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Horizontal and Vertical Intra-Industry Trade in the U.S. Food Processing Industry

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Abstract

Intra-industry trade (IIT) in the U.S. food processing industry is evaluated in this study. The IIT index is disentangled into horizontal and vertical components and evaluated at 6-digit HTS product levels. The degree of IIT varies across different trading partners and sub-industries, and, for the U.S. food processing industry as a whole, it has been steadily increasing since 1989. Most of the IIT in the U.S. food processing industry is vertical in nature. However, horizontal IIT has been increasing faster than vertical IIT. The determinants of horizontal and vertical IIT are examined in a multiple-industry and multiple-country model. Industry characteristics show more significant effects on IIT than country characteristics. Product differentiation, market structure, and scale economies are all relevant in explaining the variation of IIT.

Key words: food processing industry, horizontal, intra-industry trade, vertical.

Highlights

Intra-industry trade (IIT), the simultaneous export and import of products within the same industry, was first observed in the 1960s. In recent decades, IIT has become a striking characteristic of the international trade regime, especially in the manufacturing industry. Considering that there has been substantial two-way trade in the U.S. processed food industry in recent years, and that the methodology on IIT research has been developed, a study focusing on IIT in the U.S. food processing industry is needed.

This study was designed to evaluate the IIT in the U.S. food processing industry. The first objective is to measure the degree of IIT in the industry from 1989 to 2001, with the emphasis on 1997. The Grubel and Lloyd index is calculated and analyzed in a multi-country and multi-industry framework for the U.S. food processing industry. The IIT index is disentangled into horizontal and vertical components and evaluated at 6-digit HTS code levels to avoid the categorical problem. The degree of IIT for the U.S. food processing industry varies across different trading partners and different sub-industries. Canada is the biggest trading partner in the industry for the United States. Forty-four percent of the trade between Canada and the United States in 1997 was IIT. Other important trading partners include Japan, Mexico, France, and the United Kingdom. In 1997, four sub-industries had an IIT index over 50%. Overall, IIT has been steadily increasing in the U.S. food processing industry since 1989. Most of the IIT in the U.S. food processing industry is vertical in nature. However, horizontal IIT has been increasing faster than vertical IIT.

The second objective is to empirically evaluate the determinants of horizontal and vertical IIT in the food industry with major trading partners and across the sub-industries. Both country- and industry-specific characteristics are included in the model. Separating the IIT into horizontal and vertical components is consistent with the theoretic works and makes the interpretation of the models easier. The model for horizontal IIT fits better than that for vertical IIT in the case of the U.S. food processing industry. Industry characteristics demonstrate more significant effects on IIT than country characteristics. Product differentiation, market structure, and scale economies all show significant effects on IIT.

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INTRODUCTION

Intra-industry trade (IIT), the simultaneous export and import of products within the same industry, was first observed in the 1960s by Balassa (1966). In recent decades, IIT has become a striking characteristic of the international trade regime, especially in the manufacturing industry. The phenomenon of IIT is contradictory to the traditional Heckscher-Ohlin (H-O) model of international trade which states that differences in factor endowments are the basis for trade. In 1975, Grubel and Lloyd published their seminal work on IIT. Since then, enormous research efforts have been made to measure the magnitude of the phenomenon, develop theoretical explanations, and evaluate the determinants of its existence empirically.

A number of theoretical models have been developed to account for IIT (Fontagne and Freudenberg 1997). Differentiation between products has been considered to be one of the most important determinants of IIT, although IIT could also occur among homogeneous products (Brander and Krugman 1983). Two sets of theories have been identified for IIT in horizontally and vertically differentiated products, respectively. Horizontally differentiated products are of different characteristics and vertically are of different qualities. Horizontal IIT models relax several important assumptions of the H-O model, and the market is most often assumed to be monopolistically competitive (Dixit and Stiglitz 1977; Lancaster 1980; Helpman and Krugman 1985). In vertical IIT models, quality is assumed to be directly related to the capital-labor ratio (Falvey 1981; Shaked and Sutton 1984), and the difference in factor endowments is considered to be the basis of comparative advantage that leads to specialization in products with different qualities. Overall, the theoretical work suggests the determinants of horizontal and vertical IIT may be different, and the distinction between them is important.

Theoretical research has not been able to provide an integrated and clear-cut model on which all empirical studies can be based. In the 1990s, studies that examined the determinants of IIT were significantly aided by a method proposed by Abd-El-Rahman (1991) to empirically disentangle horizontal IIT from vertical IIT. Using this method, Greenaway, Milner, and Elliot (1999) disentangle the United Kingdom's horizontal and vertical IIT in a multi-country and multi-industry framework. Both country- and industry-specific factors are found to be relevant in explaining the pattern of the United Kingdom's trade with its European Union (EU) neighbors, and vertical IIT appears to be more important than horizontal IIT. The degree of support for the industry-specific variables is greater than one normally finds in cross section

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work. Similar studies include Greenaway, Hine, and Milner (1994, 1995) for the United Kingdom; Crespo and Fontoura (2001) for Portugal; Aturupane, Djankov, and Hoekman (1999) for eight Central and Eastern European countries; Byun (2001) for South Korea; and Hu and Ma (1999) for China. Not surprisingly, most of these empirical analyses focus on manufacturing industries in European countries, where increasing economic integration and large intra-industry trade volume have been observed.

In this study, we focus on the case of the U.S. food processing industry[1]. Trade in agricultural and food products, especially processed food products, has a significant impact on the U.S. economy. Processed food products account for the majority of international agricultural and food trade in the United States. In 1997, the total export and import values of the U.S. food processing industry reached $28 billion and $24 billion, respectively. In Figure 1, the stacked chart shows the shares of exports and imports in the total trade of each sub-industry in 1997, classified by the North American Industry Classification System (NAICS). It clearly reveals that the United States imports and exports processed food products simultaneously.

For the U.S. food processing industry, several documentary studies have reported the existence of substantial IIT. Many processed food and beverage products are highly differentiated, implying that they have the potential for IIT growth. McCorriston and Sheldon (1991) compare the IIT in processed agricultural products for the United States and the European Community (EC, now the EU). Over the period of 1977-1986, the EC demonstrated a greater tendency towards IIT specialization in its geographical pattern of trade than the United States. Qasmi and Fausti (2001) evaluate the North American Free Trade Agreement's (NAFTA) impact on bilateral trade in food products for member countries in 1995 relative to that in 1990. IIT is found to be higher for food products involving a greater degree of processing, whereas trade in bulk commodities with little or no processing is predominantly inter-industry. U.S.-Canada bilateral trade has been increasingly dominated by IIT, while the United States and Mexico have more inter-industry trade.

Among the few empirical studies involving the U.S. food processing industry, Hirschberg, Sheldon, and Dayton (1994) analyze determinants of IIT in food processing over the period of 1964-1985 for a 30-country sample which includes the United States. The results indicate that IIT in the food processing sector is a positive function of a country's GDP per capita and equality in GDP per capita between countries. Hartman, Henderson, and Sheldon (1993) examine the determinants of IIT for a sample of 36 U.S. processed food and beverage industries in 1987, and verify that IIT variation is positively related to product differentiation, economics of scale, and imperfect competition. Similarly, Tang (1996) analyzes IIT for the U.S. food processing industry at the country level and industry level over three years: 1982, 1987, and 1992. However, all of these studies neglect to disentangle the total IIT into horizontal and vertical IIT, and employ relatively high aggregation of the industry categories, leading to suspicions of aggregation bias.

[1] The food processing industry is defined by the NAICS. See the definition in a later section.

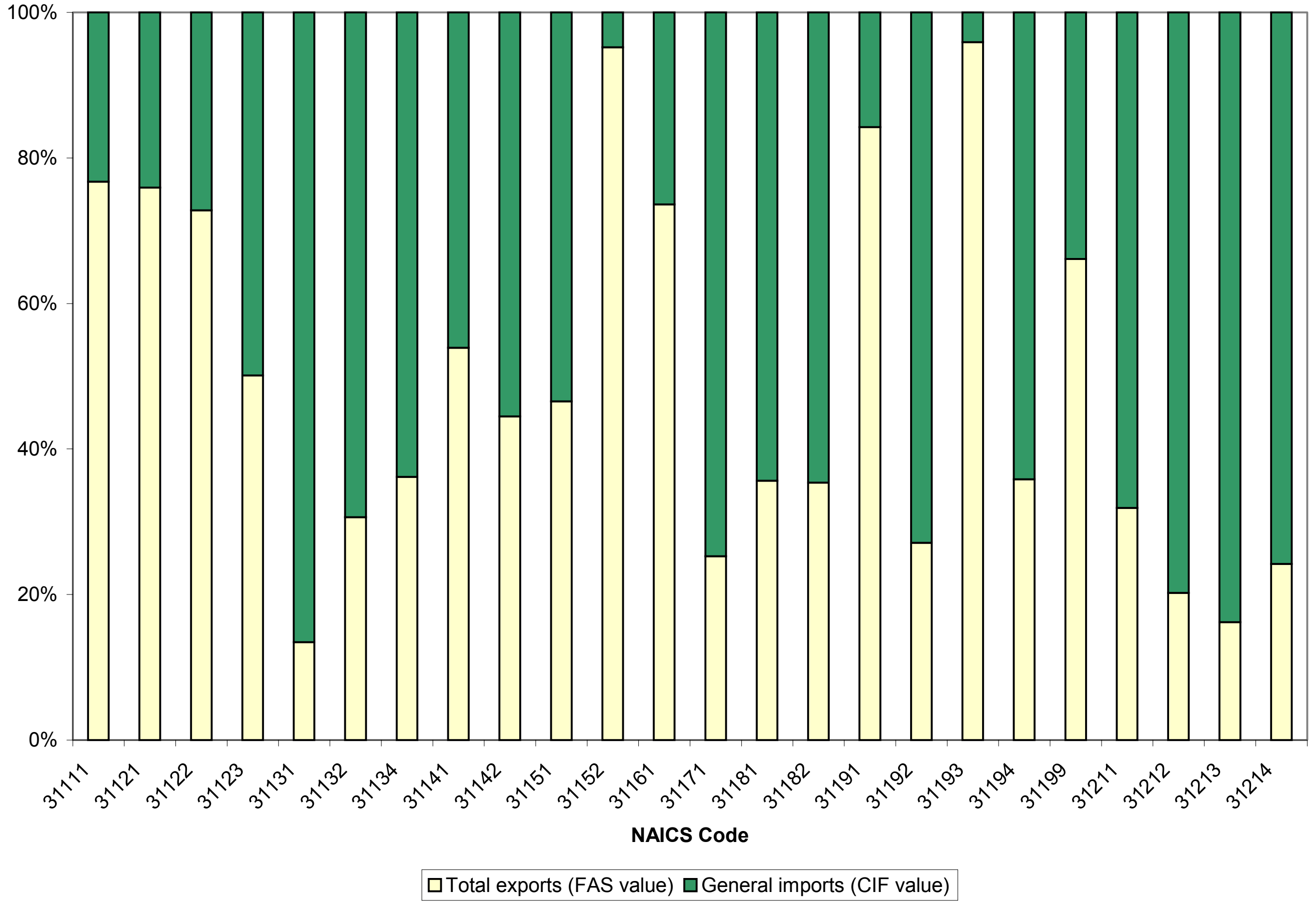

Figure 1. Trade Value of the U.S. Food Processing Industry by NAICS Sub-Industry in 1997

Note: This is a stacked chart with shares of exports and imports in total trade on the Y-axis. The X-axis represents the 24 sub-industries of food processing industry listed under the NAICS. For example, in the total trade for sub-industry 31111, export share is 77% and import share is 23%.

Overall, considering that there is substantial two-way trade in the U.S. processed food industry, and that the methodology concerning IIT research has been developed, a study focusing on IIT in the U.S. food processing industry is worthwhile. This study is designed with two objectives, following the works of van Berkum and van Meijl (1999) and De Frahan and Tharakan (1998) on agricultural and food products in the EU. The first objective is to measure the degree of IIT in the U.S. food processing industry from 1989 to 2001, and especially in 1997. This research thus updates the IIT index in previous studies. The second objective is to empirically evaluate the determinants of horizontal and vertical IIT with major trading partners and across the sub-industries in the U.S. food processing industry in 1997. The results have implications about the welfare gains and industrial adjustment from trade liberalization in the presence of IIT (Greenaway and Milner 1986).

In Sections II and III, the Grubel and Lloyd index is calculated and analyzed in a multi-country and multi-industry framework for the U.S. food processing industry. The IIT index is disentangled into horizontal and vertical components, and evaluated by the 6-digit level of the

Harmonized Trade Schedule (HTS) to avoid any categorical problem. In Section IV, the determinants of IIT are specified and variables are constructed. The model is estimated by nonlinear least squares. The empirical results are presented in Section V. In the last section, summaries and policy implications are analyzed.

MEASURING IIT

GL Index and the Aggregation Issue

Several measures of IIT have been proposed in the literature (Greenaway and Milner 1986). The most widely used in empirical studies is the Grubel and Lloyd (GL) index (Grubel and Lloyd 1975). Suppose l is one of the products in a sub-industry k. Denote the export (import) value of product l between the United States and its trading partner, or country j, as X_{jkl} (M_{jkl}). The amount of inter-industry trade (i.e., one-way trade) is $|X_{jkl} - M_{jkl}|$. Intra-industry trade (i.e., two-way trade) is the difference between the total trade ($X_{jkl} + M_{jkl}$) and inter-industry trade. Accordingly, the GL index (B_{jkl}) for product l can be defined as the share of IIT in the total bilateral trade as follows:

$$B_{jkl} = \frac{(X_{jkl} + M_{jkl}) - |X_{jkl} - M_{jkl}|}{X_{jkl} + M_{jkl}} = \frac{2\min(X_{jkl}, M_{jkl})}{X_{jkl} + M_{jkl}}. \tag{1}$$

The value of the index is between zero and one. The index is zero when either the export value (X_{jkl}) or the import value (M_{jkl}) is zero, indicating there is no trade overlap and the whole trade is inter-industry. Alternatively, the GL index is one when the export value (X_{jkl}) equals import value (M_{jkl}). In this case, there is a complete match of exports and imports and the whole trade is intra-industry.

With different choices of j, k, and l in the above equation, the GL index can be calculated at different geographical and industrial aggregation levels. Inappropriate aggregation may produce either country bias or industry bias (Greenaway and Milner 1986). First, a country such as the United States may import and export the same products from different trading partners due to various factors such as transportation costs, which is compatible with the traditional trade model. At a multilateral level, the GL index may be upwardly biased, in contrast to a bilateral level. Therefore, bilateral trade flows are preferred over multilateral trade flows in calculating IIT index.

Second, if two different sub-industries or two different products with opposite trade-imbalance signs are aggregated, the GL index will be upwardly biased. For example, Hartman, Henderson, and Sheldon (1993) calculate the GL index for 36 sub-industries in the U.S. processed food and beverage sectors in 1987. For SIC 2011 (meat packing), the import is \$2.6 billion and export is \$2.0 billion, so the resulting IIT index is 0.87. In our notation, they choose $k = 36$ and $l = 1$, and group all products in a sub-industry together. Apparently, the resulting IIT index is suspicious of upward bias. Thus, the industrial dimension of the aggregation problem emphasizes the importance of calculating IIT at a low aggregation level, with appropriate choices of *l* and *k*.

A consensus has gradually been reached in the literature about the choices of *l* and *k* (Greenaway, Hine, and Milner 1994; Greenaway, Milner, and Elliot 1999). Various trade classification systems, rather than industry classification systems, generally report trade data at a disaggregate level and should be employed for defining product categories (i.e., the choice of *l*). Two trade classification systems are employed most frequently in the literature: the HTS (e.g., Gullstrand 2002) and the Standard International Trade Classification (e.g., Greenaway, Hine, and Milner 1994). On the other hand, the selection and definition of a sub-industry (i.e., the choice of *k*) is generally based on an industry classification system, such as NAICS. The main reason is that in empirical studies of IIT, the independent variables such as industry characteristics are generally only reported in relatively aggregated domestic or regional industry classification systems. To calculate the GL index for a sub-industry *k* (e.g., defined by NAICS), the GL indexes of all the individual products *l* (e.g., defined by HTS) within the industry can be averaged, with trade volume as the weight. Some kind of concordance between the trade and the industry classification systems is needed.

Mathematically, for a sub-industry *k* with products *l*, the trade-value-weighted GL index (B_{jk}) between the United States and a trading partner *j* can be calculated as follows:

$$B_{jk} = \sum_{l \in R} \left(B_{jkl} \times \frac{X_{jkl} + M_{jkl}}{\sum_{l \in R} (X_{jkl} + M_{jkl})} \right) \tag{2}$$

$$= \frac{\sum_{l \in R} \left(2 \min(X_{jkl}, M_{jkl}) \right)}{\sum_{l \in R} (X_{jkl} + M_{jkl})}, \text{ where } R = \text{the set of products in industry } k.$$

Disentangling IIT into Vertical and Horizontal Components

Another development in measuring IIT in recent years is the division between horizontal and vertical IIT, because theories predict different forces may be at work. Horizontally differentiated products have different characteristics, and vertically differentiated products have different qualities. Abd-el-Rhaman (1991) uses a technique of unit value deviation to separate the two components, and the method has remained popular. Quality differences in trade are assumed to be measured by unit value indices, which in turn measure the average price of a bundle of items from a given product group (Greenaway, Hine, and Milner 1994). The more unit values of exports and imports differ, the higher is the difference in quality. The rationale for using price data to separate the two types of IIT is based on Stiglitz (1987). In a situation of perfect information, a variety of a product that is sold at a higher price must be of a higher quality than another variety that sells at a lower price. Even in a situation of imperfect information, price differences may to some extent reflect quality differences.

Therefore, horizontal IIT can be defined as the simultaneous export and import of a product where the unit value of exports (FOB) relative to the unit value of imports (CIF) is within a specific range. In most studies, this range is set at 0.85-1.15 and the corresponding dispersion factor is $\alpha = 0.15$. When relative unit values are outside that range, any IIT is considered to be vertical in nature. Matched trade at each product level is thus categorized as either vertical or horizontal IIT. For product *l*, if its bilateral trade flows have an export unit value of UV_{jkl}^{X} and an import unit value of UV_{jkl}^{M}, this distinction can be expressed as

$$\frac{UV_{jkl}^{X}}{UV_{jkl}^{M}} \begin{cases} \in [1-\alpha, 1+\alpha], \text{horizontal} \\ \notin [1-\alpha, 1+\alpha], \text{vertical} \end{cases} . \tag{3}$$

If in a sub-industry *k* there exist both horizontally differentiated products (*m*) and vertically differentiated products (*n*), then the total bilateral GL index can be further divided into horizontal IIT (HB_{jk}) and vertical IIT (VB_{jk}) as

$$\begin{aligned} B_{jk} &= \frac{\sum_{m \in R^h} \left(2 \min(X_{jkm}, M_{jkm})\right)}{\sum_{l \in R} (X_{jkl} + M_{jkl})} + \frac{\sum_{n \in R^v} \left(2 \min(X_{jkn}, M_{jkn})\right)}{\sum_{l \in R} (X_{jkl} + M_{jkl})} \\ &= HB_{jk} + VB_{jk} \end{aligned} \tag{4}$$

where R^h is the set of horizontally differentiated products, R^v is the set of vertically differentiated products in a sub-industry *k*, and $R = R^h + R^v$.

EVIDENCE OF IIT IN THE U.S. FOOD PROCESSING INDUSTRY

For our first objective of measuring the degree of IIT in the U.S. food processing industry from 1989 to 2001, there is a huge amount of data transformation[2] and resulting information. To facilitate presentation and to be consistent with the empirical analysis in later sections, the results are mainly presented and analyzed for 1997. The time trend of IIT is summarized at the end of the section.

In calculating an IIT index, the related parameters (i.e., *j*, *k*, and *l*) first need to be specified. In this study, a total of 24 trading partners are selected, so *j* = 24. The NAICS is employed for the definition of sub-industries, and 24 sub-industries at the 5-digit NAICS[3] level

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[2] For 473 products, 24 countries, and 13 years, the raw data could have 147,576 records. The actual data set has 113,287 records because there is no trade in some cases.

[3] NAICS replaced the outdated U.S. Standard Industrial Classification (SIC) in 1997. For food, beverage, and tobacco product manufacturing, there are 28 sub-industries at the 5-digit level. Two tobacco sub-industries (31221 and 31222) are excluded. Two additional sub-industries (31133 and 31183) are excluded for lack of trade. A total of 24 sub-industries at the 5-digit level are included.

are selected, so $k = 24$, which makes up the U.S. food processing industry in this study. The trade data are collected according to the HTS at the 6-digit level, following Gullstrand (2002) and Aturupane, Djankov, and Hoekman (1999). In total, there are 473 HTS products which are categorized under all of the selected 24 NAICS sub-industries, so $l = 473$. The concordance of the two systems and the trade data (value and quantities) are abstracted from the interactive trade database (*ITC Trade DataWeb*) hosted by the U.S. International Trade Commission (2002). Using Equations (3), the bilateral trade at the 6-digit HTS product level is first classified as vertical or horizontal IIT. Then, the bilateral trade-value weighted GL index for each sub-industry is calculated by Equation (4). In 1997, there are 574 records for HB_{jk}, VB_{jk}, and B_{jk} (two of the countries only have trade in 23 sub-industries).

The 24 selected trading partners for the United States cover most of the trade in the U.S. food processing industry (Table 1). In 1997, total U.S. exports to these partners were $24.9 billion; this figure represents 88.7% of the total exports in the food processing industry, as defined in this study. U.S. imports from these partners were $20.3 billion, 84.3% of U.S. total imports. Among individual partners, Canada is the largest trading partner by total trade volume. U.S. exports to Canada in the food processing industry comprise 16.8% of the total exports; 21.7% of U.S. imports come from Canada. Japan is the single largest importer of U.S. products, purchasing 23.7% of U.S. exports. Other major trading partners are Mexico, France, the United Kingdom, Italy, the Netherlands, and Korea.

In Table 2, the export and import values between the United States and the world for each of the 24 sub-industries in 1997 are reported. By total trade value, the sub-industry of animal slaughtering and processing (NAICS 31161) is the biggest one. Exports in this sub-industry totaled $9.3 billion, 33.1% of the total exports. Imports in this sub-industry reached $3.3 billion, 13.8% of the total imports. Other major sub-industries include 31122 (starch, vegetable fats, and oils manufacturing), 31111 (animal food manufacturing), 31213 (wineries), 31212 (breweries), and 31121 (flour milling and malt manufacturing).

For expositional convenience, the bilateral IIT indexes are clustered by country and by sub-industry. In Table 1, the trade-value weighted IIT indexes between the United States and each trading partner are reported. It is remarkable that as the most important trading partner, Canada has the highest degree of IIT with the United States, as indicated by a total IIT index of 0.42. Vertical IIT index is 0.27, making up 64% of the total. Other trading partners with total IIT indexes bigger than 0.10 are Taiwan, the United Kingdom, Mexico, and Germany. Japan and Korea are the major importers for U.S. food processing products, so they have low IIT indexes. The simple average of all IIT indexes is 0.08, but the trade-value weighted mean is 0.15. That is consistent with the fact that Canada has the highest trade volume and the biggest IIT index. Finally, vertical IIT has a large share in the total IIT for most countries.

The IIT pattern in 1997 also can be summarized by individual sub-industry (Table 2). Four sub-industries with medium trade volumes have an IIT index over 50%. They are 31181 (bread & bakery product manufacturing), 31191 (snack food manufacturing), 31123 (breakfast cereal manufacturing), and 31182 (cookie, cracker, and pasta manufacturing). Their high IIT values are consistent with their highly differentiated product characteristics. 31161 (animal slaughtering and processing manufacturing) has the highest trade volume, but the IIT index is only 0.11. The simple average of the IIT index is 0.21, but the trade-value weighted mean is 0.15. This is due to the fact that sub-industries with large trade volumes have low values of IIT index. Overall, IIT indexes for individual sub-industries have larger values than those for individual countries, but similarly, most of the IIT by sub-industry is vertical IIT.

Furthermore, the degree of IIT in the U.S. food processing industry may have changed over time. This can be determined by examining the pattern of the IIT index over time by country and by sub-industry. In Table 3, the IIT indexes for representative countries and sub-industries are reported. For Canada, the total IIT index has steadily increased from 0.33 in 1989 to 0.43 in 2001. Its vertical IIT index has been more stable than its horizontal IIT index. These findings may reflect the increasing integration between the United States and Canada in the last decade, especially after NAFTA took effect, and the decreasing price spread between exports and imports. For Mexico, the vertical, horizontal, and total IIT indexes are relatively stable over time. This differs from the conclusion drawn by Qasmi and Fausti (2001) that U.S.-Mexico trade was more characterized by inter-industry trade in 1995 relative to 1990. The difference may lie in the different aggregations of the industry categories employed. In addition, Taiwan, Brazil, and the United Kingdom have increased IIT with the Unites States in the past decade, while the rest of the individual countries have had relatively stable IIT indices. For individual sub-industries, the total IIT index for 31181 (bread and bakery products) peaked in 1996 with a value of 0.62 and decreased to 0.42 in 2001 but remained high overall. For 31142 (fruit and vegetable), the total IIT index has been increasing in the past decade, from 0.08 to 0.22. For other individual sub-industries, those with large IIT indexes in 1997, as shown in Table 2, generally have increasing IIT, while others have stable patterns.

Finally, the IIT index can be aggregated to the whole U.S. food processing industry, using trade value as the weight[4]. As shown in Figure 2, the total IIT index for the U.S. food processing industry has increased from 0.10 to 0.17. The vertical IIT index is relatively stable with a value of 0.10, while the horizontal IIT index has been increasing from 0.013 in 1989 to 0.072 to 2001. Overall, these features are significant, given that the indices in this study are calculated at such disaggregated levels.

[4] Similar to Equation (2), the trade-value weighted index for the whole U.S. food processing industry can be deducted as $B = \frac{\sum_j \sum_k \sum_l \left(2\min(X_{jkl}, M_{jkl})\right)}{\sum_j \sum_k \sum_l (X_{jkl} + M_{jkl})}$.

Table 1. Trade Value and IIT Index in 1997, by Country

Country	Export (10^6\$)	Import (10^6\$)	B (%)	HB (%)	VB (%)
Canada	4,723	5,246	42	15	27
Taiwan	797	138	17	4	13
United Kingdom	775	1,101	15	2	14
Mexico	2,382	1,803	12	2	11
Germany	487	723	11	1	10
China	531	472	9	2	7
Dominican Rep	265	529	9	0	8
Netherlands	792	934	8	1	7
Hong Kong	1,318	88	7	0	7
Denmark	132	365	7	0	7
Brazil	217	567	7	0	6
France	267	1,755	6	2	5
Korea	1,542	118	6	0	5
Japan	6,650	261	6	1	5
New Zealand	86	755	6	0	5
Thailand	195	756	5	0	5
Australia	310	868	4	0	4
Argentina	106	476	4	0	4
Philippines	395	760	3	1	2
Spain	380	539	3	0	3
Italy	318	1,474	3	0	2
Indonesia	202	511	1	0	1
Russia	1,422	100	1	0	1
Saudi Arabia	577	1	0	0	0
Total	24,871	20,339	—	—	—
Simple mean	—	—	8	1	7
Trade-weighted mean	—	—	15	4	11

Note: B is the GL index for the total IIT. HB is the horizontal IIT index. VB is the vertical IIT index. B = HB +VB.

Table 2. Trade Value and IIT Index in 1997, by Sub-Industry

NAICS code	Description	Export (10^6\$)	Import (10^6\$)	B (%)	HB (%)	VB (%)
31181	Bread & bakery product mfg	411	741	60	0	60
31191	Snack food mfg	450	84	54	38	15
31123	Breakfast cereal mfg	154	154	53	1	52
31182	Cookie, cracker, & pasta mfg	188	342	50	45	5
31134	Non-chocolate confectionery mfg	326	575	39	24	16
31199	All other food mfg	1,415	726	30	7	22
31132	Chocolate/confectionery mfg	464	1,052	29	14	15
31111	Animal food mfg	1,326	403	26	4	22
31192	Coffee & tea mfg	344	924	21	5	16
31142	Fruit & vegetable canning/pickling	1,875	2,339	17	5	12
31211	Soft drink & ice mfg	266	568	16	0	16
31212	Breweries	421	1,656	13	4	10
31171	Seafood preparation/packaging	294	870	12	2	9
31194	Seasoning & dressing mfg	317	567	11	5	6
31161	Animal slaughtering & processing	9,283	3,326	11	1	10
31141	Frozen food mfg	984	841	10	2	8
31122	Starch & vegetable fats & oils mfg	5,520	2,064	10	4	6
31152	Ice cream & frozen dessert mfg	91	5	9	2	8
31121	Flour milling & malt mfg	1,169	371	7	2	5
31214	Distilleries	612	1,914	7	0	6
31131	Sugar mfg	189	1,215	6	3	4
31151	Dairy product (except frozen) mfg	975	1,119	6	1	5
31193	Flavoring syrup & concentrate mfg	540	23	5	0	5
31213	Wineries	436	2,256	4	0	4
	Total	28,049	24,134	—	—	—
	Simple mean	—	—	21	7	14
	Trade-weighted mean	—	—	15	4	11

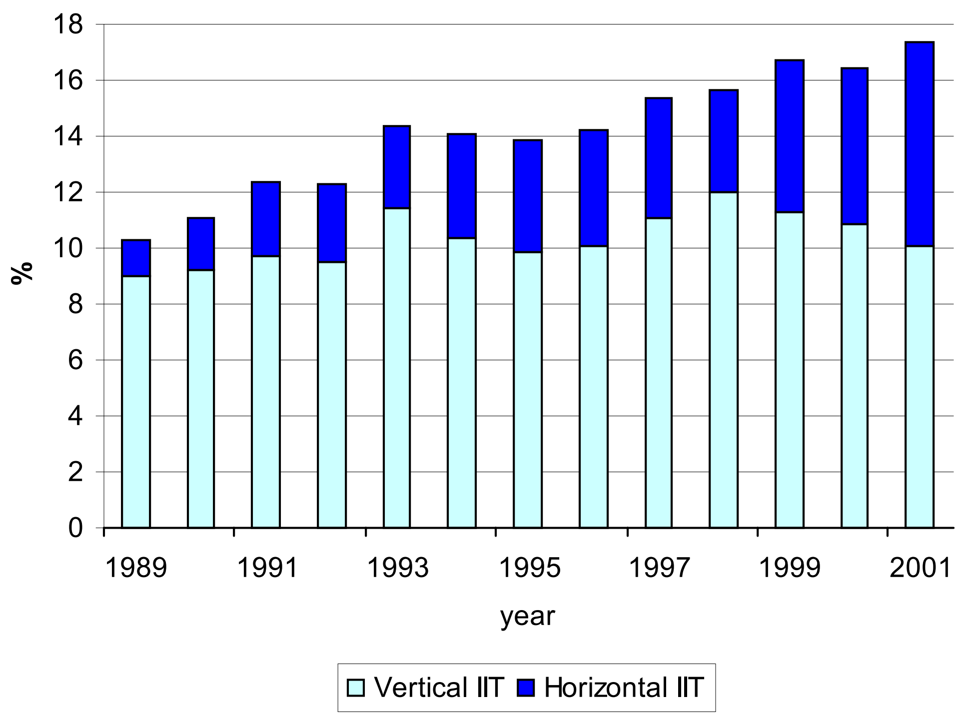
Note: The values of exports and imports are the total trade with the world. B is the GL index for the total IIT. HB is the horizontal IIT index. VB is the vertical IIT index. B = HB +VB.

Table 3. IIT Index of Selected Countries and Sub-Industries, 1989-2001

Year	Canada		Mexico		31181		31142	
	B	VB	B	VB	B	VB	B	VB
1989	33	29	12	10	21	20	8	7
1990	35	28	13	11	20	10	9	7
1991	35	26	13	11	27	12	8	7
1992	35	25	16	13	36	34	10	8
1993	37	28	18	14	53	17	11	9
1994	36	24	18	13	58	49	12	10
1995	38	23	15	13	62	55	13	10
1996	40	25	13	11	59	54	15	12
1997	42	27	12	11	60	60	17	12
1998	41	30	13	9	44	7	17	14
1999	42	24	13	10	45	11	17	15
2000	43	23	14	11	43	12	20	16
2001	43	18	13	11	42	10	22	13

Note: B is the GL index for the total IIT. HB is the horizontal IIT index. VB is the vertical IIT index. B = HB +VB. All indexes are in percentage. 31181 is bread and bakery product manufacturing; 31142 is fruit and vegetable products.

Figure 2. Trade-Value Weighted IIT Index of the U.S. Food Processing Industry, 1989-2001



DETERMINANTS OF IIT AND REGRESSION MODEL

Our empirical analysis generally follows the methodology of evaluating determinants of IIT used in recent studies (Greenaway, Hine, and Milner 1994, 1995; Greenaway, Milner, and Elliot 1999; van Berkum and van Meijl 1999). Due to data constraints for some of the industry characteristics, the empirical analysis focuses on the year 1997. In particular, explicit consideration is given to characteristics of the food industry. Proxies for factor endowments are represented by supply-side variables, such as agricultural land area, so as to distinguish from demand-side variables. Theoretical models of horizontal and vertical IIT suggest that several hypotheses, based on the deterministic roles of country-specific and industry-specific factors, can be tested for the food products trade between the United States and the major trading partners. A multiple-country and multiple-industry model is specified as follows:

$$Y_{jk} = f\,(CWD_k, LAND_k, PCD_k, SIZE_k, TIMB_k, DUM_k, HPD_j, VPD_j, COM_j, HH_j, SE_j) \qquad (5)$$

where

Y_{jk} = the horizontal IIT index (HB_{jk}) or the vertical IIT index (VB_{jk}) for a 5-digit NAICS level sub-industry (j) between the United States and a trading partner (k);

CWD_k = the absolute value of the difference in capital per worker between the United States and k;

$LAND_k$ = the absolute value of the difference in agricultural land area per worker between the United States and k. Agricultural land area includes arable land, permanent crops land, and permanent pastures, as defined by the Food and Agricultural Organization (FAO, 2002);

PCD_k = the absolute value of the difference in gross domestic product (GDP) per capita between the United States and k;

$SIZE_k$ = the average GDP level of the United States and k;

$TIMB_k$ = the ratio of the absolute value of net trade to the total trade in the food processing industry between the United States and k;

DUM_k = dummy variable for NAFTA countries. It equals 1 for Canada and Mexico, and 0 otherwise;

HPD_j = the number of 6-digit HTS products in a 5-digit NAICS sub-industry (j) in the United States;

VPD_j = the employment share of non-production workers in total employment of j in the United States;

COM_j = the number of companies in j in the United States;

HH_j = the Herfindahl-Herschmann index calculated by summing the squares of the individual company's market share percentage in j in the United States for the 50 largest companies or the universe, whichever is lower; and

SE_j = the value added per establishment in j in the United States.

CWD_k, $LAND_k$, PCD_k, and $SIZE_k$ represent the role of country-specific factors linked to the hypotheses on IIT in the models of Helpman and Krugman (1985) and Falvey (1981). Quite a few empirical studies of IIT, including Bergstrand (1983) and Greenaway, Hine, and Milner (1994), have explicitly tested the hypothesis of factor endowment differences. There exists strong empirical evidence for a negative relationship between factor endowment differences and the share of IIT, with no difference between the two types of IIT. This contradicts the hypothesized positive relationship between factor endowment and vertical IIT. Since these studies use the difference in per capita income as the proxy, the results are generally interpreted as supporting the Linder-type demand-similarity hypothesis (Greenaway, Hine, and Milner 1994; Hummels and Levinsohn 1995). In this study, the income variable PCD_k is included to test this hypothesis.

The use of the income variable as a proxy for differences in factor endowment may be insufficient (Byun 2001). As noted before, supply-side effects of factor endowment differences cannot be distinguished from demand-side effects of income differences if only the income variable is included in the model. In the present study, the absolute value of the difference in the capital-labor ratio between the United States and its trading partner (CWD_k) is used to test this hypothesis. In addition, considering that the food processing industry depends heavily on the availability of agricultural commodities, a variable ($LAND_k$) is included to reflect the factor endowment in raw materials. Both variables are expected to have a negative effect on horizontal IIT and a positive effect on vertical IIT.

As is well known, the GL index may be biased by the degree of trade imbalance. Instead of adjusting the index directly, the trade imbalance variable ($TIMB_k$) is added to control the possible bias, following Lee and Lee (1993) and Byun (2001). In addition, Canada and Mexico are members of NAFTA and close to the United States geographically. Both of them are among the most important trading partners for the U.S. food processing industry, as indicated in Table 1. A dummy variable (DUM_k) is included to reflect this influence.

Product differentiation, market structure, and scale economies are among the most important industry characteristics. However, measuring product differentiation is difficult and the empirical results are mixed (Greenaway, Milner, and Elliot 1999). The most frequently used proxies are the Hufbauer index, the classification indicator, the advertising ratio, and the percentage of non-production workers in the total employment. In this study, two measures of product differentiation are used: the number of products in a sub-industry (HPD_j), for horizontal differentiation, and the percentage of non-production workers in the total employment (VPD_j), for vertical product differentiation.

The relationship between market structure and the share of IIT is ambiguous. As discussed above, imperfectly competitive models such as in Shaked and Sutton (1984) predict that a large share of IIT will be found in highly concentrated, oligopolistic industries. IIT is viewed as a stage in the international expansion of oligopolies. On the other hand, a monopolistically competitive market structure, in which a large number of firms sell a differentiated product, may equally lead to greater IIT. Empirical studies provide little evidence to support the view that an oligopolistic market structure leads to IIT. Balassa and Bauwens (1987) test this hypothesis by using the share of total sales accounted for by the top five firms—the so-called five-firm concentration ratio—as a proxy for market structure. A significant negative sign is found on this variable, which supports the notion that a competitive market structure leads to IIT. Greenaway, Hine, and Milner (1995) test for the two types of IIT using the numbers of firms in an industry as a proxy variable. They cannot form an a priori expectation about the sign for vertical IIT because both models of IIT are applicable in explaining vertical IIT.

This study uses the number of firms (COM_j) in a sub-industry as a proxy for market structure. The coefficient of the variable COM_j is expected to have a negative sign for horizontal IIT, but either sign is possible for vertical IIT, depending on the market structure of the industry. If an industry consists of a large number of firms, then the sign is expected to be positive. On the other hand, if it is an oligopolistic market, then the sign is expected to be negative. In addition, the market concentration ratio measured by the Herfindahl-Herschmann index (HH_j) is included in the model.

Scale economies may affect IIT from the supply side. A large economy of scale leads to specialization in production. This implies limited product differentiation and a limited number of products in the market, so the degree of IIT would be greater. But in this case, a few firms would dominate the industry, and if the number of firms in an industry is directly related to the number of varieties in the market, this would lead to less IIT. While the monopolistically competitive model of horizontal IIT supported the latter case, either case is explainable for vertical IIT. Because of this ambiguity, the effect of the minimum efficient scale on vertical IIT is not certain (Greenaway, Hine, and Milner 1995). Greenway et al. find a negative sign for vertical IIT and interpret it as supporting the hypothesis that lower minimum efficient size leads to a greater number of firms in the market, supplying vertically differentiated products. Overall, empirical results are mixed, depending on the proxies that are used. Most studies show a negative relationship between the share of IIT and economies of scale as measured by the minimum efficient scale. In this study, the minimum efficient scale (SE_j) is employed and measured by the value added per establishment in a sub-industry *j* in the United States. It is expected to have a negative effect on horizontal IIT but an uncertain effect on vertical IIT.

All the variables specified above, their expected signs, and their data sources are summarized in Table 4.

ESTIMATION AND EMPIRICAL RESULTS

Because the IIT index ranges between 0 and 1, it has influenced the search for a suitable model specification. There are several choices of econometric models in the literature. Given that a linear model using the OLS method generates a predicted value that falls outside the theoretical range, many studies adopted the nonlinear least square with logistic function (Greenaway, Milner, and Elliot 1999; Balassa and Bauwens 1987) as follows:

$$Y_{jk} = \frac{1}{1+\exp(-bX_{jk})} + u_{jk} \tag{6}$$

where Y_{jk} is the horizontal IIT index (HB_{jk}) or the vertical IIT index (VB_{jk}), X_{jk} represents the explanatory variables as specified in Equation (5), and u_{jk} is the random error term.

The estimation results are presented in Table 5. The models fit well with R^2 values of 0.31 for horizontal IIT and 0.16 for vertical IIT. This is relatively high for cross-section

Table 4. Variable Definitions

	Sign		Description	Data
	HB	VB		Source
CWD_k	-	+	Capital/labor factor endowments: capital per worker	PWT
$LAND_k$	-	+	Agriculture resources: agricultural land area differential	FAO
PCD_k	-	-	Demand similarity: per-capita income differential	IMF
$SIZE_k$	+	+	Average market size: average GDP of the United States and country *k*	IMF
$TIMB_k$	-	-	Adjusting trade imbalance bias: trade imbalance/total trade	ITC
DUM_k	+	+	Canada and Mexico in NAFTA	
HPD_j	+	-	Horizontal Product differentiation: number of 6-digit HTS products in 5-digit NAICS sub-industry *j*	ITC
VPD_j	-	+/-	Vertical Product differentiation: percentage of non-production workers in the total employment in *j*	BC
COM_j	+	+/-	Market structure: # of firms in *j*	BC
HH_j	+	-	Market concentration: Herfindahl-Herschmann index	BC
SE_j	-	+/-	Scale economies: value added per establishment	BC

Note: PWT—Penn World Table (Heston, Summers, and Aten 2001); IMF—International Monetary Fund (2002); ITC—U.S. International Trade Commission (2002); BC—U.S. Bureau of Census (2001); FAO—Food and Agricultural Organization of the United Nations (2002).

regressions and higher than those in previous, similar studies. Most of the coefficients are significant.

Specifically, the variables for factor endowments (CWD_k and $LAND_k$) are not significant for both horizontal and vertical IIT models. The variable PCD_k tests the demand similarity hypothesis. It shows the expected negative sign for the horizontal IIT model and a positive sign for the vertical IIT model, but both are insignificant. The average market size ($SIZE_k$) shows a positive sign for vertical IIT but an unexpected negative sign for horizontal IIT. The variable of trade imbalance ($TIMB_k$) is intended to capture any bias from the trade imbalance on the GL index. It shows an expected negative and significant sign for both models. The NAFTA dummy variable shows a positive sign for the horizontal model, but it is not significant for either model.

The variable for horizontal product differentiation (HPD_j) is significant and shows a negative sign for both models. This is consistent with the expectation for the vertical IIT model but contradictory for the horizontal IIT model. The variable for vertical product differentiation (VPD_j) has a negative effect on horizontal IIT and a positive effect on vertical IIT. The proxies for market structure (COM_j and HH_j) have positive and significant effects for all IIT. The proxy for scale economies (SE_j) has a negative and significant effect on the horizontal IIT model. Its effect on the vertical IIT model is positive but insignificant.

Table 5. Empirical Results

	HB			VB		
	coefficient	t-ratio		coefficient	t-ratio	
Constant	105.265	2.48	*	1.290	0.99	
CWD_k	0.001	1.02		-2×10^{-6}	-0.19	
$LAND_k$	0.533	0.26		0.006	0.41	
PCD_k	-0.001	-0.90		1×10^{-6}	0.05	
$SIZE_k$	-0.018	-1.95	**	1×10^{-4}	0.59	
$TIMB_k$	-0.399	-2.23	**	-0.044	-3.91	*
DUM_k	7.724	0.61		-0.649	-1.60	
HPD_j	-0.685	-4.99	*	-0.010	-2.34	**
VPD_j	-42.595	-4.35	*	0.224	0.97	
COM_j	0.002	3.11	*	2×10^{-4}	7.65	*
HH_j	0.004	4.21	*	2×10^{-4}	1.91	***
SE_j	-8×10^{-5}	-2.81	*	5×10^{-6}	1.34	
R^2	0.31			0.16		
F(11,562)	22.65			9.77		
Log-likelihood	633.26			256.78		
N	574			574		

Note: * significant at the 1% level, ** at 5%, and *** at 10%.

Overall, the model fits better for horizontal IIT than for vertical IIT. Among the eleven explanatory variables, seven are significant for the horizontal IIT model at the 5% level or better; for the vertical IIT model, four are significant at the 10% level or better. Furthermore, the model fits better for industry characteristics than for country variables. The five industry variables are all significant for the horizontal IIT model, and three of them are significant for the vertical IIT model. However, for the six country variables, only one or two of them are significant in each model. The weak effect of country characteristics may be related to the heterogeneity of the sample countries selected in this study.

SUMMARY

In this study, the IIT of the U.S. food processing industry during the past decade, and especially in 1997, has been investigated. Several advances over earlier studies for the U.S. food processing industry are made in this study. Total IIT has been separated into horizontal IIT and vertical IIT. Attempts have been made to capture supply-side effects of the factor endowments.

The degree of IIT for the U.S. food processing industry varies across different trading partners and sub-industries. Canada is the biggest trading partner for the United States in this industry, and, in recent years, over 40% of the trade has been IIT. Moreover, the share of IIT between Canada and the United States, especially for the horizontal component, has been increasing during the past decade. Other important trading partners include Mexico, France, and the United Kingdom. Four sub-industries have an IIT index over 50%, and products within them generally are highly differentiated. These sub-industries are 31123 (breakfast cereal), 31181 (bread & bakery product), 31182 (cookie, cracker, and pasta), and 31191 (snack food). Overall, IIT has been steadily increasing in the U.S. food processing industry since 1989. Most of the IIT in the U.S. food processing industry is vertical in nature. However, horizontal IIT has been increasing faster than vertical IIT.

Separating the IIT into horizontal and vertical IIT is consistent with the body of theoretical works and makes interpretation of the models clearer. In the case of the U.S. food processing industry, the model for horizontal IIT fits better than that for vertical IIT. Industry characteristics show more significant effects on intra-industry trade flows than country characteristics. Product differentiation, market structure, and scale economies all are relevant in explaining the variations of IIT.

IIT has become an important component of trade in the U.S. food processing industry. If IIT continues to increase in the course of future trade expansion by the U.S. food processing industry, trade policies will have to adjust accordingly. Trade liberalization in the presence of IIT is likely to have benefits over the exchange and specialization in the traditional model. Trade liberalization in industries characterized by IIT is likely to generate greater gains relative to those industries where little IIT occurs (Richardson 1989). Reducing trade barriers may help increase both inter-industry and intra-industry trade, providing additional justification for these policies. Furthermore, more attention should be paid to the effects of increasing IIT on structural adjustment in the industry. If trade is increasingly intra-industry in nature, domestic industrial adjustment should be made easier than if trade is of an inter-industry nature. Future research may evaluate the possible linkage between IIT and employment market adjustment.

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