

Beyond Gravity Equation:
The Heterogeneity of Intra-industry Trade
among Industries in Bilateral Trade¹

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I. Introduction

Variation in factor endowments among countries has been the basis of traditional trade theories that offer the rationale for trade. Factor-endowments models such as Heckscher-Ohlin (henceforth H-O) theory are used to explain the occurrence of trade in homogeneous products; in other word, depending on the factor intensity of the country, each industry sector is dominated by either import or export after opening trade. This trade pattern is sometimes called inter-industry trade. Under the H-O theory, countries

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with abundant labor endowment, such as China, will export labor-intensive products, such as footwear, to capital-abundant countries such as U.S.³

Starting from 1980s, due to the substantial trade volume between countries with similar factor endowments, especially between industrial countries, the two-by-two-by-two H-O model fell short of explaining this phenomenon. Because under H-O theory, there seem to be no reason for simultaneous export and import of any homogeneous product to take place. Moreover, people were puzzled by the simultaneous export and import of products that belong to the same industry in bilateral trade. This trade pattern is called intra-industry trade.

Trying to solve this puzzle and formulate the intra-industry trade pattern, some models (Dornbusch *et al.* 1977; Dornbusch *et al.* 1980) extended H-O theories to include the analysis while others (Dixit and Stiglitz 1977; Krugman 1979; Lancaster 1980; Helpman 1981) took a different approach by assuming imperfect competition and increasing returns to scale. The large volume of trade between industrial countries also motivated substantial empirical studies and the gravity equation, which is a simple model capturing the trade patterns between countries, was well supported by empirical data. Studies that took imperfect competition and increasing returns are sometimes called “new trade theories”.

³ U.S. was the largest importer of footwear from China in year 2003: a percentage of 40.78 (value of \$547,640,680) of all the footwear exported went U.S. U.S. was followed by Japan (13.56%), Belgium (9.3%), and Netherlands (5.2%). (Source: UN Statistics Division Database 2004)

Papers by Dixit and Stiglitz and Krugman are especially worth mentioning because of their substantial influence on intra-industry trade studies following them. Increasing returns to scale and monopolistic competition are the major sources of departure in their analysis of intra-industry trade. Krugman followed Dixit and Stiglitz's model and extend the analysis specifically to international trade. The policy implication has been used widely in trade between industrial countries, for example, the Canada-U.S. trade. The Canada-U.S. trade gave rise to studies as early as 1960s, which was long before the Canada-U.S. free-trade agreement in 1989. It is believed that firms in Canada will be benefited from the access to the large market in U.S. after lifting the trade barrier. As a result of free-trade agreement, some of the firms will expand their production capacity while others will be driven out from the market. A lot of the changes during this process were captured by Krugman's "selection effect" and "scale effect".

New trade theories have justified empirically or theoretically that the intra-industry trade is one of the trade patterns that we expect to see. Unlike inter-industry trade that emerges between countries with different factor intensities, intra-industry trade prevails especially in countries with similar factor endowment. However, most of these studies, empirical and theoretical, focus on the general or integrated determinants, such as GDP, size of the economy, etc. In other word, industrial characteristic is seldom addressed or taken into consideration.

The generalization gives rise to some questions when we examine the intra-industry trade data in Table V-1. We calculate the Intra-industry Trade Index (IIT)⁴ of different commodities in bilateral trade. The table exhibits the IIT in ten industries (1-digit SITC) between U.S. and thirteen trade partners. These thirteen countries are some of the major trade partners and are countries at different stages of economic development. Some descriptive statistics of the bilateral trade are shown at the bottom of the table.

The first question that emerges from the table is the heterogeneity of intra-industry trade share within each bilateral trade. The standard deviation at the bottom of each column indicates how disperse the share of intra-industry trade is within each bilateral trade. These figures have shown that the bilateral trade pattern between U.S. and developed countries is more dispersed than we would expect. We also found that IIT of different commodities in U.S. with industrial countries (Canada, Germany, France, Italy, Japan, Singapore, and U.K.) are as dispersed as IIT in U.S. with NIEs (Taiwan and Korea) and with developing countries (Brazil, China, India, and Mexico). Moreover, the maximum and minimum IIT within each bilateral trade suggest that the range of disperse and we don't see a significant difference in developed countries either. Past empirical studies usually deal with the aggregated intra-industry trade share and the heterogeneity might be missed in the process of integration.

⁴ A standard measure of intra-industry trade is the Grubel-Lloyd Index (Grubel and Lloyd 1975). The share of the intra-industry trade of industry i between country j and k is $IIT_{ijk} = \frac{2 \min(X_{ijk}, X_{ikj})}{X_{ijk} + X_{ikj}}$. Thus $0 \leq IIT_{ijk} \leq 1$.

The second question is the magnitude of IIT. Bilateral trade between more similar and wealthier economies is expected to have greater share of intra-industry trade (Helpman 1987). However, we found that the average IIT between U.S. and developed countries are not significantly greater than NIEs or developing countries. Among developed countries, Canada, Germany, and U.K. have high average IIT while the average IIT in Italy and Japan are not as high as one might expect, even lower than the average IIT of Korea and India. The same result is reported from the monthly data from 1999-2003. This puzzle is along the line with the study done by Hummels and Levinsohn (1995). The tenuous relationship between empirical studies and the theoretical models in monopolistic competition and international trade seems to be an uncomfortable missing link. We will try to answer this question from a disaggregated industrial perspective rather than integrated trade volume viewpoint.

The remaining part of this paper is organized as follows. Section II will cover some past literatures about intra-industry trade and imperfect competition. In Section III a model, which is still evolving, motivated by different elasticity of substitution among differentiated products is introduced. Section VI is the goal of this paper and possible challenges. Section V is the data.

II. Literature Review

Intra-industry trade studies can be divided into two major approaches based on their assumptions. The first approach adopts H-O model and is modified to be applicable in intra-industry trade. Dornbusch, Fischer, and Samuelson (1980) extended the H-O theory to deal with a continuum of final goods and non-equalized factor price and were able to show the occurrence of intra-industry trade. Although this and some other factor-endowments models (for example, Dornbusch et al. 1977) provided the rationale for intra-industry trade in the comparative advantage regime, they failed to explain the substantial volume of trade between countries with similar factor intensity, such as the trade between OECD countries. Bhagwati and Davis (1992) also followed the line of Heckscher-Ohlin-Samuelson (HOS) model and allowed for international differences in production functions. They proved the intra-industry trade is not anomalous under assumptions of perfect competition and constant returns to scale.

In contrast to the modified H-O model, the second approach departs from H-O assumptions such as perfect competition and constant returns to scale, and assumes increasing returns to scale and imperfect competition. Two imperfect competition markets are used in this approach: oligopoly and monopolistic competition. Studies using oligopoly were mostly conducted in either Cournot equilibrium or Bertrand equilibrium (among others, Ben-Zvi and Helpman 1992; Krugman 1992; Wang 1995). We can generally acquire several policy implications from these studies. However, the

assumption of homogeneous product and lacking the empirical support made oligopoly approach less applicable than the monopolistic competition approach.

The connection between monopolistic competition theory and international trade had been tenuous⁵ until the revolutionary study done by Dixit and Stiglitz (1977, henceforth DS). They built an elegant and parsimonious Chamberlinian model that included monopolistic competition and the variety of commodity. Spence (1976) also built a similar model and the unique preference shared by these two studies is sometimes referred to as “Spence-Dixit-Stiglitz” preferences. Following Dixit and Stiglitz’s treatment of monopolistic competition, Krugman (1979) used an even more succinct Chamberlinian formulation and extended the analysis to include explicit trade implication. Krugman concluded with several important implications: the intra-industry trade occurs between countries with similar GDP, consumers will spread their expenditures over more product variety, which will cause the consumption of each variety to fall. Moreover, the trade will lead to a reduction in the number of firms in each country.

In DS and Krugman’s papers, another crucial assumption, which is equally important as the monopolistic competition, is increasing returns to scale. Increasing returns to scale departs from traditional constant returns and brings out several different results in trade theory. Under the assumptions of constant returns to scale, homogeneous products, and perfect competition, there is no reason for countries engaging in simultaneous export and

⁵ “...the theory of monopolistic competition has had virtually no impact on the theory of international trade.” (Johnson 1967)

import, which is intra-industry trade. The significance of increasing returns to scale in trade theory was first recognized by Bertil Ohlin (1933) and Frank Graham (1923). They suggested that increasing returns to scale might be the reason for trade between countries. DS and Krugman specifically used increasing returns as one of the assumptions to analyze the intra-industry trade. Increasing returns to scale leads to two important predictions in Krugman's paper: the scale effect and the selection effect. With the trade opening between two countries, firms in both countries have the access to the other country's market. Some of the firms will end up producing more than they used to produce in closed economy (scale effect) because increasing returns to scale enables these firms to produce more with diminishing average cost. Some others will exit the market because of the competition (selection effect). These two effects were certainly true after the U.S.-Canada Free Trade formed in 1989.

Intra-industry trade studies based on monopolistic competition can further be categorized into two major approaches that are contrasting to each other yet lead to similar results (Helpman and Krugman 1985): the "love of variety" approach that DS and Krugman employed and the "ideal variety" approach (Lancaster 1980; Helpman 1981). Studies using either "love of variety" or "ideal variety" approach have reached a similar conclusion that the intra-industry trade in manufacturers with differentiated products will occur between identical economies. Substantial empirical studies about intra-industry were motivated by these papers but the "...empirical tests closely linked to the theory remain scarce."(Hummels and Levinsohn 1995)

The comment made by Hummels and Levinsohn is not without evidence. Most of the empirical papers studying intra-industry trade only employ a scrap of the theoretical features in monopolistic competition model. For example, various regressions of IIT on country-specific determinants and the substantial usage of the gravity equation. The most generic gravity equation uses only the GDP and the distance between two bilateral economies as explanatory variables to determine the bilateral trade volume. Although empirical studies that use the gravity equation have performed with flying colors, Feenstra et al. (2001) proved that a gravity-type model can be derived from various range of models. In other word, the gravity equation is not strictly acquired from the monopolistic competition model.

An exception to Hummels and Levinsohn's statement is the study done by Helpman (1987). Helpman drew two empirically testable models directly from Helpman and Krugman (1985) and tested some hypotheses using data in fourteen industrial countries. He found that, under unrealistic assumptions such as all trade is considered intra-industry trade and identical preferences, the trade volume is strongly related to the share of country group GDP and similarity of country size. This encouraging support was later reconsidered by Hummels and Levinsohn (1995). They started with Helpman's basic setup and conducted similar tests by releasing some strong assumptions. They also included some other country-specific variables that are potential contributors to intra-industry trade. To their disappointment, they found very mixed empirical support to the trade theory based on monopolistic competition. As the conclusion, they suggested that

intra-industry trade might be specific to country-pairs and there may not be a general theory to explain that.

Although these pioneering studies have formulated the intra-industry trade mathematically and offered some insightful policy implications, we are still left with the puzzle of the discrepancy between theoretical model and empirical data after reviewing them. Motivated by the heterogeneity of IIT between different industries in bilateral trade, this paper intends to create a model that includes some product-specific factors and demonstrates the cause of intra-industry trade along the line with monopolistic competition.

III. Model

As we mention previously, intra-industry models that use monopolistic competition as theoretical foundation have been offering general theories composed by country-specific determinants. These models seldom take product-specific variables into consideration because of their departure from comparative advantage approach. This predetermination has lead to certain limitation in explaining the IIT heterogeneity shown in Table V-1.

Elasticity of Substitution

Motivated by the empirical data, we are convinced that the product-specific variables do play an important role in deciding the bilateral intra-industry trade. One of the product-

specific variables that we consider in this study is the elasticity of substitution among differentiated but similar products. Consumers possess different loyalty to certain brand of product if they consider this product cannot be substituted completely by products of other brand. For example, consumers may regard a handbag made by Louis Vuitton not substitutable by same type of handbag made by Banana Republic. However, people may regard a hammer made by Estwing a perfect substitution to a hammer made by Black & Decker. We consider the difference in elasticity of substitution as a key contributor to the heterogeneity in IIT. The elasticity of substitution differs in every product and every country thus we discard the assumption of constant elasticity throughout all products and homogenous preference assumption.

Consider a monopolistic competition model with the utility function characterized by CES and Cobb-Douglas. Domestic consumers face two categories of products, x and y . Subscripts denote different variety of product, and x_i and y_j denotes the quantity consumed where $i=1\dots n$ and $j=1\dots m$. A representative consumer has the following utility maximization problem

$$\max_{x_i, y_j} U = \left\{ \left[\sum_{i=1}^n x_i^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)} \right\}^{1-\alpha} \left\{ \left[\sum_{j=1}^m y_j^{(\delta-1)/\delta} \right]^{\delta/(\delta-1)} \right\}^{\alpha}$$

$$s.t. I = \sum_{i=1}^n x_i p + \sum_{j=1}^m y_j$$

where y is the numeraire good. δ and ρ are the elasticity of substitution between varieties in x and y , respectively. Elasticity of substitution ranges between $[0, \infty)$ where

0 implies Leontief (no-substitution) utility and ∞ implies perfect substitution. The budget I can be regarded to as GDP per capita and will be discussed further in general equilibrium context. For now we consider I as exogenous. Because of the constant elasticity of demand in x and y , the prices have a constant markup over the marginal cost. This feature will become crucial when we talk about the producer side. We also assume that if two consumption bundles give the consumer the same level of utility, the consumer will consume the one with less variety to save the transaction cost.

We use the two-stage budgeting process to solve the equilibrium where the consumer will first allocate the budget on these two bundles of products. Then he will try to maximize the utility within each bundle. In a closed economy scenario, the proposed equilibrium for the budget for bundle x and y are $(1-\alpha)I$ and αI . We first assume an extreme case by setting $\delta \rightarrow \infty$. This implies that the consumer considers all variety of product y as perfect substitutes for each other. Our revised utility function is

$$U = \left\{ \left[\sum_{i=1}^n x_i^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)} \right\}^{1-\alpha} \left(\sum_{j=1}^m y_j \right)^\alpha$$

and the proposed utility-maximizing equilibrium for x_i should satisfy

$$\frac{x_1^{-1/\rho}}{p} = \frac{x_2^{-1/\rho}}{p} = \dots = \frac{x_n^{-1/\rho}}{p} \quad \text{or } x_1 = x_2 = \dots = x_n = p^{-\rho}$$

and the consumption of y_j is characterized by the corner solution where two sets of equilibrium are possible: only one of the variety is consumed or consuming equal amount of consumption of y_1, y_2, \dots, y_m . According to our assumption, the consumer will choose to consume only one of the y_j to save the transaction cost.

Without further investigation into the producer side and exploiting all monopolistic competition features, we conclude that a typical consumer consumes n variety of product x and one variety of product y to maximize his utility. We can predict that with the economy opening to trade, consumers will consume more varieties of x from both countries but will still consume one variety of y . Thus product y is dominated by one-way trade and IIT equals to zero. Contrast to the consumption of product y , the consumption of product x will be spread over all varieties among domestic and foreign producers.

A general case with different but non-infinite elasticity of substitution is still under construction. General case requires the implementation of producer-side characteristics and the monopolistic competition features such as zero economic profit. We do not have a conclusive answer yet.

Transportation Cost

Another product-specific variable that we consider is the transportation cost. Some products, such as dairy products, do require larger transportation cost per unit compared to, for example, durable products. For example, the IIT of food product between U.S. and Japan was 0.08 in 2003. We would like to formulate the transportation cost into our model as well.

IV. Goal and Possible Challenges

Past studies using monopolistic competition and increasing returns to scale have attempted to create models that could generalize all the intra-industry trade using country-specific determinants. However, as we review these studies, the connection to monopolistic competition theory is tenuous and empirical support is mixed. Although the gravity equation has performed well, the conjuncture between gravity equation and monopolistic competition is indeterminate.

Motivated by the heterogeneity of IIT among different products, this paper attempts to include product-specific variables in the model. We hope to offer some new perspectives to the intra-industry trade study. As we show in part III, we consider the elasticity of substitution as a determinant and hope to develop a Chamberlinian model. This new approach will shift the emphasis of intra-industry trade study to consumer-driven causes. After developing our models, we hope to find some statistically testable hypothesis and give this model some tryouts.

There are two main potential challenges to future studies in this paper: challenge of formulating testable hypothesis and challenge of the data. The first challenge refers to some variables that are not directly observable in empirical data, such as elasticity of substitution of products in certain country. The second challenge is whether we are reading the correct data. For example, the multinational firm's investment makes the IIT

higher than it is supposed to be. We need to exclude some major multinational investment to avoid possible bias. Another concern about the data is how detailed do we want it. The criticism raised by John Chipman (1992) was that the SITC data-generated estimates of intra-industry trade reflect aggregation of different goods, and he argued that if we carry down to multiple digits (he suggested 18 digits), intra-industry trade will not exist. Although his argument was later rejected by Bhagwati and Davis (1992), we still need to consider if we use the correct digit of SITC to avoid the bias from aggregation.

V. Data

Table V-1 Intra-industry Trade Index (IIT) of 1-Digit SITC Commodities between U.S. and the Trade Partners (2003)

1-Digit SITC ⁶	BRA	CHN	IND	MEX	KOR	TWN	CAN	DEU	FRA	ITA	JPN	SGP	UK
0	0.32	0.59	0.25	0.98	0.15	0.31	0.91	0.95	0.88	0.65	<u>0.08</u>	0.66	0.75
1	<u>0.03</u>	0.51	<u>0.10</u>	<u>0.15</u>	0.70	0.24	0.67	0.88	<u>0.05</u>	0.09	0.08	<u>0.07</u>	0.51
2	0.42	0.22	0.65	0.35	0.20	<u>0.20</u>	0.64	0.65	0.78	0.22	0.15	0.35	0.48
3	0.24	0.45	0.66	0.32	0.81	0.92	<u>0.17</u>	<u>0.12</u>	0.37	0.62	0.58	0.35	<u>0.04</u>
4	0.45	0.14	0.94	0.22	<u>0.04</u>	0.37	0.86	0.89	0.75	<u>0.06</u>	0.50	0.97	0.61
5	0.39	0.93	0.97	0.36	0.43	0.45	0.86	0.57	0.68	0.84	0.92	0.84	0.70
6	0.26	0.22	0.16	0.84	0.50	0.35	0.81	0.53	0.57	0.39	0.56	0.23	0.91
7	0.99	0.34	0.66	0.76	0.62	0.64	0.98	0.57	0.87	0.77	0.37	0.96	0.97
8	0.61	<u>0.06</u>	0.25	0.69	0.76	0.45	0.89	0.77	0.80	0.28	0.86	0.81	0.90
9	0.38	0.26	0.80	0.77	0.74	0.47	0.52	0.54	0.58	0.64	0.55	0.71	0.93
Max	0.99	0.93	0.97	0.98	0.81	0.92	0.98	0.95	0.88	0.84	0.92	0.97	0.97
Min	<u>0.03</u>	<u>0.06</u>	<u>0.10</u>	<u>0.15</u>	<u>0.04</u>	<u>0.20</u>	<u>0.17</u>	<u>0.12</u>	<u>0.05</u>	<u>0.06</u>	<u>0.08</u>	<u>0.07</u>	<u>0.04</u>
Mean	0.41	0.37	0.54	0.54	0.49	0.44	0.73	0.65	0.63	0.46	0.47	0.59	0.68
Std. Deviation	0.24	0.24	0.31	0.28	0.27	0.20	0.23	0.23	0.24	0.27	0.28	0.30	0.27

Source: U.S. International Trade Statistics (2004)

⁶ 1-Digit SITC commodities: (0) Food and Live Animals; (1) Beverages and Tobacco; (2) Crude Materials, Inedible, Except Fuels; (3) Mineral Fuels, Lubricants and Related Materials; (4) Animal and Vegetable Oils, Fats and Waxes; (5) Chemicals and Related Products, N.E.S.; (6) Manufactured Goods Classified Chiefly by Material; (7) Machinery and Transport Equipment; (8) Miscellaneous Manufactured Articles; (9) Commodities and Transactions, N.E.S.

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