.01	28.60	24.52	75.48	41.28	32.43
Japan	72.14	27.86	19.37	8.12	60.98	39.02	36.64	0.57
Korea	75.13	24.87	20.32	0.00	93.68	6.32	5.53	0.23
Luxembourg	0.00	100.00	0.00	0.00	95.52	4.48	4.14	0.17
Mexico	99.44	0.56	0.00	0.00	73.00	27.00	9.70	17.05
Netherlands	44.05	55.95	47.07	7.89	35.25	64.75	45.52	15.50
New Zealand	5.65	94.35	90.81	0.00	90.71	9.29	1.30	0.15
Norway	84.74	15.26	11.19	0.00	63.55	36.45	33.76	2.61
Poland	63.35	36.65	21.03	14.42	58.98	41.02	26.92	12.77
Portugal	92.90	7.10	6.81	0.09	84.57	15.43	11.55	3.41
Slovak Republic	43.96	56.04	55.83	0.00	44.22	55.78	52.95	1.70
Spain	92.47	7.53	5.97	1.31	62.06	37.94	17.61	17.51
Switzerland	45.61	54.39	36.43	17.22	44.52	55.48	38.16	16.14
Sweden	14.98	85.02	55.71	27.61	30.46	69.54	62.31	3.65
Turkey	62.34	37.66	26.83	10.24	51.03	48.97	37.62	7.86
United Kingdom	58.33	41.67	37.64	3.44	32.85	67.15	18.24	45.91
USA	44.91	55.09	37.66	16.99	44.50	55.50	44.70	7.42
Core	49.70	50.30	28.22	7.87	60.86	39.14	23.97	12.62
Periphery	56.53	43.47	36.53	6.46	47.06	52.94	34.48	16.28
Mean	51.11	48.89	29.94	7.58	58.01	41.99	26.14	13.38

Sources: Author's own calculation based on OECD's ITCS International Trade by Commodity Database-Harmonized System 1996.

Table 7. Development of Intra-Industry Trade in the Austrian Auto-Parts Industry by Product Groups – G-L Index

Product Groups	1996				2006			
	Inter	IIT	VIIT	HIIT	Inter	IIT	VIIT	HIIT
Bodies and Parts	42.65	57.35	37.74	19.59	41.20	58.80	30.10	28.53
Chassis and Drivetrain Parts	28.15	71.85	50.86	20.97	31.92	68.08	44.75	23.29
Electrical and Electric Components	49.75	50.25	39.17	10.87	34.74	65.26	5.50	51.35
Engines and Parts	49.13	50.87	43.05	7.81	46.83	53.17	46.18	4.80
Tires and Tubes	100.00	0.00	0.00	0.00	70.75	29.25	24.47	4.76
Miscellaneous Parts	41.58	58.42	38.28	20.10	37.66	62.34	19.57	41.71

Source: Authors' own calculations.

Table 8. Development of Intra-Industry Trade in the Austrian Auto-Parts Industry by Product Groups- Decomposition Method

Product Groups	1996				2006			
	One-way	TWT	TWTV	TWTH	One-way	TWT	TWTV	TWTH
Bodies and Parts	11.21	88.79	59.42	29.36	11.16	88.84	43.47	45.37
Chassis and Drivetrain Parts	6.10	93.90	67.41	26.46	8.21	91.79	63.72	27.94
Electrical and Electric Components	18.06	81.94	62.13	19.53	14.70	85.30	10.28	60.23
Engines and Parts	38.51	61.49	50.88	10.60	4.96	95.04	74.95	15.54
Tires and Tubes	100.00	0.00	0.00	0.00	22.94	77.06	62.83	14.22
Miscellaneous Parts	8.86	91.14	53.35	37.74	20.60	79.40	24.42	53.24

Source: Authors' own calculations.

Table 9. Determinants of Vertical Intra-Industry Trade in the Austrian Auto-Parts Industry, 1996-2006

Independent Variables	Pooled OLS	Fixed Effects	FGLS	HT
GDP_{kt}	0.500	0.722	1.088	0.465
	(2.17)**	(0.18)	(15.63)***	(2.14)**
$DGDP_{kt}$	-0.945	0.404	-3.363	-0.928
	(-1.41)	(0.07)	(-17.38)***	(-1.39)
$DPGDP_{kt}$	1.291	-0.420	2.384	1.301
	(4.18)***	(-0.09)	(11.73)***	(4.17)***
FDI_{kt}	0.130	-0.027	0.130	0.130
	(4.00)***	(-0.37)	(6.58)***	(3.95)***
$EXCH_{kt}$	-0.026	-0.080	0.043	-0.027
	(-0.73)	(-0.63)	(1.94)*	(0.75)
$DIST_{k}$	-0.409		-0.663	-0.410
	(-4.44)***		(-14.98)***	(-4.42)***
$EU15_{k}$	-0.565		-0.109	-0.567
	(-4.82)***		(-2.02)**	(-4.80)***
Constant	-25.81	-16.101	-51.282	-25.155
	(-3.63)***	(-0.29)	(-15.90)***	(-3.61)***
R-squared	0.44	0.003		0.44
F-statistics	20.37***	0.16		19.99***
Wald statistic: χ^2 (8)			860.03***	
Wooldridge test for autocorrelation: F (1,24)			0.730	
LR-test for heteroscedasticity: χ^2 (27)			173.11***	
Chow test of FE vs OLS: F (32,179)		14.49***		
Breusch-Pagan test of RE vs OLS: χ^2 (1)			233.68***	
Hausman test of RE vs FE: χ^2 (7)			9.46	
Hausman test of HT vs FE: χ^2 (7)				5.39
Hansen overid. test: χ^2 (1)				0.001
# of groups		28	28	
# of observations	220	220	228	220

Note: The dependent variable is the logit transformation of $VIIT_{kt}$, Grubel-Lloyd index in vertically differentiated products. Heteroskedasticity-consistent t-statistics (White-Newey) are reported in the first, second, and last columns. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Table 10: Determinants of Two-Way Trade in Vertically Differentiated Goods in the Austrian Auto-Parts Industry, 1996-2006

Independent Variables	Pooled OLS	Fixed Effects	FGLS	HT
GDP_{kt}	0.781	2.217	1.814	0.774
	(1.98)**	(0.40)	(11.40)***	(1.95)*
$DGDP_{kt}$	-1.549	-1.432	-5.226	-1.527
	(-1.26)	(-0.17)	(-10.54)***	(-1.24)
$DPGDP_{kt}$	1.556	-2.756	2.093	1.564
	(2.90)***	(-0.40)	(7.65)***	(2.84)***
FDI_{kt}	0.180	0.079	0.102	0.179
	(3.098)***	(0.66)	(4.17)***	(3.90)***
$EXCH_{kt}$	-0.029	-0.170	-0.009	-0.031
	(-0.61)	(-1.35)	(-0.32)	(-0.64)
$DIST_k$	-0.509		-0.883	-0.510
	(-3.81)***		(-14.10)***	(-3.77)***
$EU15_k$	-0.657		-0.340	-0.661
	(-4.28)***		(-3.56)***	(-4.22)***
Constant	-34.834	-30.089	-64.436	-33.160
	(-3.07)***	(-0.40)	(-13.24)***	(-3.02)***
R-squared	0.42	0.01		0.41
F-statistics	16.48***	0.42		15.75***
Wald statistic: χ^2 (8)			527.40***	
Wooldridge test for autocorrelation: F (1,24)			3.054*	
LR-test for heteroscedasticity: χ^2 (27)			148.08***	
Chow test of FE vs OLS: F (32,179)		10.32***		
Breusch-Pagan test of RE vs OLS: χ^2 (1)			137.90***	
Hausman test of RE vs FE: χ^2 (7)			3.56	
Hausman test of HT vs FE: χ^2 (7)				1.08
Hansen overid. test: χ^2 (1)				0.001
# of groups		28	28	
# of observations	220	220	220	220

Note: The dependent variable is the logit transformation of $TWTV_{kt}$, the share of two-way trade in vertically differentiated products. Heteroskedasticity-consistent t-statistics (White-Newey) are reported in the first, second, and last columns. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.