Structure and Determinants of Intra-Industry Trade in the U.S. Auto-Industry

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Abstract The present paper examines composition of trade patterns, and development of intra-industry trade (IIT) between the US and its 37 trading partners in auto-industry for 1989-2006 period. This paper analyzes trade patterns and the extent of IIT in the US auto-industry by decomposing the US auto-industry trade into inter-industry trade, horizontal IIT, and vertical IIT and tests empirically various country-specific factors concerning the determinants of IIT and its components between the US and its major trading partners using the gravity model. The results show that a substantial part of IIT in the US auto-industry was vertical IIT and vertical IIT increased over the data period. Increase in vertical IIT in auto-industry indicates that the international fragmentation of production process has become important in the US auto-industry. The econometric results mainly support the hypothesis derived from the literature and also confirms the fact that determinants of horizontal IIT and vertical IIT differ. In particular, the findings show that the extent of the US horizontal IIT in auto-industry is positively correlated with difference in per capita GDP and outward FDI variable while it is negatively correlated with distance and bilateral exchange rate. On the other hand, vertical IIT is positively associated with the average market size, differences in market size, differences in per capita GDP, and outward FDI, and distance while it is negatively correlated with the bilateral exchange rate variable.

Key words: Intra-industry trade, Grubel-Lloyd index, auto-industry, the US

JEL classification: F-14, F-15

1. Introduction

The global automobile industry has been undergoing significant structural transformation in recent years.[1] First, automakers in the US 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 through FDI. 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 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.[2] 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. Consequently, these changes in the global auto-industry have forever altered the relationship between motor vehicle manufacturers and auto-parts suppliers.

These global trends that have shaped and are still shaping the US auto-industry over the last two decades also have a major impact on the international pattern of the US auto-industry trade.[3] Recent empirical findings suggest that IIT in the US auto-industry trade has been increasing and dominated by vertical IIT.[4] Restructuring and change that have characterized the auto-industry in the past two decades is one of the most important factors behind this rapid expansion of intra-industry in the US auto-industry.

Intra-industry trade is defined as the simultaneous export and import of products, which belong to the same statistical product category. According to Kol and Rayment (1989), three types of bilateral trade flows may occur between countries: inter-industry trade, horizontal IIT and vertical IIT. Historically, the international trade between countries has been inter-industry form, which is described as the exchange of products belonging to different industries. Traditional trade models, such as Heckscher-Ohlin model or Ricardian model, have tried to explain this type of trade based on comparative advantage in relative technology and factor endowments. However, a significant portion of the world trade over the last three decades took the form of the intra-industry trade rather than inter-industry trade. As a result, the traditional trade models has been considered to be inadequate in explaining this new trade pattern because in these models there is no reason for developed countries to trade in similar but slightly differentiated goods.

Based on these observed facts, a number of theoretical models of IIT have been developed in the 1980s. The recent literature on IIT increasingly emphasizes the importance of differentiating between horizontal IIT and vertical IIT because there are theoretical reasons to divide total IIT into horizontal and vertical IIT. In addition, as explained below, the determinants of IIT for horizontally differentiated goods are quite different from those for vertically differentiated goods.

Horizontal IIT has been defined as the exchange of similar goods that are similar in terms of quality but have different characteristics or attributes. The models developed by Dixit and Stiglitz (1977), Lancaster (1980), Krugman (1980, 1981), Helpman (1981), and Helpman and Krugman (1985) explain horizontal IIT by emphasizing the importance of economies of scale, product differentiation, and demand for variety within the setting of monopolistic competition type markets. In these models, IIT in horizontally differentiated goods should be greater, the greater the difference in income differences and relative factor endowments between the trading partners.

In contrast, vertical IIT represents trade in similar products of different qualities but they are no longer the same in terms unit production costs and factor intensities.[5] Falvey (1981) and Falvey and Kierzkowski (1987) have shown that the IIT in vertically differentiated goods occurs because of factor endowment differences across countries. In particular, Falvey and Kierzkowski (1987) suggest that the amount of capital relative to labor used in the production of vertically differentiated good indicates the quality of good. As a consequence, in an open economy, higher-quality products are produced in capital abundant countries whereas lower-quality products are produced in labor abundant countries. This will give rise to intra-industry trade in vertically differentiated goods: the capital abundant country exports higher-quality varieties and labor abundant country exports lower-quality products. The models of vertical IIT predict that the share of vertical IIT will increase as countries' income and factor endowments diverge.

Empirical studies on intra-industry trade abound the literature.[6] To the best of our knowledge, with the exception of Montout et al. (2001, 2002) the US auto-industry is often neglected in empirical studies of IIT.[7] However, intra-industry trade has become much more important than before in the US auto-industry in recent years due to ongoing structural changes in auto production and large investments by global assemblers. In this study, we, therefore, try to fill this gap by examining the recent change in the trade patterns of auto-industry in the US by decomposing the US auto-industry trade into inter-industry trade, horizontal IIT, and vertical IIT.[8]

The US auto-industry is selected for several reasons. First of all, the US is one of the biggest players in auto-industry along with Japan and Germany and the US is the largest single national market in auto-industry. Second, the auto-industry is one of the most important manufacturing sectors in the US economy. The auto-industry represents around 10.8 % of the total gross output of US manufacturing in 2003. Furthermore, the US auto-industry has considerable share on the US trade statistics. The share of the industry in the US total exports and exports amounted to almost 9 and 10 % in 2003, respectively.[9] Finally, there has been a major structural change in the US auto-industry brought about by several developments over the past 20 years, which may have an impact on the patterns of the US auto-industry trade. Therefore, given its crucial importance in the global auto-industry and in the US economy, the US auto-industry has become an appropriate case to study the structure and determinants of IIT.

The objective of the present paper is to examine the current trade patterns of the US auto-industry trade brought by the several developments that reshape the industry over the last two decades, and to identify country specific factors that help to determine the degree of IIT between the US and its 37 trading partners over the period 1989-2006. In particular, using finely disaggregated trade data, the most refined possible, this paper first decomposes the US auto-industry trade into inter-industry trade, horizontal IIT, and vertical IIT. Subsequently, we will investigate the influence of various country-specific factors to explain the evolution and structure of the IIT in the US auto-industry. Findings from the present study, therefore, address the proposition that there are different forces at work in determining the two types of IIT. Hypothesis drawn from IIT literature will be tested using panel data techniques over the period of 1989-2006.

The remainder of this paper is organized as follows. Section 2 outlines the methodology for measurement of IIT. Section 3 provides a brief explanation of the developments in the US auto-industry and presents a discussion of the estimated IIT indices. Empirical model, testable hypotheses, and estimation methodology are discussed in Section 4. The regression results of the empirical model are given in Section 5. The final section draws some concluding remarks.

2. Measurement of Intra-Industry Trade in the US Auto-Industry

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.

Various ways of calculating intra-industry trade have been proposed in the empirical literature, including the Balassa Index, the Grubel-Lloyd (G-L) index, the Aquino index. The most widely used method for computing the IIT is developed by Grubel and Lloyd (1971). However, beside aggregation bias, the traditional G-L index has one major problem often cited in the empirical literature. The unadjusted G-L index is negatively correlated with a 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 a particular good within an industry as weights.

Given the problems of unadjusted G-L index, this paper computes the extent of intra-industry trade between the US and its trading partner by employing the adjusted G-L index, defined as:

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

where X_{ijkt} and M_{ijkt} are the US 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 industry 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-industry products (motor vehicle products and auto-parts) 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 this study, 109 items are considered as automotive products from the six-digit level of HS.[10]

Once, the automotive 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). The first component for auto-industry represents trade among products that are similar in terms of quality, while the second one is referred to specialization in varieties of quality. Following Turkcan (2003), Ando (2006), and Wakasugi (2007), however, we argue that VIIT in the auto-industry, particularly for auto-parts, reflects not only quality differences but also international fragmentation at the same level of statistical disaggregation of 6 digit HTS. This empirical approach is clearly supported by the recent findings by Jones et al. (2002) and Ando (2006) that rapid increase in VIIT was mainly originated from the vertical linkages in production rather than trade in quality differentiated goods.

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;[11]

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

where P_{ijkt}^{X} and P_{ijkt}^{M} represent the unit value of the US' 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:

$$1.25 \leq \frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \quad \text{or} \quad \frac{P_{ijkt}^{X}}{P_{ijkt}^{M}} \leq \frac{1}{1.25} \qquad (3)$$

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 equation 3, 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 in 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-industry are divided into three components in this method; HIIT, VIIT, and non-classified IIT.

3. International Trade and Intra-Industry Trade in the US Auto-Industry

Global trends that have shaped and are still affecting the US auto-industry over the last two decades also have major impact on the pattern of the US auto-industry trade. Exports of the US auto-industry have slowed down in recent years, while imports of auto-industry have continued to increase (See Figure 1). The US auto-industry trade deficit has grown from 58 billion dollar in 1989 to 142 billion dollar. The trade figures including both motor vehicle and auto-parts products suggest that the US auto-industry deficit is indeed structural.

There are several reasons that explain this fact. First, the US domestic vehicle producers continued to lose market share to the US affiliates of foreign based manufacturers (transplant) such as Toyota, Honda, Volkswagen, and Hyundai in the last two decades. As a result, the increase in foreign transplant company shares in the US domestic market and their preference to obtain intermediate goods from their source country may explain relatively high trade deficits in the auto-industry. In addition to attracting foreign investment, the Big Three have increasingly relied more on the foreign auto-parts producers, especially from China, to reduce production costs as the competition from foreign-based companies in the domestic market intensifies. This has resulted in a substantial trade deficit in the US auto-parts trade (See Klier and Rubenstein, 2006). Finally, the US consumers are increasing their purchases of small-sized cars due to quality issues, higher gas prices, affordability, shifting consumers' tastes, and fuel economy and emission standards. It is likely that higher gas prices and fuel economy and emission standards may give a competitive advantage to foreign auto manufacturers that are traditionally specialized in the production of small-sized passenger cars.[12]

Table 1 presents data on the US auto-industry trade by country of origin for 37 trading partners during the period analyzed. The geographical composition of the US auto-industry trade reveals several important empirical facts. First, it can be easily seen that a significant portion of the US auto-industry trade occurred with NAFTA members, namely Canada and Mexico due to operations of the Big Three in those two countries. Table 1 also indicates that more than 28 % of the US auto trade deficit in 2006 was due to trade with the NAFTA members.

Among them, Canada continued to be one of the top trading partners of the US during the study period. In 2006, 58 % of all the US auto exports went to Canada and 27 % of all the US auto imports came from Canada. However, Canada, a very important trading partner of the US has been losing its position to Mexico in recent years, as seen in Table 1. Between 1989 and 2006, the share of the US exports to Mexico did increase from 11 % to 18 %. In the meantime, the import shares of Mexico in the US imports have grown substantially, from 6 % in 1989 to 19 % in 2006. As shown by Klier and Rubenstein (2006), Mexico in recent years had moved past Canada to become the leading supplier of auto-parts, such as wiring harness and seat parts, which are quite sensitive to labor costs. As a result, Mexico has become a significant factor in the US auto trade deficit in recent years.

In 2006, the US major export destinations outside the NAFTA area were Germany (% 7), Japan (2.3 %), and the UK (2 %). However, in the case of imports, other important trade partners of the US besides the NAFTA countries were Japan (24 %), Germany (10%), and Korea (5 %). As seen in Table 1, the share of Japan in the US auto exports in 2006 was relatively smaller (2.3 %), while the corresponding share of imports was quite large (24 %). The trade balance in 2006 was still heavily in Japan's favor despite the ongoing efforts by the US government to open the Japanese market wider to the US auto exports. Similarly, the US auto trade deficit with Korea has continued to climb aided by Korea's auto regime designed to protect its domestic auto-industry.

China's contribution to the US auto trade deficit in 1989 was almost negligible: the shares of China in the US auto exports and imports were less than 1 % in 1989. However, China accounted for 1.5 % of the US auto exports, while the corresponding share of imports was around 2.5 % in 2006. The share of China in the US exports, particularly motor vehicles, was boosted by China's new "Development Policy of the Automobile Industry", announced on June 1, 2004, which aim to eliminate quota restrictions, domestic content rules, and reduce duty rates imposed on motor vehicle imports (See Cooney and Yacobucci, 2005). In addition to these new trade policies, China has now become the second largest vehicle market in the World after the US due to China's strong economic growth in recent years, which helps to create favorable market conditions, especially China's growing middle class. As a result, the Big Three, notably General Motors, continue to do very well in the Chinese auto market.

On the other hand, the US auto imports from China has been pushed up mostly by imports of auto-parts. But despite rapid increase in the US auto-parts imports from China during the period analyzed, China's contribution to the US auto-parts market, especially original equipment (OE) market, is still low. This appears to be due to shipping distance between the US and China that may limit China's role as a supplier for the US auto manufacturers, which have adopted "just-in-time" inventory control and supply techniques (See Cooney and Yacobucci, 2005). In aftermarket parts market (sold to retailers not manufacturers), timeliness of delivery is not a key concern, compare with OE market.

Finally, the share of the periphery countries in the US auto-parts trade increased substantially at the expense of the core countries in recent years. As seen in Table 1, the patterns and dynamics of the US trade in auto-industry differ for core and peripheral countries.[13] Examining core countries first, Table 1 shows the share of the core countries in the US auto-industry exports has dropped from 83% in 1996 to 78% in 2006, whereas the share in the US auto-industry imports has dropped from 90% to 75% during the same period. In contrast, the share of peripheral countries in the US auto-industry exports and imports has increased from around 16% in 1996 to 21% in 2006 and from 9% to 24%, respectively. It seems that for this industry, in response to increased competition, the US auto makers and the US affiliates of foreign-based auto makers begun to source more parts from cheaper production locations, such as Mexico and China.

Using the approach outlined in the previous section, Table 2 presents measures of IIT in horizontally and vertically differentiated auto-industry products between the US and its trading partners for the period 1989 to 2006. At the more aggregated level, results are presented in Figure 2 for total IIT, horizontal IIT, and vertical IIT along with measures for inter-industry trade. Three points are worth noting: First, the US auto-industry exhibits a substantial level of inter-industry trade.[14] However, the share of inter-industry trade decreased from 84 % in 1989 to 79 % in 2006, while overall Grubel-Lloyd measure of IIT in auto-industry has increased from 15 % to 20 %. This increase in intra-industry trade was due mainly to the sharp increase in vertical

IIT. Second, in general IIT in the US auto-industry was dominated by vertical IIT. The relative significance of vertical IIT on total IIT of the US auto-industry has increased from 4 % in 1989 to 12 % in 2006. This might be due to rising importance of vertical international production sharing in the US auto-industry, in addition to intra-industry trade of quality-differentiated goods. On the other hand, the degree of horizontal IIT remained stable over the same period. Both the rapid increase in IIT and the changing patterns of horizontal IIT and vertical IIT suggest that the US trade in auto-industry mainly involves the exchange of technologically linked intermediates rather than involving the exchange of different varieties of the same products. It should be noted that the exports and imports of auto-parts have been the most rapidly growing component of the US auto-industry trade in recent years (Turkcan and Ates, 2008).

The nature and dynamics of IIT in the US auto-industry is further studied by breaking down the traditional G-L indices for each trading partner over the same period. Overall, two important findings emerge from the calculations of IIT in the US auto-industry. Our first finding is that there are wide variations of IIT indices across partner countries (see Table 2). As shown in Table 2, in 2006, it is found that Canada has the highest values of IIT in auto-industry, 59 %, followed by Mexico, Finland, the UK, and Philippines. On the other hand, Table 2 reveals that highest measure of horizontal IIT is for again Canada (32 % in 2006). Belgium, Mexico, Australia, and Netherlands are other important partner countries with a high degree of horizontal IIT. With regards to vertical IIT in 2006, Finland has the highest degree of vertical IIT in auto-industry (43 %), but there are other partner countries with rather high degrees of vertical IIT, such as Germany, Mexico, the UK, and Spain. The high IIT with NAFTA countries can be explained by the regional integration and by geographic proximity. Foreign direct investment by the global auto manufacturers might also contributed to an increase in IIT between the US and members of NAFTA.

Finally, the results reported in Table 2 indicate that vertical IIT tends to be high among countries that are different in terms of income and factor endowments. VIIT for the periphery countries was 13 % of their total trade in 2006, compared with 12 % of the core countries. Therefore, the numbers obtained here clearly prove that low wages in periphery countries have decisive impact on the pattern of the US trade in auto products, 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. In contrast, the US carries more horizontal IIT with countries at similar stage of development. In 2006, horizontal trade in auto-industry accounted for 2.5 % of the total trade for the core countries but hardly less than 1 % for the periphery countries. These findings are not surprising; it is consistent with findings of some recent studies. For instance, Montout et al. (2001) found that IIT between the US and Mexico is characterized by trade in vertical differentiated goods, while IIT between the US and Canada is overwhelmingly horizontal. Hence, these results lead to the conclusion that the US IIT in the auto-industry with developed countries tends to reflect more trade in similar goods differentiated by their attributes. On the contrary, the US IIT in the auto-industry with developing countries is likely to be involved in vertical IIT, reflecting the trade as a result of back-and-forth transactions in vertically fragmented production process, along with their specialization over the quality spectrum.

4. Empirical Model, the Determinants of Intra-Industry Trade, and Estimation

4.1 Empirical Model

This paper applies the gravity equation approach to analyze the determinants of IIT as well as its components, HIIT and VIIT, in the US bilateral auto-industry trade with 37 trading partners over the 1989-2006 period.[15] 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, estimated 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 IIT in auto-industry.

The following logit transformation model is proposed to explain the determinants of IIT:

$$\ln\left(\frac{y_{kt}}{1-y_{kt}}\right) = \alpha_k + \mu_t + \beta_1 \ln GDP_{kt} + \beta_x \ln DGDP_{kt} + \beta_3 DPGDP + \beta_4 FDI_{kt} + \beta_5 WDIST_{kt} + \beta_6 EXCH_{kt} + \varepsilon_{kt} \quad (4)$$

where y_{kt} stands for either IIT_{kt}, $HIIT_{kt}$ or $VIIT_{kt}$ between the U.S. and its trading partner country k at time t, GDP_{kt} represents the average GDP between the US and its trading partner its trading partner k at time t, FDI_{kt} denotes the US stocks of outward FDI into its trading partner k at time t, and $EXCH_{kt}$ is the nominal exchange rate between the US and its trading partner k at time t. $DGDP_{kt}$ and $DPGDP_{kt}$ indicate the absolute difference in GDP and per capita GDP of the US and its trading partner k at time t, respectively. $WDIST_{kt}$ is the weighted distance between the US's capital and its trading partner's capital at time t. In addition, 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.

4.2 The Determinants of Intra-Industry Trade

Since Grubel and Lloyd's (1975) influential study, numerous empirical studies have examined the determinants of IIT using country-specific and industry-specific hypotheses. This study considers a number of country-specific variables as possible explanatory variables explaining the degree of IIT as well as its components, HIIT and VIIT, in the US bilateral auto-industry trade with 37 trading partners over the 1989-2006 period. The presented hypotheses, drawn from the available theoretical and empirical literature, takes into account the theoretical distinction between HIIT and VIIT. The following hypotheses are considered in this study to investigate the determinants of IIT in the US auto-industry.[16]

Economic Size (GDP_{kt}): Helpman and Krugman (1985) argue that the share of IIT in manufactured goods trade tends to increase as the average market size of the two countries increases due to the presence of economies of scale. In addition, larger markets are also likely to have greater demand for foreign differentiated goods and the potential for IIT becomes high. As a result, we predict that the shares of total, horizontal, and vertical IIT, between any two countries are expected to be positively related the average market size of partner countries. The average GDP levels of the US and each of its trading partners k (in current US dollar), denoted as GDP_{kt}, is used to test this hypothesis.

Differences in Market Size ($DGDP_{kt}$): According to Helpman and Krugman (1985), differences in market size indicate differences in their ability to manufacture differentiated products; as countries become more similar in terms of their market size and factor endowments, the potential for overlapping demand for differentiated products is enhanced. Thus, $DGDP_{kt}$ is expected to be negative for total as well as horizontal IIT. In contrast, the share of vertical IIT is to be positively correlated with the differences in market sizes, serving as proxy for differences in factor endowments, because vertically differentiated goods differ in terms of factor intensities and unit production costs. Therefore, the predicted sign for this variable is negative for IIT and HIIT but positive for VIIT. The absolute value of the difference of GDP (in current US dollar) between the US and its trading partners k, is used to capture the influence of differences in market size ($DGDP_{kt}$).

Differences in Per Capita GDP ($DPGDP_{kt}$): Linder (1961) states that the countries with the most similar demand patterns for differentiated goods will tend to be those with similar per capita incomes. As a result, a greater difference in per capita income would imply a greater disparity in the demand structure of countries, which would be reflected in lower relative levels of IIT and horizontal IIT. Alternatively, the model developed by Falvey and Kierzkowski (1987) indicates that the IIT in vertically differentiated goods occurs because of factor endowment differences across countries. In this model, it is assumed that high quality products will be produced in the advanced countries, relatively capital-abundant country, and low quality products will be made in less developed countries, relatively labor-abundant country. As a result, the model predicts that a greater divergence in the capital-labor endowment of the two countries, proxied by the difference in per capita incomes, yields a higher volume of IIT in vertically differentiated goods. The absolute value of the difference in per capita GDP (in current US dollar) between the US and its trading partner k ($DPGDP_{kt}$) is used to test this hypothesis.

Foreign Direct Investment (FDI_{kt}): FDI will also influence the share of IIT, although its effect on IIT is ambiguous and depends on the nature of the investments. The complementary or substitution relationship between FDI and trade, in particular exports, has been a subject of debate in both theoretical and empirical literature since the 1970s. Some studies, such as Markusen (1984) and later Brainard (1997), predict that the substitution between FDI (market-oriented FDI) and trade prevails over complementary. In another words, a multinational firm will serve foreign market via establishing an affiliate instead of exporting products, so it will have a negative impact on the shares of IIT and HIIT.

On the contrary, others, such as Helpman (1984) and Helpman and Krugman (1985), predict complementary relationship between FDI (efficiency-seeking FDI) and trade, given the fact that FDI is typically associated with the greater specialisation in production plants located in different countries and thereby helps scale economies to appear in production which in return increases IIT. Since scale economies represent an important aspect of Multinational Enterprises (MNEs) in auto-industry, it is then not surprising to find a positive relationship between FDI and VIIT, particularly when the latter reflects the exchange of intermediate goods at various stages of production.[17] The US stocks of outward FDI into trading partner k, FDI_{kt}, is used to test this hypothesis.

Geographical Distance ($WDIST_{ijt}$): The US bilateral trade with NAFTA countries is important in examining the determinants of the US IIT in auto-industry. NAFTA nations are geographically closer to the US than the European and Asian countries. In the literature, such as in Krugman (1980) and Balassa (1986), it has been found that the share of intra-industry trade is negatively correlated with geographical distance. Distance will increase the transaction costs including insurance and transportation costs. As a consequence, the share of IIT, HIIT, and VIIT is expected to be negatively related to the geographical distance variable. In line with Balassa and Bauwens (1987), the geographical distance variable is defined as the weighted distance between the US and its trading partner k:

$$WDIST_{kt} = \frac{DIST_k * GDP_{kt}}{\sum_{k=1}^{37} GDP_{kt}} \tag{5}$$

The distance, denoted as $DIST_k$, is the direct distance in kilometers between the US's capital and its trading partners' capital.[18]

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 clear expectation on the signs coefficients of the bilateral exchange rate for all types of IIT since there is no consensus about how exchange rate changes affect the share of IIT in the literature. One would expect that a depreciation of the dollar implies an advantage for the US exports at foreign markets and a disadvantage for the US imports. The bilateral exchange rate in this study is defined as the number of foreign currency unit per US dollar so that $EXCH_{kt}$ falls with a depreciation of the dollar. Hence, a possible negative relationship in the empirical results implies that a depreciation of the dollar will increase the shares of each type of IIT between the US and its trading partners.

4.3 Estimation

In estimating the determinants of IIT in auto-industry between the US and its 37 trading partners, a number of estimation techniques are applied to equation (4) in order to ensure the robustness of the results. The results for three types of IIT index (IIT, HIIT, and VIIT) using these estimators are reported in Tables 3, 4, and 5, respectively. First, equation (4) is estimated with the pooled ordinary least squares (OLS). However, recently it has been shown that pooled OLS lead 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 most likely to affect bilateral trade flows between countries.

Using a panel data approach allows us to account for such effects. The most commonly employed panel models, which control for the existence for such effects are the fixed effects (FE) model and random effects (RE) model (Baltagi, 1995). In order to be able to choose between two possible estimation models, several statistical tests are performed. Initially, we test whether we need to use panel data techniques in the first place by using the Chow test for fixed effects (FE) and the Breusch-Pagan (BP) test for random effects (RE). As reported in Tables 3, 4, and 5, the Chow test confirms the appropriateness of the FE over the pooled OLS whereas the BP 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 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 3, 4, and 5, the resulting Hausman test statistics in all three regressions strongly indicate that the RE model should be preferred over the FE model. In conclusion, the results suggest that RE model is the appropriate estimation model.

In addition, prior to estimation of equation (7), the problems of heteroscedasticity and autocorrelation should be addressed.[19] The likelihood ratio test (LR), reported in Tables 3, 4 and 5, has strongly rejected 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 3, 4 and 5, has led to the rejection of the null of no first order serial correlation in all three regressions suggesting that autocorrelation problem is quite severe in the current panel data. Thus, tests for heteroscedasticity and serial correlation suggest the need to employ feasible generalized least squares (FGLS) in order to obtain consistent and efficient estimation results. However, as Beck and Katz (1995) have shown that test statistics based on the FGLS can be optimal 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 (4) is estimated using the panel-corrected standard errors (PCSE) method developed by Beck and Katz (1995). The PCSE results for three types of IIT index (IIT, HIIT, and VIIT) are presented in Table 3, 4, and 5, respectively.

5. Estimation Results

In estimating the determinants of total, horizontal, and vertical shares of intra-industry trade between the US and its 37 trading partners, we estimate equation (4) with four alternative estimation methods for the period 1989 to 2006.[20] The regression results for the determinants of IIT between the US and its trading partners are presented in Tables 3 through 5. Table 3 presents the results of the equation (4) where total IIT is used as the dependent variable. Tables 4 and 5 report the results for HIIT and VIIT, respectively. Following the discussion made in the previous section about the efficiency of the PCSE method over the FGLS estimates, in the remainder of the analysis only the results from PCSE estimations are discussed.

Overall, the regression results from the PCSE method reported in the last columns of Tables 3 through 5 generally are consistent with the hypotheses specified in the previous sections, especially when VIIT is used as dependent variable. In addition, the estimated coefficients are almost the same for total and VIIT with the exceptions of $WDIST_{kt}$ and $EXCH_{kt}$. This outcome is not surprising since VIIT accounts for most of IIT. In contrast, as evident in Tables 4 and 5, the determinants of HIIT and VIIT are not the same, because signs and significance of explanatory variables differ. Finally, the estimated coefficients for HIIT are less precise than those for VIIT. The reason probably originates from the fact that there are more zero observations on HIIT than on VIIT.

The results of the PCSE model when estimated using IIT as a dependent variable are not encouraging. First, the results show that the market size variable (GDP_{kt}) have a positive and significant association with IIT, as predicted by the theory. In contrast, the signs on the differences in market size between trade partners ($DGDP_{kt}$), the differences in per capita GDP ($DPGDP_{kt}$), outward FDI stocks variable (FDI_{kt}) are entirely different from what is expected. This could be due to the fact that a greater percentage of IIT is vertically differentiated auto-industry products. Therefore, it is not surprising that the estimated coefficients for IIT look similar to those for VIIT rather than HIIT.

Outward FDI stocks variable (FDI_{kt}) turns out to have positive and statistically significant coefficient, consistent with the most empirical examinations in literature that suggests a strong complementary relationship between intra-industry share and FDI, but which is contrary to theoretical predictions. Empirically, however, most of these empirical studies do not distinguish between horizontally organized and vertically organized MNEs in identification of the substitution and complementary effects of FDI on trade. Hence, distinguishing between horizontally organized and vertically organized MNEs in the future study could lessen these problems and help us to find out the expected sign between FDI and IIT. Furthermore, our results indicate that the geographical distance ($WDIST_{kt}$), shows a negative and significant relationship with IIT, as expected.[21] Finally, the bilateral exchange variable ($EXCH_{kt}$) exerts a positive impact on IIT, but is statistically insignificant. In other words, a depreciation of the dollar leads to higher degree of IIT between trading countries.

Considering the trade in horizontally differentiated auto-industry products, the major findings are as follows. First, as expected, HIIT is shown to increase with the average size of countries (GDP_{kt}) but statistically insignificant. Differences in market size variable ($DGDP_{kt}$) appears to have negative impact on HIIT as suggested by the theory but is statistically insignificant. In contrast, the coefficient of per capita income difference ($DPGDP_{ijt}$) has a positive impact on HIIT, which is inconsistent with the prediction of Helpman and Krugman's (1985) model where it is used as a proxy for factor endowment differences. This result could be due to high correlation among explanatory variables, a common problem in the empirical studies of intra-industry trade. In contrast with the hypothesis, outward FDI stock variable (FDI_{kt}) has a positive and significant impact on HIIT. The positive sign on the outward stock variable suggests that FDI and trade are at least complements in the US auto-industry trade. This might be due to measure of FDI employed in the present study that is not able to distinguish between horizontal and vertical FDI. Following expectations, our results also indicate that weighted distance variable ($WDIST_{ijt}$) shows a negative and significant relationship with HIIT. Finally, a negative and insignificant sign is obtained on the relationship between bilateral exchange rates ($EXCH_{kt}$) and HIIT, suggesting that a depreciation of the dollar will increase the share of IIT in horizontally differentiated goods.

Turning now to the results for the vertically differentiated auto-industry products, the results look similar to those obtained when IIT is used as a dependent variable. In addition, when using the share of VIIT as a dependent variable, insignificant variables became significant and also more consistent with the stated hypotheses. The results are more robust than those for HIIT. The number of significant variables increases and they become more consistent with the presented hypotheses. The regression results of the PCSE model indicate that IIT in the US auto-industry is better explained by the vertical differentiation models than horizontal differentiation models.

Individually, all the estimated coefficients have a high statistical significance and have the expected signs with the exception of $WDIST_{kt}$. Following expectations, the hypothesis concerning market size (GDP_{ijt}) performed well, which is in accord with the findings of previous studies, such as Balassa (1986) and Clark and Stanley (1999). In addition, the positive relationship between VIIT and difference in size between trading partners ($DGDP_{ijt}$) support the hypothesis that the more countries differ in relative factor endowments, the greater the expected share of VIIT. Moreover, the results illustrate that differences in per capita GDP ($DPGDP_{kt}$) have a positive and significant effect on VIIT, consistent with the predictions of the Falvey and Kierzkowski's (1987) model.

FDI variable (FDI_{kt}) has a significant positive effect on VIIT, confirming our hypothesis. As mentioned earlier sections of this study, unit price-differentials may reflect not only the quality differences but also international fragmentation. Hence, this type of exchange may appear as intra-industry trade in intermediate goods if the fragmentation processing in host country does not change the goods' statistical category. Therefore, the complementary relationship found between VIIT and FDI variable is therefore not surprising because the significant portion of auto-industry products included in the current study involves intermediate goods trade between the US and its trading partners. Thus, the complementary relationship found between outward FDI and intra-industry trade give strong support to the hypothesis that international fragmentation plays a great role in explaining the intra-firm trade between different plants within the same MNE.[22] At last, the bilateral exchange rate variable ($EXCH_{kt}$) is found to exert highly significant negative effects on the share of VIIT. The highly significant negative coefficient on the bilateral exchange rate suggests that depreciation of dollar clearly increases the share of intra-industry trade in vertically differentiated auto-industry products.

6. Summary and Conclusions

This study analyzes composition of trade and determinants of IIT in the auto-industry between the US and 37 major trading partners during the period 1989-2006, a period during in which there were several important developments that reshaped the structure of auto-industry. In particular, total IIT is decomposed into horizontal IIT and vertical IIT by using unit value dispersion criteria, and test their determinants separately.

The results show that the US auto-industry trade is mainly inter-industry trade with around 79 % share of total trade in 2006. However, the shares of intra-industry trade have exhibited increased importance over the period. The observed increase in IIT between the US and its trading partners is almost entirely due to sharp increase in vertical IIT. Another important finding is that vertical IIT tends to be high among countries that are different in terms of economic development and factor endowments. These facts lead to conclusion that the international fragmentation has become an essential part of the US auto-industry since the significant portion of products included in the current study involves intermediate goods trade between the US and its trading partners.

Using the PCSE method, the econometric results obtained here generally support the hypotheses derived from the intra-industry literature, especially when VIIT is used as dependent variable. In addition, the results indicate that the determinants of IIT for horizontally differentiated goods are quite different from those for vertically differentiated goods. In particular, the extent of the US HIIT in auto-industry is positively correlated with difference in per capita GDP and outward FDI variables while it is negatively correlated with distance and bilateral exchange rate. The results for IIT in vertically differentiated goods show that VIIT is positively associated with the average market size, differences in market size, differences in per capita GDP, outward FDI, and distance while it is negatively correlated with the bilateral exchange rate variable.

The results in this paper, however, must be interpreted with caution due to the fact that 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 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 identify whether 25% differences between unit values of exports and imports truly reflects value-added activities or quality-based exchange.

Endnotes

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

2. 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.

3. Besides the global trends in the car industry, international pattern of the US auto-industry trade has been also influenced by the regional trade arrangements: the 1965 Automobile Pact between the US and Canada and the North American Free Trade Agreement (NAFTA) among the USA, Canada, and Mexico in 1994. See Hummels et al. (1998). Also see Mohaterem (1998) for the effects of trade policies on US auto-industry.

4. See Montout et al. (2001), Montout et al. (2002), and Jones et al. (2002).

5. However, vertical IIT would also reflect the trade as a result of back-and-forth transactions in vertically fragmented production networks in the same commodity heading. See Lloyd (2004), Jones et al. (2004) and Ando (2006).

6. Some of these studies on IIT include Balassa (1986), Balassa and Bauwens (1987) Helpman (1987), Bergstrand (1983, 1990), Hummels and Levinsohn (1995), Tharakan and Kerstens (1995), Greenaway et al. (1994, 1995), Torstensson (1996), Byun and Lee (2005), and Thorpe and Zhang (2005).

7. Several empirical studies have analyzed the determinants of IIT in motor vehicle and auto-parts industry (Becuwe and Mathieu, 1992; Montout et al., 2001, 2002; Ito and Umemoto, 2004; Umemoto, 2005; Lefilleur, 2008; Leitao et al., 2009). However, among these empirical studies only Montout et al. (2002) have specifically examined IIT in the US auto-industry in the context of NAFTA for a shorter time period from 1992 to 1999.

8. Although Montout et al. (2002) segregates total IIT into horizontal IIT and vertical IIT in two bilateral trade relationships (the US-Canada and the US-Mexico), their results must be interpreted with caution. Besides NAFTA members, there are other important players in the US auto-industry trade such as Japan Germany, the UK, and Korea, thus their findings can hardly be generalized.

9. For a more detailed picture of the US auto-industry, see Cooney and Yacobucci (2005).

10. The automotive products used in this study are listed in Table A1. To select the automotive products from the trade data, we employed 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 automotive products can be found at http://www.ita.doc.gov/td/auto.html. Note that several automotive products are dropped from

estimations due to the fact that some of group headings are not common to both the import and export lists.

11. 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.

12. According to Cooney and Yacobucci (2005), foreign-brand vehicles are the dominant market force in small-sized passenger car sales while the Big Three (General Motors, Ford, and Chrysler) have high shares on the light truck market in the US. The Big Three supplied 72 % of the passenger car market in 1986. As foreign competition increased and the Big Three's attention gradually turned to light trucks, their share dropped to 41 % in 2005.

13. Table A.2 lists core/periphery categorizations of countries used in the analysis.

14. Similarly, Ando (2006) provided empirical evidence that auto-industry trade in East Asia is mainly one-way trade due 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. Jones et al. (2002) also found that the degree of IIT between the USA and Mexico in auto-industry as a whole appears to exhibit substantial level of IIT (61 % in 1999).

15. There are many papers that apply gravity equations to the analysis of the determinants of IIT with success, such as Balassa and Bauwens (1987), Bergstrand (1990), Greenaway et al. (1995), Fontagne et al. (1997).

16. The explanatory variables, their definitions, and expected signs for the different measures of IIT, as well as their sources are summarized in Table A1.

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

18. As pointed out by Egger (2001), weighted distance variable must be used in the panel regressions to capture the effects of transport costs on the trade since distance is itself a time-invariant variable.

19. 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.

20. 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 nit influence the key coefficients of interest relating IIT, HIIT, and VIIT. Overall, it is concluded that the results seem to be robust to extreme outliers.

21. This finding is similar to Klier (2005) who also find the importance of the importance of agglomeration in the auto-parts industry using detailed plant-level data on the US auto-supplier industry.

22. Similar findings also emerge in Blonigen (2001) and Türkcan (2007).

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Table 1. The US Auto-Industry Trade by Countries (Values is in Millions of $)

Countries	1989				2006			
	Exports		Imports		Exports		Imports	
	Value	Share	Value	Share	Value	Share	Value	Share
Australia	417.8	0.0141	66.6	0.0008	1,448.1	0.0148	428.2	0.0018
Austria	81.7	0.0028	76.0	0.0009	948.3	0.0097	2,296.3	0.0096
Belgium	297.7	0.0101	554.5	0.0063	630.0	0.0064	1,273.8	0.0053
Brazil	152.3	0.0052	1,224.0	0.0140	674.3	0.0069	2,172.1	0.0091
Canada	19,305.4	0.6531	29,013.0	0.3307	57,628.2	0.5887	65,503.9	0.2741
China	37.8	0.0013	59.6	0.0007	1,400.3	0.0143	6,155.8	0.0258
Czech Rep.	0.0	0.0000	0.0	0.0000	29.1	0.0003	178.6	0.0007
Denmark	15.7	0.0005	9.4	0.0001	48.6	0.0005	30.2	0.0001
Finland	141.3	0.0048	10.0	0.0001	697.4	0.0071	585.9	0.0025
France	467.9	0.0158	942.6	0.0107	800.1	0.0082	1,124.2	0.0047
Germany	881.4	0.0298	7,083.6	0.0807	7,129.2	0.0728	26,112.0	0.1093
Greece	12.7	0.0004	0.2	0.0000	75.6	0.0008	11.0	0.0000
Hong Kong	29.5	0.0010	166.2	0.0019	234.9	0.0024	118.2	0.0005
Hungary	4.0	0.0001	56.7	0.0006	85.0	0.0009	276.1	0.0012
Iceland	8.5	0.0003	0.0	0.0000	48.2	0.0005	0.4	0.0000
Indonesia	8.6	0.0003	7.9	0.0001	37.0	0.0004	398.6	0.0017
Ireland	9.6	0.0003	4.4	0.0000	49.1	0.0005	19.7	0.0001
Italy	132.1	0.0045	773.1	0.0088	310.3	0.0032	1,399.0	0.0059
Japan	1,173.8	0.0397	34,554.0	0.3939	2,336.0	0.0239	57,864.9	0.2421
Korea	199.7	0.0068	2,374.0	0.0271	765.9	0.0078	12,077.0	0.0505
Malaysia	11.0	0.0004	12.4	0.0001	27.7	0.0003	207.5	0.0009
Mexico	3,531.7	0.1195	5,711.0	0.0651	17,961.5	0.1835	47,206.8	0.1975
Netherlands	195.6	0.0066	49.9	0.0006	604.8	0.0062	99.8	0.0004
New Zealand	25.3	0.0009	24.2	0.0003	90.8	0.0009	13.2	0.0001
Norway	57.3	0.0019	7.1	0.0001	69.3	0.0007	27.2	0.0001
Philippines	45.2	0.0015	165.0	0.0019	147.6	0.0015	498.8	0.0021
Poland	3.5	0.0001	3.9	0.0000	133.0	0.0014	93.7	0.0004
Portugal	9.1	0.0003	17.0	0.0002	26.2	0.0003	214.2	0.0009
Singapore	94.1	0.0032	121.5	0.0014	257.4	0.0026	78.9	0.0003
Slovak Rep.	0.0	0.0000	0.0	0.0000	11.1	0.0001	907.9	0.0038
Spain	35.5	0.0012	353.7	0.0040	379.9	0.0039	404.1	0.0017
Sweden	302.5	0.0102	1,821.5	0.0208	284.6	0.0029	2,536.7	0.0106
Switzerland	259.7	0.0088	27.4	0.0003	156.6	0.0016	62.6	0.0003
Taiwan	902.2	0.0305	677.3	0.0077	177.6	0.0018	1,652.3	0.0069
Thailand	49.3	0.0017	113.8	0.0013	91.2	0.0009	888.8	0.0037
Turkey	42.1	0.0014	11.1	0.0001	69.4	0.0007	91.0	0.0004
The UK	617.7	0.0209	1,634.2	0.0186	2,022.6	0.0207	6,002.3	0.0251
Core	24,775.6	0.8381	79,740.8	0.9089	77,167.3	0.7884	179,646.3	0.7517
Periphery	4,783.7	0.1619	7,986.0	0.0910	20,719.6	0.2117	59,365.4	0.2485
World	29,559.30		87,726.80		97,886.90		239,011.7	

Source: Authors' own calculations.

Table 2. Development of Intra-Industry Trade in US Auto-Industry, 1989-2006

Countries	1989					2006				
	Inter	IIT	VIIT	HIIT	IIT (no unit value)	Inter	IIT	VIIT	HIIT	IIT (no unit value)
Australia	0.862	0.138	0.031	0.001	0.103	0.840	0.160	0.069	0.040	0.051
Austria	0.833	0.167	0.140	0.004	0.023	0.924	0.076	0.044	0.000	0.032
Belgium	0.770	0.230	0.133	0.004	0.092	0.771	0.229	0.031	0.182	0.016
Brazil	0.848	0.152	0.030	0.001	0.121	0.720	0.280	0.234	0.008	0.038
Canada	0.381	0.619	0.081	0.349	0.189	0.409	0.591	0.165	0.326	0.099
China	0.814	0.186	0.035	0.011	0.140	0.790	0.210	0.163	0.004	0.043
Czech Rep.	1.000	0.000	0.000	0.000	0.000	0.853	0.147	0.027	0.007	0.112
Denmark	0.783	0.217	0.028	0.004	0.185	0.853	0.147	0.116	0.000	0.031
Finland	0.935	0.065	0.031	0.000	0.034	0.554	0.446	0.430	0.001	0.015
France	0.740	0.260	0.051	0.100	0.110	0.652	0.348	0.184	0.011	0.153
Germany	0.812	0.188	0.103	0.012	0.073	0.595	0.405	0.389	0.004	0.012
Greece	0.978	0.022	0.010	0.000	0.012	0.974	0.026	0.006	0.000	0.020
Hong Kong	0.909	0.091	0.055	0.000	0.037	0.801	0.199	0.065	0.004	0.131
Hungary	0.888	0.112	0.003	0.000	0.109	0.876	0.124	0.040	0.000	0.084
Iceland	1.000	0.000	0.000	0.000	0.000	0.997	0.003	0.002	0.000	0.001
Indonesia	0.917	0.083	0.018	0.000	0.065	0.900	0.100	0.040	0.000	0.060
Ireland	0.842	0.158	0.066	0.000	0.092	0.785	0.215	0.139	0.000	0.076
Italy	0.827	0.173	0.102	0.011	0.060	0.815	0.185	0.144	0.008	0.034
Japan	0.940	0.060	0.020	0.021	0.019	0.934	0.066	0.044	0.011	0.010
Korea	0.893	0.107	0.044	0.004	0.059	0.898	0.102	0.092	0.001	0.008
Malaysia	0.937	0.063	0.009	0.000	0.055	0.821	0.179	0.120	0.001	0.058
Mexico	0.617	0.383	0.069	0.034	0.280	0.546	0.454	0.317	0.067	0.071
Netherlands	0.769	0.231	0.038	0.034	0.158	0.876	0.124	0.070	0.029	0.025
New Zealand	0.870	0.130	0.012	0.047	0.071	0.875	0.125	0.078	0.000	0.047
Norway	0.920	0.080	0.005	0.005	0.070	0.764	0.236	0.111	0.000	0.125
Philippines	0.939	0.061	0.003	0.001	0.057	0.663	0.337	0.011	0.000	0.327
Poland	0.757	0.243	0.003	0.000	0.240	0.716	0.284	0.054	0.000	0.230
Portugal	0.937	0.063	0.021	0.000	0.043	0.884	0.116	0.110	0.001	0.005
Singapore	0.813	0.187	0.039	0.008	0.141	0.724	0.276	0.209	0.001	0.066
Slovak Rep.	1.000	0.000	0.000	0.000	0.000	0.993	0.007	0.002	0.000	0.005
Spain	0.912	0.088	0.014	0.002	0.073	0.681	0.319	0.267	0.001	0.051
Sweden	0.859	0.141	0.012	0.068	0.060	0.900	0.100	0.091	0.001	0.008
Switzerland	0.935	0.065	0.010	0.000	0.055	0.895	0.105	0.076	0.002	0.028
Taiwan	0.861	0.139	0.059	0.002	0.078	0.875	0.125	0.104	0.001	0.020
Thailand	0.771	0.229	0.019	0.000	0.210	0.853	0.147	0.091	0.011	0.045
Turkey	0.795	0.205	0.116	0.001	0.089	0.724	0.276	0.214	0.000	0.062
The UK	0.638	0.362	0.167	0.001	0.194	0.634	0.366	0.307	0.028	0.031
Core	0.854	0.146	0.045	0.025	0.076	0.806	0.194	0.123	0.024	0.047
Periphery	0.826	0.174	0.036	0.005	0.134	0.761	0.239	0.135	0.009	0.095
Mean	0.846	0.154	0.043	0.020	0.092	0.794	0.206	0.126	0.020	0.060

Source: Authors' own calculations.

Table 3. Determinants of Total Intra-Industry Trade in the US Auto-Industry, 1989-2006

Independent Variables	Pooled OLS	Fixed Effects	FGLS	PCSE
GDP_{kt}	1.665	1.508	0.837	1.665
	(1.64)	(1.01)	(1.31)	(2.01)**
$DGDP_{kt}$	1.487	-0.371	0.689	1.487
	(2.55)**	(-0.45)	(1.84)*	(3.05)***
$DPGDP_{kt}$	0.223	0.026	0.277	0.223
	(6.77)***	(0.39)	(10.48)***	(7.96)***
FDI_{kt}	0.325	0.092	0.222	0.325
	(8.77)***	(1.22)	(9.83)***	(14.82)***
$WDIST_{kt}$	-0.373	-0.066	-0.505	-0.373
	(-9.31)***	(-0.21)	(-19.01)***	(-14.69)***
$EXCH_{kt}$	0.016	-0.055	0.001	0.016
	(0.91)	(-1.74)	(0.10)	(0.83)
Constant	-94.486	-34.834	-45.804	-94.486
	(-2.08)**	(-0.76)	(-1.60)	(-2.50)**
R-squared	0.45	0.22		0.45
F-statistics	119.37***	1.54		
Wald statistic: χ^2 (7)			2150.38***	1987.71***
Wooldridge test for autocorrelation: F (1,33)			22.32***	
LR-test for heteroscedasticity: χ^2 (33)			269.12***	
Chow test of FE vs OLS (47,476)		10.04***		
Breusch-Pagan test for RE vs OLS: χ^2 (1)			663.79***	
Hausman test of FE vs RE: χ^2 (7)			1.98	
# of groups		34	34	34
# of observations	531	531	531	531

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

Table 4. Determinants of Horizontal Intra-Industry Trade in the US Auto-Industry, 1989-2006

Independent Variables	Pooled OLS	Fixed Effects	FGLS	PCSE
GDP_{kt}	3.065	5.258	3.352	3.065
	(1.15)	(1.10)	(2.32)**	(1.16)
$DGDP_{kt}$	-1.780	-2.419	-1.676	-1.780
	(-1.19)	(-1.00)	(-2.07)**	(-1.22)
$DPGDP_{kt}$	0.263	0.268	0.306	0.263
	(3.09)***	(1.18)	(3.74)***	(3.19)***
FDI_{kt}	0.364	-0.152	0.357	0.364
	(4.84)***	(-0.54)	(5.78)***	(4.07)***
$WDIST_{kt}$	-1.125	-1.153	-1.550	-1.125
	(-8.62)***	(-1.00)	(-22.35)***	(-9.52)***
$EXCH_{kt}$	-0.057	0.070	-0.026	-0.057
	(-1.45)	(0.55)	(-0.72)	(-1.39)
Constant	-36.167	-81.488	-44.245	-36.167
	(-0.30)	(-0.55)	(-0.70)	(-0.31)
R-squared	0.36	0.01		0.36
F-statistics	56.77***	2.52**		
Wald statistic: χ^2 (7)			3585.28***	446.21***
Wooldridge test for autocorrelation: F (1,33)			5.59**	
LR-test for heteroscedasticity: χ^2 (33)			134.45***	
Chow test of FE vs OLS (47,476)		2.06***		
Breusch-Pagan test for RE vs OLS: χ^2 (1)			12.21***	
Hausman test of FE vs RE: χ^2 (7)			10.06	
# of groups		34	34	34
# of observations	472	472	472	472

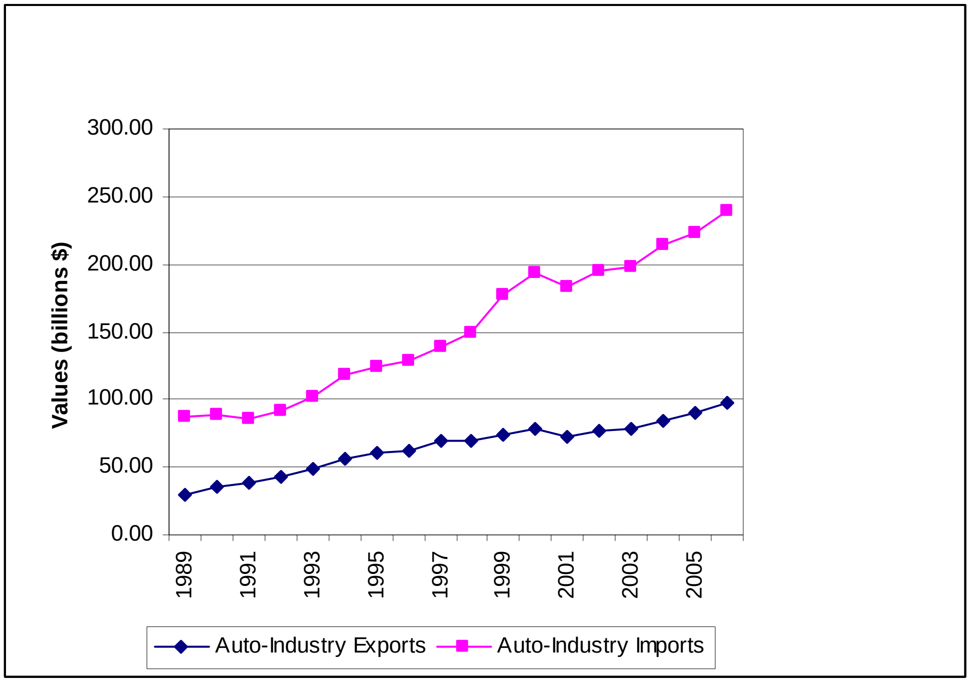
Notes: The dependent variable is the logit transformation of $HIIT_{kt}$, G-L index in horizontally differentiated products. Heteroskedasticity-consistent t-statistics (White-Newey) are reported in the first, the second, and the last columns. ***, **, * indicate statistical significance at 1%, 5 %, and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

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

Independent Variables	Pooled OLS	Fixed Effects	FGLS	PCSE
GDP_{kt}	4.375	0.336	2.731	4.375
	(2.78)***	(0.13)	(2.77)***	(2.09)**
$DGDP_{kt}$	2.668	1.375	1.785	2.668
	(3.09)***	(1.17)	(3.45)***	(2.20)**
$DPGDP_{kt}$	0.086	0.002	0.290	0.086
	(1.84)*	(0.02)	(8.38)***	(2.17)**
FDI_{kt}	0.452	0.503	0.390	0.452
	(9.09)***	(4.29)***	(12.31)***	(10.12)***
$WDIST_{kt}$	0.112	0.434	-0.238	0.112
	(1.54)	(0.76)	(-3.74)***	(2.04)**
$EXCH_{kt}$	-0.494	-0.106	-0.045	-0.494
	(-2.04)**	(-1.44)	(-3.34)***	(-2.24)**
Constant	-213.148	-58.935	-137.847	-213.148
	(-3.06)***	(-0.78)	(-3.22)***	(-2.22)**
R-squared	0.35	0.37		0.35
F-statistics	46.80***	8.57***		
Wald statistic: χ^2 (7)			985.75***	660.55***
Wooldridge test for autocorrelation: F (1,33)			12.61***	
LR-test for heteroscedasticity: χ^2 (33)			231.76***	
Chow test of FE vs OLS (47,476)		6.42***		
Breusch-Pagan test for RE vs OLS: χ^2 (1)			318.81***	
Hausman test of FE vs RE: χ^2 (7)			1.92	
# of groups		34	34	34
# of observations	530	530	530	530

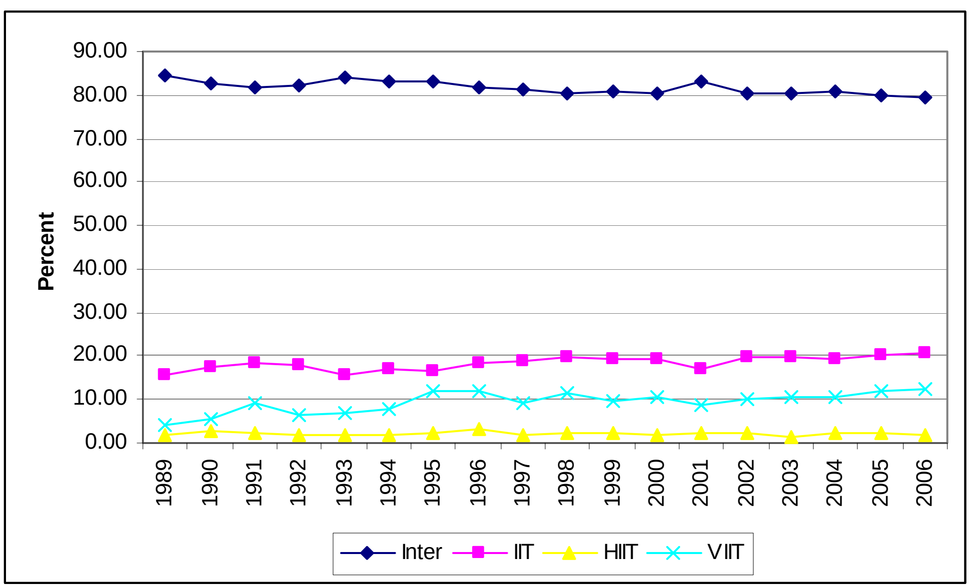
Notes: The dependent variable is the logit transformation of $VIIT_{kt}$, G-L index in vertically differentiated products. Heteroskedasticity-consistent t-statistics (White-Newey) are reported in the first, the second, and the last columns. ***, **, * indicate statistical significance at 1%, 5 %, and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

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



Source: Authors' own calculations

Figure 2. Development of Intra-Industry Trade in the US Auto-Industry, 1989-2006



Source: Authors' own calculations

Appendix

Definition of Auto-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 6-digit level of the HTS. There are about 6,000 items at the 6-digit level of the HTS. For the measurement of IIT in the auto-industry, 109 items are considered as automotive products from the six-digit level of HS. The 6-digit HTS codes classified as auto-industry products (motor vehicle products and auto-parts) are listed in Table A1.

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

The data on GDP and per capita GDP for the US and its trading partners is obtained from World Development Indicators (WDI) CD-ROM. The data on bilateral exchange rates were taken from the International Financial Statistics (IFS) CD-ROM. Outward FDI stock data in current dollars come from Bureau of Economic Analysis' webpage: 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 production, such as real estate investment. Nonetheless, considering the limited availability of the data, outward FDI stock data may be best available proxy.

At last, distance is in kilometers and the geographical distance data between the US and its trading partners is taken from United States Department of Agriculture's web page: http://www.usda.gov.

For this study, the top 37 trading partners are chosen. The countries included in this study are provided in Table A2. 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 HTS requires not only trade values but quantity information. In addition, we divide our sample of countries into core and peripheral countries using the categorization drawn up by the World Bank. Table A.2 provides core/periphery categorizations of countries included into calculations.

Table A1. HTS-6 Codes relevant to Auto-Industry

381900	830230	851120	870333	870899
382000	840734	851130	870390	871690
400912	840820	851140	870421	902910
400922	840991	851150	870422	902920
400932	840999	851180	870423	902990
400942	841330	851190	870431	910400
400950	841391	851220	870432	940120
401110	841430	851230	870490	940190
401120	841459	851240	870600	940390
401210	841520	851290	870710	
401211	842123	852520	870790	
401212	842131	852721	870810	
401219	842139	852729	870821	
401220	842549	853180	870829	
401310	842691	853641	870831	
401699	843110	853910	870839	
681310	848210	854430	870840	
681390	848220	870120	870850	
700711	848240	870210	870860	
700721	848250	870290	870870	
700910	848310	870322	870880	
732010	850710	870323	870891	
732020	850790	870324	870892	
830120	850790	870331	870893	
830210	851110	870332	870894	

Notes: 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 automotive products can be found at http://www.ita.doc.gov/td/auto.html.

Table A2. Countries Included in Regression Analysis

Australia^{C}	Hungary^{C}	Poland^{P}
Austria^{C}	Iceland^{C}	Portugal^{C}
Belgium^{C}	Indonesia^{P}	Singapore^{C}
Brazil	Ireland^{C}	Slovak Republic^{C}
Canada^{C}	Italy^{C}	Spain^{C}
China^{P}	Japan^{C}	Sweden^{C}
Czech Republic^{C}	Korea^{C}	Switzerland^{C}
Denmark^{C}	Malaysia^{P}	Taiwan^{P}
Finland^{C}	Mexico^{P}	Thailand^{P}
France^{C}	Netherlands^{C}	Turkey^{P}
Germany^{C}	New Zealand^{C}	United Kingdom^{C}
Greece^{C}	Norway^{C}	
Hong Kong^{C}	Philippines^{P}	

Notes: Countries that we consider in this study account for roughly 95 % of the US automotive trade. ^{C} and ^{P} indicate the countries that are classified as core countries and periphery countries, respectively.

Table A3. Variable Definitions, Expected Signs, and Sources

Variable Definition	Expected Signs			Sources
	IIT	HIIT	VIIT	
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	-	-	+	United States Department of Agriculture's web page: http://www.usda.gov
$WDIST_{kt}$ =The distance between the US and its trading partner	-	-	-	Bureau of Economic Analysis' webpage: http://www.bea.gov.
$EXCH_{kt}$ =Bilateral exchange rate between the US and its trading partner	+/-	+/-	+/-	International Financial Statistics (IFS) CD-ROM

Notes: IIT: Intra-industry trade in differentiated products; HIIT: Intra-industry trade in horizontally differentiated products; and VIIT: Intra-industry trade in vertically differentiated products.

Table A4. Summary Statistics of Different Concepts of Intra-Industry Trade Index and Explanatory Variables

Variable	Mean	St. Deviation	Minimum	Maximum	Observations
IIT_{kt}	0.183	0.128	0	0.638	666
$HIIT_{kt}$	0.021	0.059	0	0.393	666
$VIIT_{kt}$	0.094	0.093	0	0.604	666
GDP_{kt}	29.159	0.178	28.875	29.741	646
$DGDP_{kt}$	29.740	0.208	28.657	30.064	646
$DPGDP_{kt}$	9.483	0.867	4.573	10.523	646
FDI_{kt}	8.083	1.554	4.189	11.379	560
$WDIST_{kt}$	4.514	1.331	0.658	8.067	646
$EXCH_{kt}$	1.527	2.199	-6.214	9.236	616

Notes: All variables are in natural logarithmic form except intra-industry indexes.

Table A5. Correlation Matrix Between Explanatory Variables

Variables	GDP_{kt}	$DGDP_{kt}$	$DPGDP_{kt}$	FDI_{kt}	$WDIST_{kt}$	$EXCH_{kt}$
GDP_{kt}	1.000					
$DGDP_{kt}$	0.456	1.000				
$DPGDP_{kt}$	-0.024	0.208	1.000			
FDI_{kt}	0.426	-0.069	-0.124	1.000		
$WDIST_{kt}$	0.339	-0.388	-0.013	0.447	1.000	
$EXCH_{kt}$	0.082	-0.038	0.197	-0.226	0.073	1.000

Notes: All variables are in logarithmic form.