VERTICAL INTRA-INDUSTRY TRADE and FRAGMENTATION: AN EMPIRICAL EXAMINATION OF THE U.S. AUTO-PARTS INDUSTRY

Kemal TÜRKCAN* **and Ayşegül ATEŞ****

ABSTRACT

In this study the extent of intra-industry trade in the U.S. auto-parts trade is analyzed by decomposing the U.S. auto-parts trade into one-way trade, vertical intra-industry trade (IIT) and horizontal intra-industry trade. Then the development of vertical IIT in auto-part industry, as an indicator for international fragmentation of production process between the U.S. and its 29 trading partners, are examined and various country-specific hypotheses drawn from fragmentation literature are tested using newly developed panel econometrics techniques and more recent data period from 1989 to 2006. The results show that a substantial part of intra-industry trade in U.S. auto-parts industry is vertical IIT and econometric results mainly support the hypotheses drawn from the fragmentation literature.

Key words: Intra-industry trade, Vertical intra-indıstry trade, The U.S. auto-parts industry, Fragmentation, intermediate goods.

JEL classification: F-14, F-15

* Kemal Türkcan, Akdeniz University, Department of Economics, Dumlupınar Bulvarı Kampüs, 07058, Antalya, Turkey; Tel: (242)-3106427; Fax: 242-2274454; Email: kturkcan@akdeniz.edu.tr.

** Ayşegül Ateş, Akdeniz University, Department of Economics, Dumlupınar Bulvarı Kampüs, 07058, Antalya, Turkey; Tel: (242)-3101860; Fax: 242-2274454; Email: aates@akdeniz.edu.tr

VERTICAL INTRA-INDUSTRY TRADE and FRAGMENTATION: AN EMPIRICAL EXAMINATION OF THE U.S. AUTO-PARTS INDUSTRY

1. INTRODUCTION

A distinguishing feature of present economic globalization is fragmentation of production.[1] As the 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 that led to an increase in trade of intermediate goods as goods are designed, produced and assembled in different locations.

Despite the increase in intermediate goods trade, the empirical literature on the fragmentation has so far simply provided descriptive statistics on the importance of trade in intermediate goods induced by international fragmentation of production process (Feenstra, 1998; Hummels et al., 1999; Yeats, 2001; Kimura and Ando, 2005; Kaminski and Ng, 2005; Ando, 2006). With the exception of Görg (2000), Jones et al. (2005), Egger and Egger (2005), and Kimura et al. (2007), the empirical studies of the determinants of fragmentation remain sparse. In this study, we try to fill this gap by studying the determinants of fragmentation in the U.S auto-parts industry, where the trade based on production sharing is important.

[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).

One of the empirical problems in aforementioned 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 and Ando (2006) argues that vertical intra-industry trade (IIT) in intermediate goods resulting from production sharing activities seems to be appropriate indicator to address the extent of fragmentation for a particular industry. Hence, following Ando (2006) and Wakasugi (2007), the goal of this paper is to calculate the indices of vertical IIT in auto-industry between the U.S. and its 29 trading partners and analyze the determinants of vertical IIT, which is used as a proxy for the extent of fragmentation in this study.[2]

Auto-parts and components trade drastically increased in both exports and imports.[3] The nominal value of imported auto-parts tripled from $ 31.5 billion in 1989 to $ 93 billion and the nominal value of exported auto-parts also rose from $ 17 billion in 1989 to $ 53 billion in 2006 in the U.S. (See Figure 1). This increase in auto-parts trade implies that intra-industry trade and fragmentation has become much more important than before in the U.S. auto-parts industry. In this paper, the extent of IIT in the U.S. auto-parts trade is analyzed by decomposing the U.S. auto-parts trade into one-way

[2] Several empirical studies have analyzed the determinants of vertical IIT 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. Besides, among those studies only Montout et al. (2002) examine IIT in the U.S. auto-industry in the context of NAFTA for a shorter time period from 1992 to 1999.

[3] See Table 1 for the U.S. auto-parts trade by countries.

trade, vertical IIT and horizontal IIT.[4] Then, fragmentation in the U.S. auto-parts industry are examined over time by using vertical IIT as an indicator of fragmentation between the U.S. and its 29 trading partners for the period, 1989 to 2006. The paper provides empirical support for the structure and determinants of vertical IIT as an indicator of fragmentation process in the U.S. auto-parts industry by using finely disaggregated auto-parts trade data. Hypothesis drawn from the fragmentation literature are tested using panel data techniques.

Major findings include: 1) we identify the dominance of vertical IIT over horizontal IIT for the U.S. auto-parts bilateral IIT and vertical IIT in the U.S. auto-parts increased in 2006 compared with 1989 for almost all countries, 2) trade in bodies and parts, and chassis and drivetrain parts subcategories are mainly IIT and vertical IIT dominates in these subcategories, and 3) hypothesis drawn from the fragmentation literature contribute to explain vertical IIT.

This paper is organized as follows: Section 2 surveys empirical methodologies on the measurement of fragmentation and outlines the methodology for measurement of IIT. Section 3 discusses the determinants of vertical IIT and empirical model. Section 4 explains the empirical findings and Section 5 concludes the study.

2. BRIEF SURVEY of EMPIRICAL METHODOLOGIES on THE MEASUREMENT of FRAGMENTATION and IIT

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

[4] 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 rest is classified as vertical IIT.

2.1. 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.[5] 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 imported intermediate goods usage and export of each industry's output (See Feenstra and Hanson, 1996 and 1997, Campa and Goldberg, 1997, and Hummels et al., 1998). It is difficult to capture the degree of fragmentation with the available I-O tables due to the fact that these tables do not include information 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) measures fragmentation by using outward processing trade (OPT) and inward processing trade (IPT) statistics.[6] 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

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

[6] 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.

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 goods, which are then exported back to its home base for assembly.[7] Despite the fact that intra-firm trade statistics clearly establish the link between fragmentation and MNEs thus it is better than other three 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 volume of trade in parts and components (See Yeats, 2001, Kaminski and Ng, 2005, and Kimura et al., 2007) or intra-industry trade index (Kol and Rayment, 1989; Schüler, 1995; and 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

[7] 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.

approach is that many parts related to above groups come under different headings.[8] Hence, this method also 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 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 is considered as vertical IIT, which may capture trade in intermediate goods with different quality. Vertical IIT also could 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 was mainly originated from the vertical linkages in production rather than trade in quality differentiated goods.[9]

Overall, aforementioned brief review of fragmentation literature suggests that vertical IIT in intermediate goods seems to be an appropriate indicator to address the

[8] 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.

[9] 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 the U.S. auto-parts trade.

extent of fragmentation in a particular industry. [10] 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 that is not related to 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. Turning to the effects of vertical specialization, we expect that vertical specialization definitely generates unit value differences across exported and imported intermediates where both are technologically related. 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 U.S. auto-parts industry.

2.2. 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 may 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.

---

[10] 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 the U.S. auto-parts industry mainly due to data constraints.

The most widely used method called G-L index for computing the IIT is developed by Grubel and Lloyd (1971).[11] In recent years, an alternative method suggested by Fontagne and Freudenberg (1997), Fontagne et al. (1997), and Fontagne et al. (2006) is used 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 (TWTH).[12] As Fontagne and Freudenberg (1997) point out that the G-L index can create a problem that there are two different explanations for the same majority trade flow (such as exports): inter-industry part of the majority flow by traditional trade theory and intra-industry part of the majority flow by the new trade theories. To avoid this problem, Fontagne and Freudenberg (1997) proposed a 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 percent of the majority flow. Otherwise, both exports and imports are regarded as inter-industry trade.[13]

---

[11] 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.

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

[13] 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.

Given the criticisms of Fontagne and Freudenberg (1997) over the measurement of intra-industry trade, we apply both the G-L type trade decomposition and the Fontagne and Freudenberg's method to the U.S.'s auto-parts industry trade with its trading partners to decompose bilateral trade flows into its components of inter-industry trade, horizontal IIT and vertical IIT.[14] These two methods used to measure intra-industry trade are briefly described in the following subsections.

2.2.1. The Grubel-Lloyd Type Trade Decomposition

As indicated above over the problems of unadjusted G-L index, this paper computes the extent of intra-industry trade between the U.S. 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 the U.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 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 is 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

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

from the 6-digit level of HTS.[15]

Once, the auto-parts products are selected for our study, the second step is to decompose total IIT into its two components of horizontal IIT and vertical IIT by using the method suggested by Abd-el-Rahman (1991), Greenway 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;[16]

$$\frac{1}{1.25} \leq \frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \leq 1.25 \qquad (2)$$

where P_{ijkt}^{X} and P_{ijkt}^{M} represent the unit value of the U.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 outside this range:

---

[15] 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.

[16] The choice of 25 % is arbitrary. In trade literature, two common values are often employed, 15 % and 25 %. Greenway et al. (1994), 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.

$$1.25 \le \frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \qquad (3)$$

or

$$\frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \le \frac{1}{1.25} \qquad (4)$$

After goods satisfy equation (2) are determined, the amount of horizontal IIT, $HIIT_{ijkt}$, is calculated using the equation (1). Similarly, when we determine a trade flow as being trade in vertically differentiated goods by using the equations 3 and 4, the G-L index for those goods, $VIIT_{ijkt}$, is measured using the 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 named 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 with 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.

2.2.2. The Decomposition-Type Threshold Method

For comparison purposes, 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 hence 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 percent of the majority flow of trade and as OWT otherwise:[17]

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

where X_{ijkt} and M_{ijkt} are the U.S. exports and imports of product i of industry j with country k at period t.[18]

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:

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

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 one of three trade categories depending on the corresponding trade type, i referring the product, j the industry, k the partner country in year t.

---

[17] 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.

[18] Most previous studies such as Umemoto (2005) used 10 % as benchmark, though there are some studies use different benchmark values such as Montout et al. (2002). In our study, 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.

2.2.3 Evidence of IIT in the U.S. Auto-Parts Industry

Using approaches outlined in the previous section, Figure 2 presents IIT and its components in auto-parts industry in the U.S. over the period 1989 to 2006. In the auto-parts industry, one-way trade is still the main pattern of trade and vertical IIT has become important (See Figure 2).[19] Most of IIT in auto-parts is vertical IIT and vertical IIT has been rising since 2000s. This might be due to rising importance of vertical international production sharing suggesting that international fragmentation has become an essential part of the U.S. auto-parts industry. Horizontal IIT is very low compare with vertical IIT in auto-parts trade. These results also hold qualitatively for share results obtained from decomposition type of threshold method. However, quantatively the results of decomposition type of threshold method measure for TWT is systematically higher than G-L index results confirming the results of Fontaigne et al. (2006).

There are wide variations of IIT indices and TWT shares across countries (Tables 2 and 3). However, IIT is much higher for auto-parts trade between the U.S. and

[19] Lall et al. (2004) argue that in auto-industry fragmentation is more constrained than 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 are heavy thus making their processing suitable for relocation in closer areas rather than in distant areas.

other members of NAFTA than with other trading partners (Tables 4 and 5). This result can be interpreted as the significance of regional integration on the intensity of IIT in the U.S. auto-industry trade. These findings are in line with Montout et al. (2002)'s results. With the exception of Finland and Austria, vertical IIT went up in 2006 compare to 1989 values (Tables 2 and 3).

IIT in subcategories of auto-parts are shown in Table 4. Compare with 1989 IIT drastically increased in most of the subcategories. As can be seen in Table 4, bodies and parts category has the highest vertical IIT, followed by chassis and drivetrain category. In those two categories IIT exceeded one-way trade in 2006. This finding suggests that mentioned categories are most subject to fragmentation of production process.

In conclusion, one-way trade is the main pattern in the U.S. auto-parts industry. Second, vertical IIT dominates horizontal IIT uniformly. Third, there was an increase in vertical IIT during 2000s, whereas horizontal IIT remained stable during the same period. Fourth, IIT is the main pattern in auto-parts trade between the U.S. and NAFTA countries. Fifth, trade in bodies and parts, and chassis and drivetrain parts subcategories are mainly IIT with 61 % (85 %) and 55 % (77 %) respectively according to the G-L index (decomposition method) and vertical IIT dominates in these subcategories.

3. EMPIRICAL MODEL and the DETERMINANTS of VERTICAL IIT

The following logit transformation model is proposed to explain the determinants of vertical IIT in bilateral auto-parts trade between the U.S. and its 29 trading partners over the 1989-2006 period:

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

where y_{kt} stands for either $VIIT_{kt}$ or $TWTV_{kt}$ between the U.S. and its trading partner country (k), Z_{kt} is a set of m country-specific variables, $DIST_k$ represents the geographic distance, 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 vertical IIT index between the U.S. and its trading partners (k) are used for comparison purpose: 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. The regression analysis is performed using the fixed and random effects models.

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.[20]

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 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 auto-parts industry is expected to be positively related the average market size of the U.S. and its trading partner, denoted as GDP_{kt}.

Differences in market size ($DGDP_{kt}$): Grossman and Helpman (2005) show that trading partner's market size encourages greater degrees of fragmentation between two countries. Firms are likely to find a trading partner in a 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 also reasons to believe that large markets are 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.[21] Consequently, the difference in market size ($DGDP_{kt}$), measured by the

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

[21] 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.

absolute difference of total GDP between the U.S. 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 the U.S. 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 the fragmentation. Following the same logic, in the current study differences in factor endowments is proxied by the absolute value of the difference in per capita GDP between the U.S. 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 will also influence 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.[22] 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 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. The U.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 service-link costs should encourage the international fragmentation of production across countries. [23] 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 service link costs and transportation costs are typically assumed to be a linear function of geographical distance. For instance, Kimura et al. (2007) claim that geographical distance between countries can be viewed as indicative of service-link costs, particularly the transportation and telecommunication

[22] 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.

[23] 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.

costs. Hence, geographical distance between the capital cities of the U.S. and its trading partners, $DIST_k$, is used as 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 the U.S. and its trading partner.[24]

The remaining variables that influence vertical IIT are the bilateral exchange rate and dummy variable for the countries belonging to the NAFTA.

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 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 the U.S. and its trading partners.

NAFTA dummy ($NAFTA_{kt}$): 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 North American Free Trade Agreement ($NAFTA_{kt}$) which takes value 1 if both the

[24] 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.

U.S. and its trading partner are members of the NAFTA and zero otherwise. Regional integration is expected to have positive influence on the share of vertical IIT.

4. EMPIRICAL RESULTS

In estimating the determinants of vertical IIT in auto-parts industry between the U.S. and its 29 trading partners, we estimate equation (7) with four alternative estimation methods for two different concepts of vertical IIT index ($VIIT_{kt}$ and $TWTV_{kt}$) over the period 1989 to 2006. Panel data techniques are employed to empirically investigate the determinants of vertical IIT. Since the dependent variable ranges between 0 and 1, a logit transformation of vertical IIT indices is employed.

Panel data techniques can be performed by both fixed and random effects models as described by Baltagi (1995). In order to be able to choose between the two possible estimation models, several statistical tests were performed. All variables in the estimation equations can vary across country and across time. The question is then whether the data should be pooled across products and across time. One can test the joint significance of these country-specific effects and time-specific effects by employing the Chow's test to determine whether the data should be pooled or not. Under the null hypothesis, the efficient estimator is pooled OLS. Based on the results of the Chow test, the calculated test-statistics, reported in the second columns of Tables 5 and 6, strongly reject the null hypotheses at 1 % significance level which indicates that there are no specific effects. Therefore, the fixed effects specification should be preferred over the simple pooled OLS in our econometric analysis.

In addition, the Breusch-Pagan test is carried out to test for the significance of random individual effect, where the null hypothesis is that there is no random effects. Rejecting the null hypothesis implies that the random effects model should be used over the pooling method. The results reported in the third columns of Tables 5 and 6, reject the null hypothesis of no random effects. In conclusion, Chow test confirms the appropriateness of fixed effects model whereas the Breusch-Pagan test advocates the use of the random effects model. Consequently, the question of model selection arises. To decide whether the fixed effects model or random effects model is appropriate, the Hausman specification test is applied under the null hypothesis that individual effects are uncorrelated with the other regressors in the model. As evident in the third columns of Tables 5 and 6, the resulting Hausman test statistics strongly indicate that the random effects model should be preferred over the fixed effects model. In conclusion, the results suggest that a random effects model is the appropriate estimation model.

In addition, prior to estimation of equation (7), the problems of heteroscedasticity and autocorrelation should be addressed.[25] First, the likelihood ratio test (LR), reported in Tables 5 and 6, has strongly reject the null hypothesis of homoskedasticty suggesting that error variances are specific to countries. In addition to heteroscedasticity, the Wooldridge test for autocorrelation, reported in Tables 5 and 6, has led to the rejection of the null of no first order serial correlation only in the case of $TWTV_{kt}$ suggesting that autocorrelation problem is less severe in the current panel data. Tests for heteroscedasticity and serial correlation suggest the need to employ feasible generalized least squares (FGLS) in order to obtain consistent and efficient estimators. However, as Beck and Katz (1995) have shown that test statistics based on the FGLS can be optimal

[25]Besides addressing the problem of heteroscedasticity and autocorrelation, collinearity among independent variables are also examined and reported in Table A.3. After an examination of collinearity among explanatory variables, it is found that none of the explanatory variables is strongly correlated with each other.

only when there are substantially more time periods per unit than there are cross-sectional units. Since the sample of the model in the current study contains less annual observations per country than number of countries, the FGLS method is not considered as an appropriate technique and therefore, the equation (7) is estimated using the panel-corrected standard errors (PCSE) method developed by Beck and Katz (1995).[26] The PCSE results for two different specifications of vertical IIT index ($VIIT_{kt}$ and $TWTV_{kt}$) are presented in Tables 5 and 6, respectively. Since the PCSE method generate reliable point estimates over the FGLS estimates, in the remainder of the analysis only the results from PCSE estimations are discussed.

The regression results from the PCSE model reported in Tables 5 and 6 generally support the hypotheses drawn from the theoretical models of fragmentation. In addition, as can be seen from the results in Tables 5 and 6, the estimated coefficients are almost the same for $VIIT_{kt}$ and $TWTV_{kt}$ with the exception of $DPGDP_{kt}$, suggesting that the results are robust across both specifications of vertical IIT index.[27] In particular, the results show that the market size variable (GDP_{kt}) have a positive and significant association with vertical IIT, as predicted by the theory. As suggested by Jones and Kierzkowski (2001), greater levels of market size promote greater degree of

---

[26] The signs and significance of the explanatory variables in Tables 5 and 6 are fairly consistent across different econometric models with the exceptions of $DPGDP_{kt}$ and $NAFTA_{kt}$.

[27] Although we do not report the detailed results here, the sensitivity of the results with respect to outliers is also checked. A HTS product is considered as an outlier if its unit value in any year is more than two standard deviations away from the population mean. Outliers 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 outliers.

fragmentation due to increasing returns to scale in service-link activities. This is in line with the result of Jones et al. (2005) and Kimura et al. (2007).

The variable representing difference in size between trading partners ($DGDP_{kt}$) is positively related to both $VIIT_{kt}$ and $TWTV_{kt}$, a common result in the empirical studies of vertical IIT but which is contrary to the predictions of Grossman and Helpman (2005). Hence, the results favor the predictions of Falvey and Kierzkowski (1987) model, where differences in market size gives rise to more trade in vertically differentiated goods, reflecting differences in factor endowments. The findings also confirm the hypothesis that large markets are most likely to be served by local production due to 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.

The results illustrate that dissimilarities in GDP per capita as an indicator of differences in factor endowments have a negative and significant effect on $TWTV_{kt}$ but insignificant effect on $VIIT_{kt}$, inconsistent with the predictions of both Helpman and Krugman's (1985) and Feenstra and Hanson's (1997) theoretical models where the volume of vertical trade or outsourcing tends to increase with greater differences in factor endowments between two countries. This result also differs from previous studies such as Balassa and Bauwens (1987), Blanes and Martin (2000) and Egger and Egger (2005), which include per capita income difference as a proxy for factor endowment differences. 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.[28] Consequently, the negative estimate of the coefficient of $DPGDP_{kt}$ implies that income gap between trading partners discourage firms in developed countries to establish international production networks due to lack of location advantages in developing countries. Given the fact that there are large 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 become dominant and consequently large differences in per capita GDP have a negative influence on the fragmentation of production.[29]

FDI variable (FDI_{kt}) has a significant positive effect on both $VIIT_{kt}$ and $TWTV_{kt}$, confirming our hypothesis that FDI stimulates exchange of intermediates. This result is consistent with 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). This is an important result, since it supports the view that international fragmentation plays a great role in explaining the intra-firm trade in intermediate goods between different plants within the same multinationals.

Moreover, our results indicate that distance variable ($DIST_k$) as a proxy for service-link costs shows a negative and significant relationship with both specifications of vertical IIT, as expected. According to this result, transportation costs significantly

---

[28] 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.

[29] For instance, Kimura et al. (2007) report 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.

hamper the fragmentation of production across countries, verifying the hypothesis developed by Jones and Kierzkowski (2001) that cross-border outsourcing is more favorable if service-link costs are lowered.[30]

Regarding the impact of regional integration on the vertical IIT in intermediate goods, the coefficients for $NAFTA_{kt}$ are positive and statistically significant in the case of $VIIT_{kt}$ and but negative and insignificant in the case of $TWTV_{kt}$.[31] It seems that the NAFTA has been boosting auto-parts trade across borders but not as much as we expected. This result confirms the claim that before NAFTA was in place, the U.S. and especially Canada had very open bilateral trade in automotive industry due to Canada-USA Auto Pact of 1965. As a result of this open trade, the implementation of NAFTA did not have a significant impact on the trade of intermediate goods between the U.S. and member countries.

Finally, bilateral exchange rate changes ($EXCH_{kt}$) have a significant and positive impact on both concepts of vertical IIT. In other words, the magnitude of vertical IIT in auto-parts will decline with depreciation of the dollar. This result is in line with the findings of Swenson (2000) that dollar depreciation has a negative influence on outward processing of U.S. firms.

---

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

[31] This finding is somewhat consistent with the findings of Montout et al. (2001) that NAFTA have a negative impact on the vertical IIT in automotive industry between NAFTA countries using TWTV as dependent variable. In another study, however, Montout et al. (2002) found that considering the degree of specialization by quality within automobile industry, the share of vertical IIT in auto-parts within NAFTA members is positively and significantly associated with NAFTA membership.

5. CONCLUDING REMARKS

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 the U.S. auto-parts industry IIT that represents improvements over previous studies as follows. First, the pattern of the IIT and its components in U.S. auto-parts industry is carefully examined with the applications of different methods to measure IIT between the U.S. and its 29 trading partners. Second the development of the U.S. vertical IIT in auto-parts industry is analyzed, as an indicator for fragmentation, and various country-specific hypotheses drawn from fragmentation literature are tested using panel econometrics techniques.

The results show that a substantial part of IIT in auto-parts industry between the U.S. and its trading partner is vertical IIT. This finding suggests that the international fragmentation has become an essential part of the U.S. auto-industry. Additionally, the vertical IIT is higher in auto-parts trade between the U.S. and other members of NAFTA. Their IIT with the U.S. can be explained by geographical proximity and regional integration. Third, trade in bodies and parts, and chassis and drivetrain parts subcategories are mainly IIT and vertical IIT dominates in these subcategories.

The results obtained from PCSE estimation mainly support the hypotheses drawn from the fragmentation literature. The estimated coefficients are outstandingly similar and robust across the various estimation methods for both specifications of vertical IIT index. In particular, the extent of the U.S. vertical IIT is positively correlated with average market size, difference in market size, outward FDI, exchange rate changes, regional integration dummy while it is negatively correlated with differences in per capita GDP and distance. All the variables are statistically significant in both specifications of vertical IIT index with the exception of differences in per capita GDP and regional integration dummy.

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 reflects 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.

REFERENCES

Abd-el-Rahman, K. S. (1991), "Firms' Competitive and National Comparative Advantages as Joint Determinant of Trade Composition" *Weltwirtschaftliches Archiv*, 127(1):83-97.

Andersson, Thomas and Torbjorn Fredriksson (2000), "Distinction between Intermediate and Finished Products in Intra-Firm Trade", *International Journal of Industrial Organization*, 18:773-792.

Ando, M. (2006), "Fragmentation and Vertical Intra-Industry Trade in East Asia" *North American Journal of Economics and Finance*, 17:257-281.

Ando, Mitsuya and F. Kimura (2007), "Fragmentation in East Asia: Further Evidence", Working Paper, Hitotsubashi University.

Arndt, Sven W. (1997), "Globalization and the Open Economy", *North American Journal of Economics and Finance*, 8(1):71-79.

Arndt, S. W. (2001), *Fragmentation New Production Patterns in the World Economy*. Oxford, Oxford University Press.

Arndt, S. W. and A. Huemer (2005), "Trade, Production Sharing and the Exchange Rate: A Decade of U.S.-Mexican Integration" Working Paper, Lowe Institute of Political Economy.

Aquino, A. (1978), "Intra-Industry Trade and Inter-Industry Specialization as Concurrent Sources of International Trade in Manufactures", *Weltwirtschafiliches Archive*, 114: 175-196.

Balassa, B. (1986), "The Determinants of Intra-Industry Specialization in the United States Trade", *Oxford Economic Papers*, 38, June, 220-233.

Balassa, B. and L. Bauwens (1987), "Intra-Industry Specialization in a Multi-Country and Multi-Industry Framework", *The Economic Journal*, 97(388):923-939.

Baltagi, B. H. (1995), *Econometric Analysis of Panel Data*, New York: John Wiley and Sons.

Beck, N. and J. N. Katz (1995), "What to do (and not to do) with Time-Series Cross-Section Data" *The American Political Science Review*, 89 (3):634-647.

Becuwe, Stephane and Claude Mathieu (1992), "The Determinants of Intra-Industry Trade: The Case of the Automobile Industry", *Weltwirtschaftliches Archiv*, 128(1):34-51.

Blanes, Jose V. and Martin, Carmela (2000), "The Nature and Causes of Intra-Industry Trade: Back to the Comparative Advantage Explanation: The Case of Spain", *Weltwirtschaftliches Archiv*, 136(3):423-441.

Blonigen, Bruce A. (2001), "In Search of Substitution between Foreign Production and Exports", *Journal of International Economics*, 53:81-104.

Borga, Maria and William J. Zeile (2004), "International Fragmentation of Production and the Intrafirm Trade of U.S. Multinational Companies", Bureau of Economic Analysis Working Papers, 013.

Brulhart, M. (2008), "An Account of Global Intra-Industry Trade, 1962-2006" Working Paper 0810, Universite de Lausanne, Institute of Research in Management.

Byun, Jae Jin and Sang-Hyop Lee (2005), "Horizontal and Vertical Intra-Industry Trade: New Evidence from Korea, 1991-1999", *Global Economy Journal*, 5(1):1-29.

Campa and Goldberg (1997), "The Evolving External Orientation of Manufacturing Industries: Evidence from four Countries" NBER Working Papers 5919.

Caves, Richard E. (1981), "Intra-Industry Trade and Market Structure in the Industrial Countries", *Oxford Economic Papers*, 33:203-223.

Chen, H., Kondratowicz, M. and K. Yi (2005), "Vertical Specialization and Three Facts about U.S. International Trade", *North American Journal of Economics and Finance*, 16:35-49.

Clark, Don P. and D. L. Stanley (2003), "Determinants of Intra-Industry Trade between the United States and Industrial Nations", *International Economic Journal*, 17(3): 1-17.

Cooney S. and B. D. Yacobucci (2005) "US Automotive Industry: Policy Overview and Recent History" CRS Report for Congress, 1-102. www.ncseonline.org/NLE/CRSreports/05apr/RL32883.pdf.

Deardoff, Alan V. (1998), "Fragmentation in Simple Trade Models" Discussion Paper No.422, Research Seminar in International Economics, University of Michigan, January 7.

Deardoff, Alan V. (2000), "Financial Crisis, Trade, and Fragmentation" Discussion Paper No.458, Research Seminar in International Economics, University of Michigan, April 18.

Deardoff, Alan V. (2001), "Fragmentation across Cones" In S. Arndt and H. Kierzkowski (eds.), *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press.

Diehl, M. (2001), "International Trade in Intermediate Inputs: The Case of Automobile Industry" Kiel Working Paper, No.1027.

Dixit, A. K. and Joseph, E. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity" *American Economic Review* 67:297-308.

Durkin, John T. and Markus Krygier (2000), "Differences in GDP Per Capita and the Share of Intraindustry Trade: The Role of Vertically Differentiated Trade", *Review of International Economics*, 8 (4):760-774.

Egger, P., M. Pfaffermayr, and Y. W. Schnitzer (2001), "The International Fragmentation of the Value Added Chain: The Effects of Outsourcing to Eastern Europe on Productivity and Wages in Austrian Manufacturing", Austrian Institute of Economic Research (WIFO) Working papers, February.

Egger, Hartmut and Peter Egger (2005), "The Determinants of EU Processing Trade", *World Economy*, 28(2):147-168.

Ethier, W. J. (1982), "National and International Returns to Scale in the Modern Theory of International Trade" *American Economic Review* 72(3):389-405.

Falvey, R. E. (1981), "Commercial Policy and Intra-Industry Trade" *Journal of International Economics,* 11:95-111.

Falvey, R. E. and H. Kierzkowski (1987), "Product Quality, Intra-industry Trade and Imperfect Competition" in H. Kierzkowski (ed.), *Protection and Competition in International Trade*, Oxford: Basil Blackwell.

Feenstra, Robert C. (1998), "Integration of Trade and Disintegration of Production in the Global Economy." *Journal of Economic Perspectives*, 12:31-50.

Feenstra, Robert C. and Gordon H. Hanson (1995), "Foreign Investment, Outsourcing and Relative Wages," NBER Working Papers 5121.

Feenstra, Robert C. and Gordon H. Hanson (1996), "Globalization, Outsourcing, and Wage Inequality," NBER Working Papers 5424.

Feenstra, Robert C. and Gordon H. Hanson (1997), "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras", *Journal of International Economics*. 42:371-393.

Feenstra, Robert C. and Gordon H. Hanson (2001), "Global Production Sharing and Rising Inequality: A Survey of Trade and Wages," NBER Working Papers 8372.

Fontagne, Lionel and M. Freudenberg (1997), "Intra-Industry Trade: Methodological Issues Reconsidered", CEPII Working Paper No: 1997-01.

Fontagne, L., M. Freudenberg, and N. Peridy (1997), "Trade Patterns in the Single Market". CEPII Working Paper No: 1997-07.

Fontagne, L. and M. Freudenberg (2002),"Long-term Trends in Intra-Industry Trade", in H. Grubel and H.-H. Lee (eds.) *Frontiers of Research on Intra-Industry Trade*, Palgrave, London.

Fontagne, L., M. Freudenberg, and G. Gaulier (2006), "A Systematic Decomposition of World Trade into Horizontal and Vertical IIT", *Review of World Economics/Weltwirtschaftliches Archiv,* 142(3):459–475.

Görg, Holger (2000), "Fragmentation and Trade: US Inward Processing Trade in the EU", *Weltwirtschaftliches Archiv*, 136 (3):403-422.

Graziani, G. (2001), "International Subcontracting in the Textile and Clothing Industry". In Swen W. Arndt and H. Kierzkowski (eds.) *Fragmentation:New Production Patterns in the World Economy*, Oxford University Press

Greene, William H. (1997), *Econometric Analysis*, Prentice-Hall Inc., 3rd ed.

Greenway, D. and C. Milner (1986), *The Economics of Intra-Industry Trade*, NewYork, Basil Blackwell Ltd.

Greenway, D., R. Hine, and C. Milner (1995), "Vertical and Horizontal Intra-Industry Trade: A Cross Industry Analysis for the United Kingdom" *Economic Journal*, 105: 1505-1519.

Grossman, Gene M. and E. Helpman (2005), "Outsourcing in a Global Economy", *Review of Economic Studies*, 72:135-159.

Grubel, H. and P. J. Lloyd (1971), "The Empirical Measurement of Intra-Industry Trade", *Economic Record*, 470:494-517.

Grubel, H. and P. J. Lloyd (1975), *Intra-Industry Trade: Theory and Measurement of International Trade in Differentiated Products*, John Wiley&Sons Inc., New York.

Gullstrand, Joakim (2002), "Demand Patterns and Vertical Intra-Industry Trade with Special Reference to North-South Trade", *Journal of International Trade & Economic Development*, 11(4):429-455.

Helpman, Elhanan (1981), "International Trade in the Presence of Product Differentiation, Economies of Scale, and Monopolistic Competition: A Chamberlain-Heckscher-Ohlin Approach", in Gene M. Grossman (eds.), 1992, *Imperfect Competition and International Trade*, The MIT Press.

Helpman, Elhanan (1984), "A Simple Theory of International Trade with Multinational Corporations", *Journal of Political Economy*, 92(3):451-471.

Helpman, E. and Paul Krugman. (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*, MIT Press, Cambridge, MA.

Hummels, D., D. Rapoport, and Kei-Mu Yi (1998), "Vertical Specialization and the Changing Nature of World Trade". *FRBNY Economic Policy Review*, June.

Hummels, D., J. Ishii, and Kei-Mu Yi, (1999), "The Nature and Growth of Vertical Specialization in World Trade", Staff Reports 72, Federal Reserve Bank of New York.

Hummels, D. (2007), "Transportation Costs and International Trade Over Time", Working Paper, Purdue University.

Jones, R. W. and H. Kierzkowski (1990), "The Role of Services in Production and International Trade: A Theoretical Framework", in Jones and A. Krueger (eds.) *The Political Economy of International Trade*, Blackwells.

Jones, R. W. and H. Kierzkowski (2000), "Globalization and Fragmentation of Production" CIES Policy Discussion Paper No.0010, June.

Jones, R. W. and H. Kierzkowski (2001), "A Framework for Fragmentation", in S.W. Arndt, and H. Kierzkowski, *Fragmentation: New Production Patterns in the World Economy*, Oxford University Press.

Jones, R. W., H. Kierzkowski, and Gregory Leonard (2002), "Fragmentation and Intra-Industry Trade". In Lloyd and Lee (eds.), *Frontiers of Research in Intra-Industry Trade*. Palgrave Macmillan Ltd.

Jones, R. W. and H. Kierzkowski (2004), "International Fragmentation and the New Economic Geography", HEI Working Paper, No. 11/2004.

Jones, R., H. Kierzkowski, and C. Lurong (2005). "What does the Evidence Tell us about Fragmentation and Outsourcing", *International Review of Economics and Finance*, 14:305-316.

Ito, K. and M. Umemoto (2004), "Intra-Industry Trade in the ASEAN Region: The Case of Automotive Industry" ICSEAD Working Paper Series, 2004-23.

Kaminski, Bartlomiej and Francis Ng (2005), “Production Disintegration and Integration of Central Europe into Global Markets”, *International Review of Economics and Finance*, 14:377-390.

Kimura, F., Y. Takahashi, and K. Hayakawa (2007), “Fragmentation and Parts and Components Trade: Comparison between East Asia and Europe”, *North American Journal of Economics and Finance*, 18:23-40.

Kimura, Fukunari and Mitsuyo Ando (2005), “Two-dimensional Fragmentation in East Asia: Conceptual Framework and Empirics”, *International Review of Economics and Finance*, 14:317-348.

Klier, Thomas L. and James M. Rubenstein (2006), “Competition and Trade in the U.S. Auto Parts Sector”, *Chicago Fed Letter*, No.222, January.

Kol, J. and P. Rayment. (1989), “Allyn-Young Specilization and Intermediate Goods in Intra-Industry Trade”, In P. K. M Tharakan and Jacob Kol (eds.), *Intra-Industry Trade: Theory, Evidence, and Extensions,* St. Martin’s Press, New York.

Krugman, Paul (1979), “Increasing Returns to Scale, Monopolistic Competition, and International Trade” *Journal of International Economics*, 9:469-479.

Krugman, Paul (1980), “Scale Economies, Product Differentiation, and the Pattern of Trade”, *American Economic Review*, 70:950-959.

Krugman, Paul (1981). “Intra-Industry Specialization and the Gains from Trade” *Journal of Political Economy*, 89, 959-971.

Krugman, Paul and A. J. Venables (1995), “Globalization and the Inequality of Nations”, *Quarterly Journal of Economics*, 110 (4):857-880.

Lall, S., M. Albaladejo, and J. Zhang (2004), "Mapping Fragmentation: Electronics and Automobiles in East Asia and Latin America", *Oxford Development Studies*, 32 (3):407-432.

Lancaster, K. (1979), *Variety, Equity, and Efficieny*. New York, Columbia University Press.

Lancaster, K. (1980), "Intra-Industry Trade under Perfect Monopolistic Competition" *Journal of International Economics*, 10:151-175.

Lloyd, Peter J. (2004), "How Intra-Industry Trade Changed Our Perception of the World Economy," *Singapore Economic Review*, 49(1), 1-17.

Luthje, Teit (2000), "Intra-Industry Trade in Intermediate Goods", Economic Discussion Papers, University of Southern Denmark, No.9.

Martin, J. A. and V. Orts (2001), "A Two-stage Analysis of Monopolistic Competition Models of Intra-Industry Trade", *Investigaciones Economicas*, 25(2): 315-333.

Montout, S., J. L. Mucchielli, and S. Zignago (2001), "Horizontal and Vertical Intra-Industry Trade of NAFTA and MERCOSUR : The Case of the Automobile Industry", Working Paper, presented at 3rd Annual Conference of ETSG.

Montout, S., J. L. Mucchielli, and S. Zignago (2002), "Regionalization and Intra Industry Trade. An Analysis of Automobile Industry Trade in NAFTA", Revue Region et Developpement No:16-2002.

Sanyal, Kalyan K. (1983), "Vertical Specialization in a Ricardian with Continuum of Stages of Production", *Economica*, 50:71-78.

Schuler, M. K. (1995), "On Intra-Industry Trade in Intermediates", *Economia Internazionale*, 48(1):67-84.

Swenson, D. L. (2000), "Firm Outsourcing Decisions: Evidence from U.S. Foreign Trade Zones", *Economic Inquiry*, 38(2):175–189.

Thorbecke, Williem (2008), "The Effect of Exchange Rate Volatility on Fragmentation in East Asia: Evidence from Electronics Industry", Research Institute of Economy, Trade and Industry Discussion Papers.

Türkcan, Kemal (2003), *Determinants of Intra-Industry Trade in Intermediate Goods between the US and OECD Countries,* Unpublished Ph.D. Thesis, North Carolina State University, Raleigh, NC, USA.

Türkcan, Kemal (2007), "Outward Foreign Direct Investment and Intermediate Goods Trade: Evidence from the USA", *Economie Internationale*, 112(4):51-71.

Umemoto, M. (2005), "Development of Intra-Industry Trade between Korea and Japan: The Case of Automobile Parts Industry", CITS Working Paper Series, No. 2005-03 Yokohoma National University.

Venables, A. J. (1996), "Equilibrium Locations of Vertically Linked Industries" *International Economic Review*, 37(2):341-359.

Yeats, Alexander J. (2001), "How Big is Global Production Sharing?", In S. Arndt and H.Kierzkowski (eds.), *Fragmentation: New Production Patterns in the World Economy*. Oxford University Press.

Wakasugi, Ryuhei (2007), "Vertical Intra-Industry Trade and Economic Integration in East Asia", *Asian Economic Papers*, 6(1):26-36.

U.S. Department of Commerce, Office of Aerospace and Automotive Industries' Automotive Team, (2006), "U.S. Automotive Parts Industry Annual Assessment", April http://www.ita.doc.gov/td/auto/domestic/2006Parts.pdf

APPENDIX A.

Definition of Auto-Parts Industry Trade:

The bilateral trade flows data at the 6-digit HTS (Harmonized Tariff System) used in this study were obtained from United States International Trade Commission's (USITC) website: http//www.usitc.gov. The USITC database provides detailed annual bilateral trade data for product exports and imports in values and quantities (in thousands of $ US at current prices) at the six-digit level of the HTS. There are about 5403 items at the 6-digit level of the HTS. For the measurement of IIT in auto-parts industry, we choose to identify 92 items as auto-parts from the 6-digit level of HTS. 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.

Unit values at the 6-digit product level of the HTS 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 the U.S. and its 29 OECD countries are mainly retrieved from World Development Indicators (WDI) CD-ROM. The size of market size (GDP_{kt}) is proxied by the log of the average GDP of the U.S. and its trading partner, expressed in current US dollars ($GDP_{kt} = GDP_{ht} - GDP_{kt}/2$). In addition, $DGDP_{kt}$ is the log of the absolute difference in market size between the U.S. and its trading markets and given as $DGDP_{kt} = \left| GDP_{ht} - GDP_{kt} \right|$, expressed in current U.S. dollars. The log of the absolute difference in per capita GDPs of the U.S. and its trading partner k is defined as $DPGDP_{kt} = \left| PGDP_{ht} - PGDP_{kt} \right|$, expressed in current US dollars.

Moreover, FDI_{kt} is the log of the U.S.'s outward FDI stock into its trading partner k, measured in current US dollars. Outward FDI stock data in current dollars come from Bureau of Economic Analysis database that can be downloaded from http://www.bea.gov. 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 the USA's capital and its trading partner's capital and taken from United States Department of Agriculture's webpage: http//www.usda.gov. 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 data on bilateral exchange rates were taken from the International Financial Statistics (IFS) CD-ROM. The explanatory variables, their predicted signs, and their sources are summarized in Table A.1. Table A.2 provides the summary statistics for different concepts of the IIT index and explanatory variables while Table A.3 presents the correlation matrix between explanatory variables.

Following twenty-nine top USA trading partners are included in the regression analysis: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Singapore, Spain, Sweden, Thailand, Turkey, and the United Kingdom.[32]

[32] The purpose of this choice is 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.

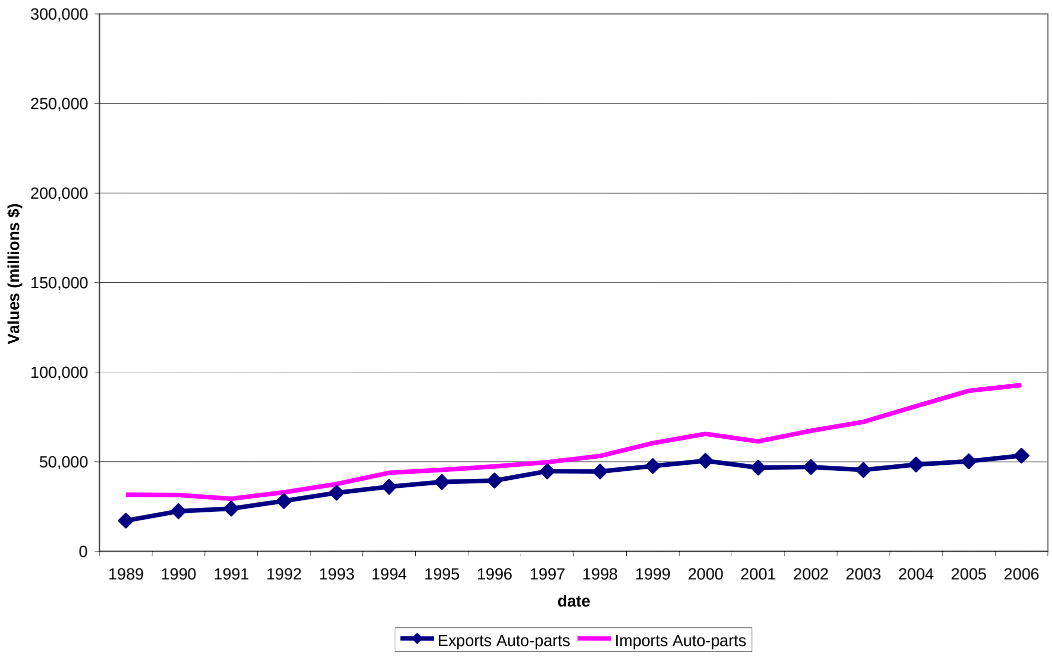
Table A.1. Variable Definitions, Expected Signs, and Sources		
Variable Definition	**Expected Signs**	**Sources**
GDP_{kt} = Average GDP between the US and its trading partner	+	World Bank Development Indicators CD-ROM
$DGDP_{kt}$ = Absolute difference of GDP between the US and its trading partner	+/-	World Bank Development Indicators CD-ROM
$DPGDP_{kt}$ = Absolute difference of per capita GDP between the US and its trading partner	+/-	World Bank Development Indicators CD-ROM
FDI_{kt} = Outward FDI stocks from the US into its trading partner	+	Bureau of Economic Analysis' webpage: http://www.bea.gov.
$DIST_{k}$ = The distance between the US and its trading partner	-	United States Department of Agriculture's web page: http://www.usda.gov
$EXCH_{kt}$ = Bilateral exchange rate between the US and its trading partner	+/-	International Financial Statistics (IFS) CD-ROM
$NAFTA_{kt}$ =Regional integration dummy,1 if the trading partner belongs to NAFTA, else 0	+	

Table A.2. Summary Statistics of Different Concepts of Intra-Industry Trade Index and Explanatory Variables					
Variable	**Mean**	**St. Deviation**	**Minimum**	**Maximum**	**Observations**
$VIIT_{kt}$	0.135	0.104	0.000	0.558	522
$TWTV_{kt}$	0.228	0.174	0.000	0.765	522
GDP_{kt}	29.168	0.180	28.878	29.741	521
$DGDP_{kt}$	29.727	0.216	28.657	30.055	521
$DPGDP_{kt}$	9.491	0.728	5.771	10.518	521
FDI_{kt}	8.304	1.471	4.189	11.379	478
$DIST_{k}$	8.931	0.594	6.610	9.676	522
$EXCH_{kt}$	1.135	1.780	-6.214	7.245	508
Note: All variables are in natural logarithmic form.					

Table A.3. Correlation Matrix Between Explanatory Variables

Variables	GDP_{kt}	$DGDP_{kt}$	$DPGDP_{kt}$	FDI_{kt}	$DIST_{k}$	$EXCH_{kt}$
GDP_{kt}	1.000					
$DGDP_{kt}$	0.394	1.000				
$DPGDP_{kt}$	-0.036	0.289	1.000			
FDI_{kt}	0.458	-0.049	-0.023	1.000		
$DIST_{k}$	-0.023	-0.005	0.165	-0.372	1.000	
$EXCH_{kt}$	0.148	-0.128	0.009	-0.162	0.318	1.000

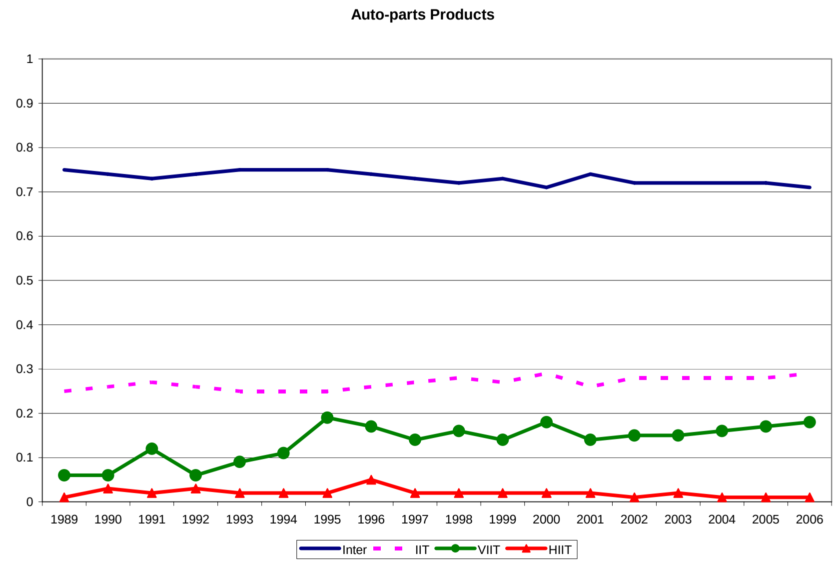
Figure 1. The U.S. Auto-Parts Trade with World, 1989-2006



Authors' own calculations

Figure 2. Development of Intra-Industry Trade in the U.S. Auto-Parts Trade

a. G-L Index



b. Decomposition-Type Threshold Method

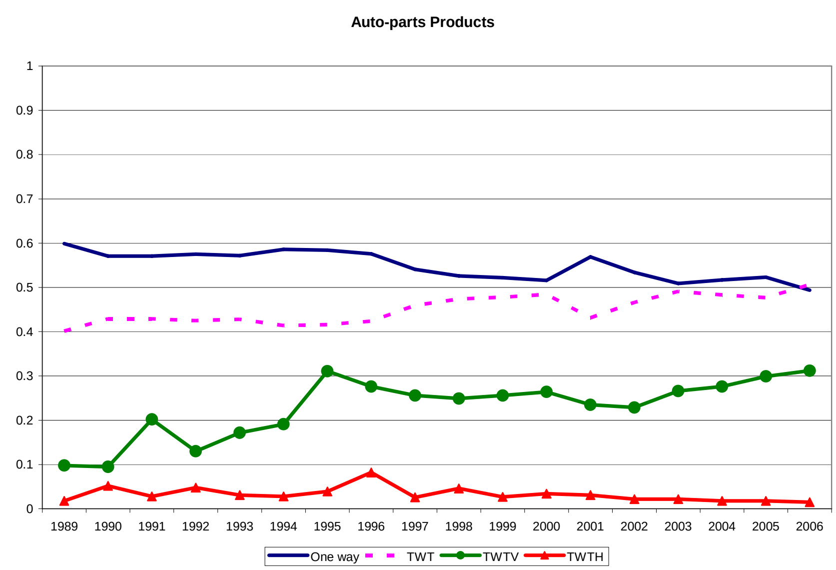


Table 1. The U.S. Auto-Parts Trade by Countries (Values is in Millions of $)								
	1989				2006			
Countries	Exports		Imports		Exports		Imports	
	Value	Share	Value	Share	Value	Share	Value	Share
Australia	357.9	0.0210	63.7	0.0020	874.3	0.0164	185.0	0.0020
Austria	35.5	0.0021	74.3	0.0024	887.7	0.0166	355.5	0.0038
Belgium	195.7	0.0115	107.9	0.0034	394.5	0.0074	136.0	0.0015
Brazil	141.7	0.0083	840.3	0.0266	601.2	0.0113	2,002.5	0.0216
Canada	9,828.5	0.5781	9,387.5	0.2973	31,895.7	0.5970	17,274.5	0.1861
China	23.7	0.0014	59.5	0.0019	815.3	0.0153	6,147.4	0.0662
Denmark	7.6	0.0004	9.4	0.0003	17.4	0.0003	30.2	0.0003
Finland	16.2	0.0010	10.0	0.0003	42.2	0.0008	52.8	0.0006
France	133.0	0.0078	776.6	0.0246	657.0	0.0123	1,115.4	0.0120
Germany	410.9	0.0242	1,939.7	0.0614	1,591.2	0.0298	6,582.2	0.0709
Hong Kong	24.0	0.0014	166.2	0.0053	102.8	0.0019	118.0	0.0013
Ireland	8.1	0.0005	4.3	0.0001	39.7	0.0007	19.7	0.0002
Italy	78.5	0.0046	432.2	0.0137	139.2	0.0026	723.9	0.0078
Japan	618.4	0.0364	10,954.8	0.3469	1,747.7	0.0327	13,255.8	0.1428
Korea	158.9	0.0093	696.3	0.0221	570.1	0.0107	3,136.3	0.0338
Malaysia	4.5	0.0003	12.4	0.0004	25.9	0.0005	207.4	0.0022
Mexico	3,310.4	0.1947	4,390.3	0.1390	12,795.1	0.2395	23,688.2	0.2552
Netherlands	121.7	0.0072	49.6	0.0016	356.4	0.0067	90.9	0.0010
New Zealand	18.1	0.0011	24.2	0.0008	30.5	0.0006	13.0	0.0001
Norway	10.9	0.0006	7.0	0.0002	28.9	0.0005	27.2	0.0003
Philippines	26.9	0.0016	165.0	0.0052	115.6	0.0022	498.7	0.0054
Poland	2.8	0.0002	3.9	0.0001	47.5	0.0009	93.7	0.0010
Portugal	5.1	0.0003	17.0	0.0005	18.8	0.0004	91.5	0.0010
Singapore	83.0	0.0049	121.5	0.0038	238.5	0.0045	78.9	0.0008
Spain	28.3	0.0017	353.7	0.0112	277.9	0.0052	403.4	0.0043
Sweden	102.9	0.0061	124.3	0.0039	197.8	0.0037	550.2	0.0059
Thailand	37.1	0.0022	113.8	0.0036	78.7	0.0015	888.3	0.0096
Turkey	30.7	0.0018	11.1	0.0004	41.6	0.0008	91.0	0.0010
United Kingdom	447.1	0.0263	660.2	0.0209	871.5	0.0163	938.6	0.0101

Source: Authors' own calculations.

Table 2. Development of Intra-Industry Trade in US Auto-Parts Industry-G-L Index										
	1989					2006				
Countries	Inter	IIT	VIIT	HIIT	IIT (no unit value)	Inter	IIT	VIIT	HIIT	IIT (no unit value)
Australia	0.861	0.139	0.021	0.001	0.113	0.795	0.205	0.116	0.002	0.086
Austria	0.793	0.207	0.168	0.005	0.033	0.825	0.175	0.094	0.000	0.080
Belgium	0.700	0.300	0.039	0.010	0.251	0.838	0.162	0.106	0.002	0.054
Brazil	0.792	0.208	0.039	0.001	0.168	0.708	0.292	0.242	0.009	0.041
Canada	0.355	0.645	0.167	0.016	0.462	0.404	0.596	0.251	0.104	0.241
China	0.787	0.213	0.039	0.012	0.161	0.776	0.224	0.174	0.004	0.046
Denmark	0.687	0.313	0.040	0.006	0.266	0.761	0.239	0.188	0.001	0.051
Finland	0.633	0.367	0.174	0.000	0.193	0.747	0.253	0.039	0.011	0.202
France	0.766	0.234	0.049	0.016	0.169	0.639	0.361	0.191	0.006	0.163
Germany	0.667	0.333	0.046	0.040	0.247	0.678	0.322	0.265	0.009	0.046
Hong Kong	0.907	0.093	0.056	0.000	0.037	0.690	0.310	0.100	0.006	0.205
Ireland	0.828	0.172	0.072	0.000	0.100	0.759	0.241	0.155	0.000	0.085
Italy	0.827	0.173	0.049	0.019	0.105	0.710	0.290	0.209	0.015	0.067
Japan	0.891	0.109	0.015	0.034	0.059	0.804	0.196	0.143	0.013	0.038
Korea	0.725	0.275	0.088	0.013	0.175	0.725	0.275	0.243	0.004	0.028
Malaysia	0.913	0.087	0.012	0.000	0.075	0.821	0.179	0.120	0.001	0.058
Mexico	0.555	0.445	0.076	0.040	0.329	0.441	0.559	0.409	0.027	0.124
Netherlands	0.681	0.319	0.053	0.047	0.219	0.851	0.149	0.104	0.008	0.038
New Zealand	0.851	0.149	0.014	0.054	0.081	0.719	0.281	0.172	0.000	0.108
Norway	0.720	0.280	0.016	0.018	0.246	0.604	0.396	0.187	0.000	0.209
Philippines	0.934	0.066	0.003	0.001	0.062	0.648	0.352	0.011	0.000	0.341
Poland	0.736	0.264	0.004	0.000	0.261	0.552	0.448	0.085	0.000	0.363
Portugal	0.926	0.074	0.024	0.000	0.050	0.808	0.192	0.180	0.001	0.011
Singapore	0.806	0.194	0.040	0.008	0.145	0.719	0.281	0.213	0.001	0.067
Spain	0.910	0.090	0.014	0.002	0.074	0.642	0.358	0.300	0.001	0.057
Sweden	0.356	0.644	0.090	0.003	0.552	0.801	0.199	0.166	0.002	0.031
Thailand	0.756	0.244	0.020	0.000	0.224	0.851	0.149	0.092	0.011	0.046
Turkey	0.748	0.252	0.142	0.001	0.109	0.671	0.329	0.255	0.000	0.074
United Kingdom	0.494	0.506	0.117	0.003	0.386	0.479	0.521	0.364	0.020	0.133
Mean	0.745	0.255	0.058	0.012	0.185	0.706	0.294	0.178	0.009	0.107

Source: Authors' own calculations.

Table 3. Development of Intra-Industry Trade in US Auto-Parts Industry- Decomposition-Type Threshold Method

Countries	1989					2006				
	One-way	TWT	TWTV	TWTH	Not Classified TWT	One-way	TWT	TWTV	TWTH	Not Classified TWT
Australia	0.841	0.159	0.029	0.000	0.129	0.735	0.265	0.156	0.001	0.107
Austria	0.447	0.553	0.501	0.023	0.029	0.602	0.398	0.342	0.000	0.056
Belgium	0.543	0.457	0.064	0.015	0.378	0.595	0.405	0.316	0.002	0.087
Brazil	0.741	0.259	0.039	0.000	0.220	0.476	0.524	0.463	0.001	0.060
Canada	0.072	0.928	0.207	0.028	0.693	0.175	0.825	0.379	0.142	0.305
China	0.648	0.352	0.063	0.014	0.274	0.616	0.384	0.325	0.005	0.055
Denmark	0.660	0.340	0.030	0.006	0.304	0.601	0.399	0.294	0.003	0.102
Finland	0.342	0.658	0.188	0.000	0.470	0.546	0.454	0.031	0.031	0.392
France	0.635	0.365	0.070	0.004	0.291	0.457	0.543	0.306	0.013	0.224
Germany	0.473	0.527	0.084	0.072	0.372	0.431	0.569	0.456	0.020	0.092
Hong Kong	0.897	0.103	0.039	0.000	0.064	0.361	0.639	0.244	0.006	0.388
Ireland	0.699	0.301	0.139	0.000	0.162	0.487	0.513	0.229	0.000	0.283
Italy	0.676	0.324	0.090	0.002	0.232	0.543	0.457	0.333	0.023	0.101
Japan	0.883	0.117	0.019	0.051	0.047	0.608	0.392	0.285	0.043	0.064
Korea	0.585	0.415	0.163	0.015	0.237	0.457	0.543	0.498	0.002	0.042
Malaysia	0.850	0.150	0.014	0.000	0.135	0.726	0.274	0.166	0.002	0.107
Mexico	0.310	0.690	0.124	0.067	0.499	0.210	0.790	0.534	0.069	0.187
Netherlands	0.343	0.657	0.100	0.066	0.491	0.700	0.300	0.221	0.006	0.073
New Zealand	0.830	0.170	0.036	0.073	0.061	0.555	0.445	0.289	0.000	0.156
Norway	0.540	0.460	0.020	0.060	0.380	0.431	0.569	0.205	0.000	0.364
Philippines	0.988	0.012	0.001	0.001	0.010	0.170	0.830	0.018	0.000	0.813
Poland	0.640	0.360	0.001	0.000	0.359	0.450	0.550	0.115	0.000	0.435
Portugal	0.982	0.018	0.010	0.000	0.007	0.553	0.447	0.422	0.001	0.025
Singapore	0.757	0.243	0.070	0.005	0.168	0.554	0.446	0.353	0.004	0.089
Spain	0.937	0.063	0.022	0.003	0.038	0.415	0.585	0.510	0.002	0.074
Sweden	0.189	0.811	0.114	0.007	0.689	0.513	0.487	0.416	0.001	0.069
Thailand	0.252	0.748	0.068	0.000	0.680	0.698	0.302	0.138	0.019	0.145
Turkey	0.536	0.464	0.171	0.004	0.289	0.470	0.530	0.425	0.000	0.105
United Kingdom	0.074	0.926	0.366	0.004	0.556	0.188	0.812	0.576	0.042	0.195
Mean	0.599	0.401	0.098	0.018	0.285	0.494	0.506	0.312	0.015	0.179

Source: Authors' own calculations.

Table 4. Development of Intra-Industry Trade in US Auto-Parts Industry by Product Groups

a. G-L Index

Product Groups	**1989**				**2006**			
	Inter	**IIT**	**VIIT**	**HIIT**	**Inter**	**IIT**	**VIIT**	**HIIT**
Bodies and Parts	0.637	0.363	0.113	0.000	0.389	0.611	0.537	0.009
Chassis and Drivetrain Parts	0.517	0.483	0.002	0.002	0.452	0.548	0.271	0.004
Electrical and Electric Components	0.679	0.321	0.059	0.005	0.791	0.209	0.080	0.016
Engines and Parts	0.629	0.371	0.348	0.002	0.630	0.370	0.158	0.182
Tires and Tubes	0.627	0.373	0.158	0.215	0.750	0.250	0.243	0.006
Miscellaneous Parts	0.511	0.489	0.022	0.005	0.654	0.346	0.166	0.006

b. Decomposition-Type Threshold Method

Product Groups	**1989**				**2006**			
	One-way	**TWT**	**TWTV**	**TWTH**	**One-way**	**TWT**	**TWTV**	**TWTH**
Bodies and Parts	0.369	0.631	0.160	0.032	0.151	0.849	0.718	0.023
Chassis and Drivetrain Parts	0.331	0.669	0.003	0.002	0.233	0.767	0.406	0.007
Electrical and Electric Components	0.513	0.487	0.066	0.006	0.631	0.369	0.140	0.072
Engines and Parts	0.511	0.489	0.421	0.031	0.371	0.629	0.287	0.292
Tires and Tubes	0.370	0.630	0.233	0.397	0.641	0.359	0.356	0.003
Miscellaneous Parts	0.306	0.694	0.048	0.012	0.311	0.689	0.384	0.020

Source: Authors' own calculations.

Table 5. Determinants of Vertical Intra-Industry Trade in the U.S. Auto-Parts Industry, 1989-2006

Independent Variables	**Pooled OLS**	**Fixed Effects**	**FGLS**	**PCSE**
GDP_{kt}	6.751	22.424	1.344	6.751
	(4.11)***	(8.73)***	(3.96)***	(5.32)***
$DGDP_{kt}$	3.191	12.179	0.405	3.191
	(3.53)***	(8.39)***	(1.68)*	(4.00)***
$DPGDP_{kt}$	-0.051	-0.086	0.287	-0.051
	(-0.74)	(-1.27)	(3.79)***	(-1.26)
FDI_{kt}	0.195	0.087	0.244	0.195
	(4.23)***	(1.85)*	(4.79)***	(7.57)***
$DIST_{k}$	-0.242	-0.215	-0.351	-0.242
	(-2.56)**	(-2.35)**	(-3.80)***	(-4.43)***
$EXCH_{kt}$	0.036	0.059	0.058	0.036
	(1.29)	(2.22)**	(2.39)**	(2.71)***
$NAFTA_{kt}$	0.243	0.296	0.046	0.243
	(1.19)	(1.51)	(0.34)	(2.24)**
Constant	-290.784	-1017.049	-55.047	-290.784
	(-4.00)***	(-8.67)***	(-6.87)***	(-4.86)***
R-squared	0.29	0.06		0.29
F-statistics	23.96***	34.69***		
Wald statistic: χ^2 (7)			263.72***	29174.05***
Wooldridge test for autocorrelation: F (1,28)			10.70***	
LR-test for heteroscedasticity: χ^2 (28)			177.20***	
Chow test (43,415)		6.43***		
Breusch-Pagan LM test for random effects: χ^2 (1)			219.85***	
Hausman specification test: χ^2 (6)			3.40	
# of groups	29	29	29	29
# of observations	466	466	466	466

Notes: The dependent variable is the logit transformation of $VIIT_{kt}$, G-L index in vertically differentiated products.

Heteroskedasticity-consistent t-statistics (White-Newey) are reported in the first and second columns. ***, **, * indicate statistical significance at 1%, 5 %, and 10% levels, respectively.

Table 6: Determinants of Two-Way Trade in Vertically Differentiated Goods in the U.S. Auto-Parts Industry, 1989-2006

Independent Variables	Pooled OLS	Fixed Effects	FGLS	PCSE
GDP_{kt}	5.339	24.704	1.176	5.339
	(2.55)**	(7.55)***	(3.73)***	(3.77)***
$DGDP_{kt}$	2.213	13.337	0.101	2.213
	(1.88)*	(6.97)***	(0.45)	(2.60)***
$DPGDP_{kt}$	-0.102	-0.146	0.191	-0.102
	(-1.26)	(-1.81)*	(3.04)***	(-1.66)*
FDI_{kt}	0.295	0.167	0.369	0.295
	(5.47)***	(3.08)**	(8.40)***	(9.69)***
$DIST_{k}$	-0.395	-0.343	-0.553	-0.395
	(-3.13)***	(-2.92)***	(-5.36)***	(-3.74)***
$EXCH_{kt}$	0.057	0.085	0.071	0.057
	(1.57)	(2.49)**	(2.81)***	(3.33)***
$NAFTA_{kt}$	-0.079	0.039	-0.120	-0.079
	(-0.28)	(0.16)	(-0.76)	(-0.42)
Constant	-219.617	-116.43	-38.752	-219.617
	(-2.35)**	(-7.37)***	(-5.26)***	(-3.34)***
R-squared	0.29	0.10		0.29
F-statistics	25.63***	34.12***		
Wald statistic: χ^2 (7)			428.55***	4547.53***
Wooldridge test for autocorrelation: F (1,28)			2.134	
LR-test for heteroscedasticity: χ^2 (28)			161.21***	
Chow test (43,415)		5.58***		
Breusch-Pagan LM test for random effects: χ^2 (1)			201.65***	
Hausman specification test: χ^2 (6)			1.60	
# of groups	29	29	29	29
# of observations	466	466	466	466

Notes: 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 and second columns. ***, **, * indicate statistical significance at 1%, 5 %, and 10% levels, respectively.