Regime Selection as an Alternative to the Grubel-Lloyd Index

Honggue Lee

Konkuk University
1 Hwayang-dong, Gwangjin-gu
Seoul 143-701, Korea

February, 2004

Regime Selection as an Alternative to the Grubel-Lloyd Index

Honggue Lee
Konkuk University

Abstract

This paper contends that the regime selection probability can provide an "empirically justifiable" alternative to the GL index as a measurement of intra-industry trade. The regime selection probability is an average of sample selection probability that each trade flow data comes from inter-industry trade (or equivalently from intra-industry trade). It measures the extent to which a given set of observations is explained by the inter-industry trade regime (or the intra-industry trade regime). The Heckman two-step procedure is used: a probit model is fitted first to a separation indicator, and then the estimated parameters are incorporated into the unconditional probability equation for the second stage estimation. The sample selection model requires an auxiliary separation indicator to partition the sample, so that each of its elements may match up with either comparative advantage or product differentiation with scale economies.

As it is a selection criterion based on "empirical regularities" for separating intra-industry trade from inter-industry trade, the regime selection probability can improve upon the GL index as a relevant indicator of intra-industry trade. It can also be used to infer a transition in trade patterns, since a change in its value indicates how a shifting of explanatory power from comparative advantage to product differentiation takes place.

Key Words: Intra-industry Trade, the Grubel-Lloyd Index, Sample Selection
JEL classification: F12, L11

Honggue Lee
Department of International Trade, Konkuk University,
Hwayang-dong 1, Gwangjin-gu, Seoul 143-701, Korea
Tel.: +82-02-450-3647; Fax: +82-02-3436-6610
honglee@konkuk.ac.kr

I. Introduction

For a given mode of international transactions, one particular model explains the bilateral volume of trade better than another model. A standard model that focuses on relative factor abundance as a source of comparative advantage is appropriate for explaining *inter-industry* trade in homogeneous goods. A monopolistic competition model based on product differentiation with scale economies well explains the exchange of varieties or *intra-industry* trade. If trading partners have identical factor proportions, no inter-industry trade is caused by comparative advantage. On the other hand, if the differences in factor proportions between the trading partners are large enough to rule out factor price equalization and diversification of production, all inter-industry trade results.[1] However, it is too simplistic to relate all the observations either to inter-industry or to intra-industry trade. If these two models are mutually exclusive, their shares in total trade sum up to one by definition. Either the share of intra-industry trade or the share of inter-industry trade constitutes only a fraction in total trade. Each individual model cannot explain the whole volume of trade, but only a certain part of trade it is responsible for. So it is plausible to explain trade volume by a mixture of the two competing models.

The Grubel-Lloyd (GL) index is a widely used indicator measuring the extent of intra-industry trade as opposed to that of inter-industry trade. It is an aggregate indicator, summed up over every country pairs on all goods traded. The GL index sorts out the amount of trade flows a pair of countries simultaneously import and export. If a country exports and imports the same number of varieties simultaneously, there is only intra-industry trade and the GL index will be equal to one. On the other hand, if a country either exports or imports each of its products unilaterally, no intra-industry trade occurs and the GL index will become zero. This index varies from zero (all inter-industry trade) to one (all intra-industry trade), and the sum over the shares of the two mutually exclusive forms of trade amounts to one in each country's aggregate trade. In calculating the GL index, individual observations on bilateral trade flows among countries are classified into two different data sets, the intra-industry and inter-industry sets. Some observations whose export and import values are identical are deemed to belong to the intra-industry trade set. Other observations whose export and import values are not identical are regarded as belong to the inter-industry trade set. The likelihood that a particular observation comes from intra-industry trade is inversely related to the absolute value of the

[1] Specialization occurs because differences in factor proportions are larger than those in factor intensities of the goods produced.

difference between its exports and imports.[2] If a particular observation passes such "selection" test, it is classified into the data set belonging to intra-industry trade and put into the formula as such.

Focusing on the role of selectivity in the calculation of the intra-industry trade index, this paper contends that the sample selection probability provides an empirical justification for such an index. Sample selection by model presumes that the observed data of a specified model are not randomly selected, but are drawn from the population only when they satisfy certain selection criteria. For example, individual trade data are regarded as having been assigned to the two trade regimes by "self-selection" rather than by random assignment. The inter-industry trade data are drawn from the population only when comparative advantage prevails in determining the forms of trade flows. On the contrary, a sample of intra-industry trade will be drawn, if product differentiation with scale economies prevails in the selection process. Sample selection deals with a special form of the selectivity problem whose solution depends on the auxiliary model embedding selection criteria. So a priori information about the selection process is required: that is, how to partition the sample so that each of its elements may match up with the underlying regime, either comparative advantage or product differentiation with scale economies.[3] The Heckman two-step procedure is useful to estimating such a model, in which a probit model is fitted first to a separation or a censoring indicator, and the estimated parameters are used to estimate the unconditional probability equation. This Heckman estimation method combines the two mutually exclusive trade regimes, using all the data. The sample selection probability that an observation is on the intra-industry trade equation or the inter-industry trade equation is calculated after the parameters of the selection model have been estimated. The average of sample selection probability that each trade flow data comes from inter-industry trade (or equivalently from intra-industry trade) can be regarded as an intra-industry trade index.

The GL index can also be interpreted as a weighted average of selection probabilities that particular observations on trade flows come from the subpopulation to which the intra-industry trade model is applicable. With the whole population composed of the two exclusive subpopulations, this index can be referred to as the probability that the subpopulation of intra-

---

[2] The index is a weighted average whose weights are the differential shares in the total amount of bilateral exports and imports, the absolute differences divided by the total amount of bilateral trade.

[3] This sample selection model is equivalent to a switching regression model with the endogenous sample separation indicator. A switching regression with endogenous switching is equivalent to the disequilibrium model with unknown sample separation. See Maddala (1983, p302).

industry trade generates a particular sample of observations. What is characteristic of the GL index is that the selection criterion used in its calculation is the difference between exports and imports of each good. Under this criterion, the exporting or importing of a good is regarded as having been induced by the force of comparative advantage unless the difference between exports and imports of a certain good is zero. The GL index measures the extent of overlapped trade between trading partners as opposed to that of unilateral trade.

This paper deals with a couple of related questions. The first one is whether the GL index is an appropriate indicator of the share of trade based on intra-industry trade. Given the equivalence between the GL index and the sample selection probability, it is questionable that the selection criterion of the GL index is appropriate. The selection criterion of the GL index is the existence of two-way trade. Yet this criterion, the absolute value of the difference between exports and imports, is not well founded on theoretical underpinnings or empirical justification. If a better selection criterion for separating intra-industry trade from inter-industry trade is available, the GL index can be improved upon as a more relevant indicator of intra-industry trade.

The second question is whether it is possible to infer a transition in trade patterns from the evolution of the regime selection probability. Observations on trade flows are not likely to fit well with a specified regression equation that is constant over the observation period. For example, as the export pattern of a particular sector changes, the volume of exports in that sector will be explained over time by two different regimes of the gravity equation: first by the conventional Heckscher-Ohlin regime and then by the monopolistic competition regime or *vice versa*. A switching regression model is appropriate for such study on a transition in trade patterns in which a shifting from comparative advantage to product differentiation occurs. A change in the regime selection probabilities may indicate that a transition in trade patterns is taking place in the sense that the bilateral trade flows have come to be better explained by product differentiation with scale economies than by comparative advantage or *vice versa*.

With these objectives and aims, this paper proposes a model based on the gravity equation to show how each country's export flows can be explained simultaneously by comparative advantage and industrial organization, using the data from Korea and Taiwan. The model draws on the two different sets of explanatory variables in assessing the magnitude of bilateral trade flows, specific to comparative advantage and product differentiation with scale economies. Then the two-stage estimation methods are used to derive the sample selection (regime selection) probability. The comparison of the sample selection probability with the GL index will reveal how they are correlated with each other among various commodity groups. Moreover, since the GL index indicates the degree to which trade flows are determined by product differentiation with scale economies, the change in the magnitude of the GL index will show how a transition in export performance occurs over time.

The rest of the paper is organized as follows: in Section II, a brief summary is given on the usefulness of the GL index as a measure of intra-industry trade. In Section III, a sample selection model based on two versions of gravity equations, each of which is generated from the underlying trade models, is presented. Unlike the switching regression model of Section III which assumes that all trade is either inter-industry or intra-industry, but not both, the intra-industry trade index of Section II takes a more practical approach, which assumes that some trade is intra-industry and other trade inter-industry. A short discussion on the compilation of the data set is given in Section IV. Estimation results based on the data of Korea and Taiwan are reported along with the corresponding GL indices in Section V. Interpretations and implications are summarized in Section VI and a conclusion is provided in Section VII.

II. The Grubel-Lloyd Index

An increase in the volume of trade can be caused either by changes in the pattern of comparative advantage (inter-industry trade) or by increasing product differentiation with scale economies (intra-industry trade). With many economies in the world following different paths of industrialization, it is likely that at certain point of time they specialize in different export items in accordance with what their comparative advantage dictates. However, it is also likely that, with "convergence" in their income level, trade patterns become increasingly complementary among the economies that compete with one another in similar export items. Trade due to product differentiation with increasing returns to scale (IRS) plays an important role in explaining trade between countries particularly when the differences in factor proportions are not very large. So any measure of intra-industry trade (or inter-industry trade) must somehow reflect how these two alternative forms of trade are combined to generate the actual trade data.

The GL index is a standard indicator of measuring the share of intra-industry trade from a data set composed of both homogeneous and differentiated goods.[4] This index is calculated from the share of intra-industry trade in total trade. It measures the degree of intra-industry trade due to product differentiation with scale economies, which indicates how a country import and export simultaneously varieties of a particular product. Expressed as the ratio of intra-industry trade (two-way trade within industries) to total trade (sum of intra-industry trade and inter-industry trade), the GL index can be defined as

[4] Since the inter-industry trade and intra-industry trade indices sum to one, the former can be immediately measured once the latter is made known.

$$GL^{ij} = 1 - \left[\frac{\sum_g \left| M_g^{ij} - M_g^{ji} \right|}{\sum_g \left(M_g^{ij} + M_g^{ji} \right)} \right].$$

The index, $GL^{ij} \left(0 \le GL^{ij} \le 1 \right)$, will be equal to zero in the absence of intra-industry trade, but to one in the absence of inter-industry trade. Thus, if the bilateral GL index is relatively large for a set of trade flow data, it can be inferred that a relatively large proportion of bilateral trade in this data set is associated with two-way trade in differentiated products.[5]

Yet this index is not a perfect indicator of measuring the share of trade due to product differentiation with scale economies. Its magnitude depends not only on the level of aggregation, but also on the method of industry classification. Moreover, since increasing returns to scale would not necessarily make a distinction between inter-industry trade and intra-industry trade, the GL index is inevitably prone to have a bias in its calculation.[6] The more fundamental problem with the GL index, however, is that this index lacks theoretical foundations or empirical regularities. Apparently since Helpman (1987) established a formal link between data and theory, there have been similar lines of empirical works. Most empirical works have examined the index in light of the determinants of intra-industry trade. Since the index is not posited on a formal theory, the most the empirical works can do is to relate it to country characteristics for given industries or industry characteristics within each country.[7]

In the calculation of the GL index, a particular observation on bilateral trade is regarded as belonging to intra-industry trade if the difference between the bilateral exports and imports is zero, but as belonging to inter-industry trade if that difference is greater than zero in absolute value. If a particular observation satisfies this "selection" criterion for intra-industry trade, it is put into the formula for calculating the GL index. This method is equivalent to calculating the weighted selection "probability." That is, a certain observation is given probability one when it satisfies the selection criterion of the GL index. Then the number of probability one observations in the sample is counted, and the weighted sum of them, whose weights are the ratios of (intra-industry) exports or imports to total trade, is calculated. The GL index thus calculated is nothing but the weighted sum of probabilities that particular observations are in the intra-industry regime. This weighted sum is proportional to the ratio of probability one observations to all the observation in the sample. What this implies is that calculating the intra-industry trade index is comparable to estimating the regime selection probability by which each of the two

---

[5] Grubel and Lloyd (1975)

[6] Evenett and Keller (2002, p288) and Leamer and Levinsohn (1995, p1376) discuss the problems associated with using the GL index as an indicator of the measurement of trade due to IRS.

[7] See Hummels and Levinsohn (1995) and Leamer and Levinsohn (1995) for more information about the related literature.

versions of the gravity equation is selected. For example, if the share of intra-industry trade increases, the regime selection probability gets higher in favor of the monopolistic competition regime. In this regard, as a measurement of intra-industry trade, the GL index can be improved upon, since a more feasible selection criterion will bring about a better intra-industry trade index.

In this paper, the comparability of the GL index with the regime selection probability is at issue. While the selection mechanism of the GL index lacks empirically plausible foundation, the sample selection does not. So this paper looks into the extent to which the GL index is correlated with the regime selection probability, an empirically verifiable concept.[8] A high correlation between them will indirectly corroborate the usefulness of the GL index. The presumption is that although the GL index lacks empirical justification, the regime selection probability is robust to empirical regularities. Moreover, if this presumption can be justified, the validity of the conventional index can be enhanced by employing more plausible selection criteria, and an inference from the intra-industry trade index can be made about the information on structural transition in trade patterns.

III. Regime Selection

A. Two Versions of the Gravity Equation

As the export pattern of a particular sector changes, the volume of exports in that sector can be explained over time by two different regimes of the gravity equation: first by a conventional Heckscher-Ohlin regime and then by a monopolistic competition regime or *vice versa*. If only comparative advantage matters, trade flows can be explained by the gravity equation based on a unicone Heckscher-Ohlin model with factor price equalization. On the other hand, if only product differentiation with scale economies matters, trade flows can be explained by the gravity equation based on a monopolistic competition model with complete specialization. Yet between these two extremes most observations on trade flows are likely to be explained partly by comparative advantage and partly by product differentiation with scale economies. The likelihood of observing these “in-between” observations can be constructed as the weighted sum of probabilities predicted from the two simplified models, which can be referred to as the sample selection probabilities. Moreover, if a transition had occurred in the export pattern, it should change the average of the sample selection probabilities, that is, the regime selection

[8] So, unlike the previous studies, this paper does not consider the intra-industry trade index as a function of country characteristics or industry characteristics, nor does it try to explain the patterns of intra-industry trade in terms of those variables.

probability. This regime change causes the shifting of main explanatory power from the variables associated with comparative advantage to the other variables associated with product differentiation with scale economies.

In the following, a two-country, two-good, and two-factor (2X2X2) model will be considered to establish the connection between the regime selection probability and the intra-industry trade index. Three variations of this model are possible. At one extreme, intra-industry trade may be ruled out, so that two homogenous goods are produced and traded in accordance with the patterns of comparative advantage. At the other extreme, all intra-industry trade in which two differentiated goods are produced and traded can be considered. Most of the time, however, a two-sector model with a homogenous good and a differentiated good is used to explain both intra-industry and inter-industry trade.

Evenett and Keller (2002) provide a reference model that assumes balanced trade, no trade in intermediate goods, identical production technologies, and identical homothetic preferences. In the following, two extreme versions of a gravity equation will be constructed. One extreme version is the "unicone"[9] Hecksher-Ohlin model laid out in Evenett and Keller (2002), which is appropriate for explaining trade flows due to comparative advantage. The other extreme version is the monopolistic competition model adapted from Hummels and Levinsohn (1995),[10] which is suitable for explaining trade flows due to product differentiation with scale economies. The mixed version with both homogeneous and differentiated goods can be constructed as a linear combination of these two extreme versions.

B. A Unicone Heckscher-Ohlin Model with Factor-price Equalization

Consider the unicone Heckscher-Ohlin model in which two countries diversify production and trade goods according to their comparative advantage. Suppose that country i has comparative advantage in good X. Then country i will ship good X to both countries, but it cannot export good Z to its trading partner. Analogously, suppose that country j has comparative advantage in good Z. Country j will ship good Z to both countries, but it cannot export good X to country i.

Since both goods are homogeneous and are produced under constant-returns-to-scale technology, country i's exports to country j are given by

$$X^{ij} = p_X\left(X^i - s^i X^W\right) \quad (1)$$

[9] This is a model of two-country, two-good, and two-factor with factor price equalization, in which diversification of production occurs and the share of inter-industry trade increases with differences in factor proportions. Evenett and Keller (2002) call this model the "unicone" Heckscher-Ohlin model with CRS/CRS goods.

[10] Theirs basically follows Helpman and Krugman (1985).

where p_X denotes the relative price of good X in terms of the *numeraire* good Z [11], X^i country *i*'s production of good X , X^W world production of good $X, s^i = \frac{Y^i}{Y^W}$ the country *i*'s share of world income, Y^i country *i*'s income, and Y^W world income.[12]

The share of the exportable good X in country *i*'s GDP can be defined as $\theta^i = \frac{p_X X^i}{Y^i}$. Then substituting θ^i into equation (1) and collecting terms will yield a gravity equation expressed as

$$X^{ij} = \frac{Y^i Y^j}{Y^w}\left(\theta^i - \theta^j\right) \quad (2)$$

where $\theta^{i(j)}$ is the share of the exportable good (import competing good) in country *i*(*j*)'s GDP.[13] The difference between θ^i and θ^j increases with an increase in the difference in the capital-labor ratios between the two countries. This difference in GDP shares will tend to zero if factor proportions in the two countries converge. On the contrary, with the factor proportions substantially divergent enough to rule out factor price equalization, it will tend to one as the share of the exportable good in one of the two countries approaches one, whereas that in the other country approaches zero.[14] If trade is dictated by comparative advantage alone, then equation (2) will make the appropriate gravity equation for explaining bilateral trade flows.

In the presence of trade barriers (transport costs), on the other hand, equation (2) will be modified as follows.

$$X^{ij} = \frac{Y^i Y^j}{Y^w}\left(\overline{\theta}^i - \overline{\theta}^j\right) \quad (2')$$

To make equation (2') operational, suppose that $\overline{\theta}^i$ corresponds to the share of the exportable good in the following domestic production possibility frontier, which gives the maximum combinations of X and Z .[15]

$$\overline{Q}^i = A^i\left[\overline{\theta}^i\left(X^i\right)^\rho + \left(1-\overline{\theta}^i\right)\left(Z^i\right)^\rho\right]^{\frac{1}{\rho}} \quad (3)$$

The first-order conditions of the transformation curve provide the equilibrium ratio of X to Z . That is, the ratio of X to Z in country *i* is given by

---

11 Z is assumed to be the importable good.

12 What this equation implies is that good X is capital intensive in production if country *i* is capital abundant or that good X is labor intensive in production if country *i* is labor abundant.

13 Or it can be expressed as $\frac{\left(\theta^j - \theta^i\right)Y^i Y^j}{Y^w}$ if the relative abundance of country *i*'s factor endowment is reversed.

14 Evenett and Keller (2002, p286)

15 The economy's budget constraint, domestic expenditure valued at domestic prices, equals output also valued at domestic prices (GDP) plus the tax revenue returned to the consumers.

$$\frac{X^i}{Z^i} = \left[\frac{\overline{\theta}^i T^{ji}}{\left(1-\overline{\theta}^i\right)p_X^i}\right]^{\frac{1}{1-\rho}} \quad (4),$$

where T^{ij} *is* the trade cost factor from country *i* to country *j*. Solving equation (4) for $\overline{\theta}^i$ yields

$$\overline{\theta}^i = \frac{1}{\left(T^{ji}/p_X^i\right)\left(Z^i/X^i\right)^{1-\rho} + 1} \quad (5)$$

Analogously, suppose that the foreign transformation function can be given as

$$\overline{Q}^j = B^j\left[\overline{\theta}^j\left(X^j\right)^\rho + \left(1-\overline{\theta}^j\right)\left(Z^j\right)^\rho\right]^{\frac{1}{\rho}} \quad (6).$$

Then the equilibrium ratio of X to Z in country *j* is derived as

$$\frac{X^j}{Z^j} = \left[\frac{\overline{\theta}^j}{\left(1-\overline{\theta}^j\right)p_X^i T^{ij}}\right]^{\frac{1}{1-\rho}} \quad (7).$$

The share of the import competing good in country *j*'s GDP, $\overline{\theta}^j$, can be expressed as

$$\overline{\theta}^j = \frac{1}{\left(1/p_X^i T^{ij}\right)\left(Z^j/X^j\right)^{1-\rho} + 1} \quad (8).$$

Substituting $\overline{\theta}^i\left(= \frac{p_X^i X^i}{p_X^i X^i + T^{ji} Z^i}\right)$ and $\overline{\theta}^j\left(= \frac{p_X^i T^{ij} X^j}{p_X^i T^{ij} X^j + Z^j}\right)$ into equations (5) and (7) and collecting terms will further simplify $\overline{\theta}^i$ and $\overline{\theta}^j$ as functions of individual prices and trade costs. That is,

$$\overline{\theta}^i = \frac{p_X^i}{p_X^i + T^{ji}} \quad (5')$$

$$\overline{\theta}^j = \frac{p_X^i T^{ij}}{p_X^i T^{ij} + 1} \quad (8')$$

Since the world export and import prices are fixed for a small country, $\overline{\theta}^i$ decreases with T^{ji}, but $\overline{\theta}^j$ increases with T^{ij}: the share of X (exportable good) in GDP decreases in country *i* if the import price (the price of good Z) increases with the imposition of tariffs, and the share of X (import competing good) in GDP increases in country *j* if import price (the price of X) increases with the imposition of tariffs.

Given $\overline{\theta}^i$ and $\overline{\theta}^j$, it is convenient to express their difference $\left(\overline{\theta}^i - \overline{\theta}^j\right)$ in terms of the price indices. The price indices corresponding to the respective transformation functions (equations (3) and (6)) can be expressed as

$$\overline{P}^i = \left(A^i\right)^{-1}\left[\left(\overline{\theta}^i\right)^{\frac{1}{1-\rho}}\left(p_X^i\right)^{\frac{\rho}{\rho-1}} + \left(1-\overline{\theta}^i\right)^{\frac{1}{1-\rho}}\left(T^{ji}\right)^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}} \quad (9)$$

$$\overline{P}^j = \left(B^j\right)^{-1}\left[\left(\overline{\theta}^j\right)^{\frac{1}{1-\rho}}\left(p_X^i T^{ij}\right)^{\frac{\rho}{\rho-1}} + \left(1-\overline{\theta}^i\right)^{\frac{1}{1-\rho}}\right]^{\frac{\rho-1}{\rho}} \quad (10)$$

Substituting equations (5') and (8') into equations (9) and (10) respectively will yield the following relationships.

$$\overline{P}^i \propto k^i\left(p_X^i + T^{ji}\right) \quad (11)$$
$$\overline{P}^j \propto k^j\left(p_X^i T^{ij} + 1\right) \quad (12)$$

where k^i and k^j are constants. Equations (5') and (8') can be simplified as $\overline{\theta}^i = \frac{p_X^i}{\overline{P}^i}$ and $\overline{\theta}^j = \frac{p_X^i T^{ij}}{\overline{P}^j}$.[16] Then the difference in shares is expressed as $\left(\overline{\theta}^i - \overline{\theta}^j\right) = p_X^i T^{ij}\left(\frac{1}{\overline{P}^i T^{ij}} - \frac{1}{\overline{P}^j}\right)$.

Estimation Equation

Taking the log of equation (2') gives the basic estimation equation as follows.

$$\ln X^{ij} = \alpha_1 \ln\left(Y^i + Y^j\right) + \alpha_2 \ln\left(S^i S^j\right) + \alpha_3 \ln\left(\overline{\theta}^i - \overline{\theta}^j\right) + \varepsilon \quad (13)$$

The first two terms of equation (13) are derived from the product of GDPs term, $\frac{Y^i Y^j}{Y^W}$ in equation (2), which is equivalent to $\left(Y^i + Y^j\right)S^i S^j$, where $S^i = \frac{Y^i}{Y^i + Y^j}$ and $S^j = \frac{Y^j}{Y^i + Y^j}$. The first term represents the effect of "market expansion." The second term represents the "size dispersion" effect, which reflects the effects of IRS-based trade and is foreign to the standard Heckscher-Ohlin model. The third term gets larger as differences in factor proportions between country *i* and country *j* increase. The term $\left(\overline{\theta}^i - \overline{\theta}^j\right)$ is a function of trade costs and relative prices. Yet the gravity equation does not directly express the third term in those variables that make prices differ across countries, along with transport costs, tariffs, or exchange rate changes. Instead, the third term includes these trade costs only implicitly.

C. A Monopolistic Competition Model with Complete Specialization

In the monopolistic competition model, each producer chooses a variety and produces from an identical IRS production technology. Scale economies lead to specialization in every variety. While each variety can be regarded as a different product, competition among varieties dictates

---

[16] With symmetrical trade costs, $T^{ji} = T^{ij}$, the shares can be expressed in terms of trade cost and prices. That is, $\overline{\theta}^i = \overline{\theta}\left(P^i, T^{ij}, p_X^i\right)$ and $\overline{\theta}^j = \overline{\theta}\left(P^j, T^{ij}, p_X^i\right)$, or $T^{ij} = \frac{\overline{\theta}^j \overline{P}^j}{\overline{\theta}^i \overline{P}^i}$.

an identical price. Then the amount of each variety produced is the same, and the total output supply is equal to the number of varieties multiplied by the amount of each variety.[17] All consumers are assumed to have identical preferences, so that their behavior can be inferred from that of a representative consumer. In free trade equilibrium with no transport costs, the output supply should equal the aggregate demand.

Suppose that both X and Z are differentiated products, each of which comes in many varieties. Yet each country is assumed to produce only one product (variety) and ship it to both domestic and foreign markets. For example, country *i*'s exports to country *j* of the product in which country *i* is specializing can be expressed as $X^{ij} = s^j Y^i$ in the absence of trade barriers, and country *i*'s shipments of that product to its own market can be expressed as $X^{ii} = s^i Y^i$. Here s^i denotes country *i*'s share of world income, and s^j country *j*'s share. That is,

$$X^{ij} = s^j Y^i = \frac{Y^i Y^j}{Y^W} \quad (14),$$

where Y^W, Y^i, Y^j denote the GDPs of the world, country *i*, country *j* respectively.

In the presence of trade barriers (transport costs), however, it is more convenient to look at the consumption demand, which is identical across countries and homothetic.[18] Suppose that consumers maximize

$$\overline{U} = \left[X^{\alpha} + Z^{\alpha}\right]^{\frac{1}{\alpha}} \quad (15)$$

subject to the budget constraint[19]

$$p_X X + Z = Y \quad (16).$$

Then the exports of country *i* to country *j* (the demand for country *i* good X in country *j*) can be expressed as:

---

[17] See Helpman and Krugman (1985, p 153), Chapter 7, for the derivation of the equilibrium values of the endogenous variables.

[18] The demand for each product variety can be derived as follows. Suppose that the utility function can be expressed as $U = \left(\sum_{i=1}^{N} d_i^{\alpha}\right)^{\frac{1}{\alpha}}$, where $0<\alpha<1$, d is the consumption level, and N the number of varieties. From the indirect utility function, the demand function for each variety can be derived as $d_i = \frac{E\, p_i^{-\beta}}{\sum_k p_k^{1-\beta}} = \left(\frac{E}{P}\right)\left(\frac{p_i}{P}\right)^{-\beta}$ where $\beta = 1/(1-\alpha)$ represents the elasticity of substitution between varieties, $P = \left(\sum_k p_k^{1-\beta}\right)^{\frac{1}{1-\beta}}$ refers to a price index, and E is the amount of expenditure allocated to the consumption of the product as a whole. Again, if each variety commands the identical price, the quantity demanded of each variety is the same.

[19] Distribution parameters in the utility function are omitted. But this omission does not affect

$$X^{ij} = Y^j \left(\frac{p^{ij}}{P^j} \right)^{1-\beta} \quad (17)$$

where $p^{ij} \left(\equiv T^{ij} p^i \right)$ denotes the price in country *j* of the variety produced in country *i*, T^{ij} trade costs or "barriers to trade," and $\beta = 1/(1-\alpha)$.

Some modification of equation (17) is desirable for further operation.[20] Since the GDP of country *i* can be expressed as

$$Y^i = X^{ii} + X^{ij} = Y^i \left(\frac{p^{ii}}{P^i} \right)^{1-\beta} + Y^j \left(\frac{p^{ij}}{P^j} \right)^{1-\beta} \quad (18)$$

and the price of country *i* good for country *j* consumers as $p^{ij} = T^{ij} p^i$, the equilibrium prices are given by

$$p^i = \left(Y^i\right)^{\frac{1}{1-\beta}} \left[\left(\frac{T^{ii}}{P^i} \right)^{1-\beta} Y^i + \left(\frac{T^{ij}}{P^j} \right)^{1-\beta} Y^j \right]^{\frac{-1}{1-\beta}} \quad (19).$$

Substituting these prices into equation (17) yields

$$X^{ij} = Y^i Y^j \left(\frac{T^{ij}}{P^j} \right)^{1-\beta} \left[\left(\frac{T^{ii}}{P^i} \right)^{1-\beta} Y^i + \left(\frac{T^{ij}}{P^j} \right)^{1-\beta} Y^j \right]^{-1} = \frac{Y^i Y^j}{Y^W} \left(\frac{T^{ij}}{P^j \Pi^i} \right)^{1-\beta} \quad (20)$$

where

$$\Pi^i = \left[\left(\frac{T^{ii}}{P^i} \right)^{1-\beta} s^i + \left(\frac{T^{ij}}{P^j} \right)^{1-\beta} s^j \right]^{\frac{1}{1-\beta}}.$$

Moreover, substituting the equilibrium prices into the price index yields

$$P^j = \left[\left(p^{ij}\right)^{1-\beta} + \left(p^{jj}\right)^{1-\beta} \right]^{\frac{1}{1-\beta}} = \left[\left(\frac{T^{ij}}{\Pi^i} \right)^{1-\beta} s^i + \left(\frac{T^{jj}}{\Pi^j} \right)^{1-\beta} s^j \right]^{\frac{1}{1-\beta}} \quad (21).$$

If the trade barriers are symmetric, $T^{ij} = T^{ji}$, as in Anderson and van Wincoop (2003), it can be shown that $P^i = \Pi^i$. Then equation (21) can be simplified as

$$\left(P^j\right)^{1-\beta} = \left(T^{ij}\right)^{1-\beta} \left(P^i\right)^{\beta-1} s^i + \left(T^{jj}\right)^{1-\beta} \left(P^j\right)^{\beta-1} s^j \quad (22)$$

And equation (20) becomes

---

the derivation of the gravity equation.

[20] The derivation of the following equations is based on Anderson and van Wincoop (2003, p175).

$$X^{ij} = \frac{Y^i Y^j}{Y^W}\left(\frac{T^{ij}}{P^i P^j}\right)^{1-\beta} \quad (20')$$

The solution to this equation requires additional information on the trade cost factor, T^{ij}, which is supposed to include all the elements that impede cross-border trade such as transport costs, tariffs, and exchange rate changes.

Estimation Equation

The estimation strategy is to construct the bilateral trade flow equation from the gravity equation derived above. The basic regression equation is expressed as

$$\ln X^{ij} = \beta_1 \ln\left(Y^i + Y^j\right) + \beta_2 \ln\left(S^i S^j\right) + \beta_3 \ln\left(\frac{T^{ij}}{P^i P^j}\right) + \varepsilon \quad (23)$$[21]

The terms of equation (23) come from the corresponding terms in equation (20'), representing market expansion, size dispersion, trade costs, and "bilateral resistance"[22] effects respectively. The $\frac{Y^i Y^j}{Y^W}$ term in equation (20') can be transformed into an equivalent term, $\left(Y^i + Y^j\right)S^i S^j$. The trade cost term T^{ij} is one in the absence of trade barriers. Otherwise, the T^{ij} term is assumed to be an increasing function of variables hindering trade flows across countries such as bilateral distance, exchange rate variations, and tariffs. The price index of each country $P^k\ (k = i, j)$ is a function of bilateral trade barriers, in which each bilateral trade barrier is normalized by the exporting (supplying) country's consumer price index before it is weighted by the exporting (supplying) country's income share to calculate the importing country's consumer price index. A larger price index implies a higher degree of "resistance," meaning a higher weighted average of bilateral barriers. The $\frac{T^{ij}}{P^i P^j}$ term in equation (20'), the ratio of the bilateral trade costs to the product of consumer price indices, is supposed to capture the "product differentiation" effect, the degree of which depends on how similar the prices of these goods become. All goods are in effect differentiated by place of origin in the present model. The substitution possibility between these goods makes the price indices tend to become identical, increasing their product and reducing the value of the ratio. The $\frac{T^{ij}}{P^i P^j}$ term also implies that trade between two countries is a function of the bilateral barrier between them relative to the

---

21 $\beta_3 = 1 - \beta < 0$, since $\beta > 1$.

22 See Anderson and van Wincoop (2003, p176) for discussion of the related concept.

product of average trade barriers that each country faces with its other trading partners. Relative trade barriers change the level of trade between the two countries. For example, larger P^i and P^j (average prices of goods imported from all countries) increase trade between country *i* and country *j* as these price indices reduce the relative price of goods imported from country *i*. [23]

D. Switching Regression with "Imperfect" Sample Separation

It is not plausible to explain the patterns of actual trade flows exclusively on the basis of one particular version of the gravity equation: either explaining a given volume of trade solely by comparative advantage, or explaining trade flows solely by product differentiation with scale economies. A latent structure in which two versions of the gravity equation are embedded can generate the actual data in accordance with a sample selection mechanism.[24] Even in this structure, however, an individual observation is applicable to only one of the two regimes, either intra-industry or inter-industry, with appropriate probability.[25] If an observation in the sample crosses the threshold required by the sample selection criteria, the model associated with those criteria is observed, and the corresponding set of the independent variables that are associated with the underlying regime is selected. Yet, while each observation may come from either one of the two distinct regression models, the central tendency of the whole data set depends on the extent to which all the observations in the set satisfy the selection criteria on average.

Suppose that the possible attributes of trade flow data can be represented by the two basic equations (13) and (23) and that the extent of intra-industry trade (or inter-industry trade) can be measured by the proportion of the observations attributable to product differentiation with scale economies (or comparative advantage). For example, suppose that, with probability Φ, a particular set of observations comes from the gravity equation posited on comparative advantage, that is, Regime 1

$$\ln X_1^{ij} = \alpha_1 \ln\left(Y^i + Y^j\right) + \alpha_2 \ln\left(S^i S^j\right) + \alpha_3 \ln\left(\overline{\theta}^i - \overline{\theta}^j\right) + \varepsilon_1 \quad (13').$$

Analogously, with probability $1-\Phi$, a given set of observations falls on the gravity equation

[23] Anderson and van Wincoop (2003, p176)

[24] Obviously, the dichotomous model identification is too simplistic. However, the extension of its results to a more general case is straightforward.

[25] This presumption is justifiable for a given practice of industry classification and aggregation used in constructing trade flow data. The current practice of industry classification puts many different products under the same category. But since it is difficult to relate unambiguously each observation to ether one of the two forms of trade regardless of the level of aggregation, the separation of inter-industry from intra-industry trade is often made arbitrarily.

posited on product differentiation with scale economies, that is, Regime 2

$$\ln X_0^{ij} = \beta_1 \ln\left(Y^i + Y^j\right) + \beta_2 \ln\left(S^i S^j\right) + \beta_3 \ln\left(\frac{T^{ij}}{P^i P^j}\right) + \varepsilon_0 \qquad (23')$$

Note that $\varepsilon_1 \sim N\left(0, \sigma_1^{\ 2}\right)$ and $\varepsilon_0 \sim N\left(0, \sigma_0^{\ 2}\right)$.

Equations (13') and (23') can be combined to be estimated simultaneously. In that case, all the observations on X^{ij} can be used. The combined model is expressed as

$$E\left(\ln X^{ij}\right) = E\left(\ln X^{ij} \mid I = 1\right) \Pr(I = 1) + E\left(\ln X^{ij} \mid I = 0\right) \Pr(I = 0) \qquad (24)$$

Here the unconditional (incomplete data) density is described as[26]

$$f\left(\ln X^{ij}\right) = f\left(\ln X^{ij} \mid I = 1\right) \Pr(I = 1) + f\left(\ln X^{ij} \mid I = 0\right) \Pr(I = 0)$$
$$= \frac{\Phi}{\sqrt{2\pi}\sigma_1} \exp\left(-\frac{\left(\ln X^{ij} - \alpha' \Gamma\right)^2}{2\sigma_1^{\ 2}}\right) + \frac{1-\Phi}{\sqrt{2\pi}\sigma_0} \exp\left(-\frac{\left(\ln X^{ij} - \beta' \mathrm{H}\right)^2}{2\sigma_0^{\ 2}}\right)$$

Note that Γ and H denote explanatory variables in equations (13) and (23) respectively, $I = 1$ Regime 1, $I = 0$ Regime 2, $\Phi = \Pr(I = 1)$, and $1 - \Phi = \Pr(I = 0)$.

The determination on whether a certain observation comes from a particular regime is different from that on how much trade comes from that regime once the selection is made. As a result, α 's and β 's in equation (24) should be estimated in two stages in which two different models are used: the univariate probit model and then the sample selection model.

In the first stage, a binomial probit model is estimated. The model is expressed as

$$\Pr[I = 1] = \Phi(\gamma' z) \qquad I = 1 \qquad \text{if} \quad I^* = \gamma' z \geq \varepsilon$$
$$\Pr[I = 0] = 1 - \Phi(\gamma' z) \qquad I = 0 \qquad \text{if} \ I^* = \gamma' z < \varepsilon$$

What this model implies is as follows: if $I^* \geq \varepsilon$, an observation on export flows is better explained by comparative advantage, and otherwise, it is better explained by economies of scale with product differentiation. The residual term ε is assumed to have a normal distribution with mean 0 and variance 1, and $I^* = \gamma' z$ is a sample separation indicator[27] that separates the export flow based on comparative advantage from that based on scale economies with product differentiation. The problem with the probit model is that the sample separation indicator, $I^*(= \gamma' z)$, is not observable, and neither are the factors causing exports from a certain country to its trading partners. Thus a dichotomous variable I , a counterpart for I^*, has to be devised to indicate whether I^* crosses a threshold.

---

26 Maddala (1983, p 299), Quandt (1988, p 54)

27 Lee and Porter (1984) name it an imperfect criterion function. Maddala (1983, p 302) calls this kind of model a switching regression model with endogenous switching.

The sample separation indicator equals one if one of the three conditions for inter-industry trade[28] is satisfied. The first condition refers to the relationship between relative production shares and comparative advantage. In the pure comparative advantage model, exporting is expected when the difference between the production vector and the consumption vector is positive. For example, compare the ratio of the exportable to the importable in country *i* (the exporting country) and the ratio of the importable to the exportable in country *j* (the importing country).If the difference between them is positive (negative) and country *i* (the exporting country) is capital (labor) abundant, the corresponding observation on export flows belongs to Regime 1 (based on comparative advantage). More specifically, suppose that a certain observation satisfies that

$$\left(\frac{\theta^i}{1-\theta^i}-\frac{\theta^j}{1-\theta^j}\right)>0 \text{ if } \left(\frac{K^i}{L^i}-\frac{K^j}{L^j}\right)>0 \text{, or } \left(\frac{\theta^i}{1-\theta^i}-\frac{\theta^j}{1-\theta^j}\right)<0 \text{ if } \left(\frac{K^i}{L^i}-\frac{K^j}{L^j}\right)<0.$$ [29]

Then that observation is regarded as having come from Regime 1. The second condition, which is applicable when the first condition fails, gives one to the sample separation indicator one if the amount of exports is zero. Observations with zero values for X^{ij} belong to Regime 1 as they represent complete inter-industry specialization, since with intra-industry trade neither exports nor imports can be zero. The third condition, which is applicable to the "mixture" model where the first two conditions are not satisfied, compares the amount of production and that of consumption in the exportable good sector. In the mixture model, if the homogeneous good is to be exported, the amount of exportable good production must exceed the amount of its consumption. Consequently, if a certain observation satisfies none of these three conditions, it is

---

[28] The first two conditions are applied to the pure Heckscher-Ohlin model. The third condition for inter-industry trade pertains to the "hybrid" model, in which the differentiated good is produced by capital intensive technology. By definition, inter-industry trade is ruled out in the monopolistic competition model.

[29] To see what this implies, compare the "production parallelogram" with the "consumption parallelogram" in the simple (2X2X2) "integrated economy" diagram depicted in Dixit and Norman (1980). If the value added share of this country's exports in its GDP is θ^i in the (2X2X2) model, its share of importable goods is $(1-\theta^i)$. If country *i*'s exportable good is capital intensive, this country must be capital abundant. Since country *j*'s importable good is country *i*'s exportable good, θ^j is the share of country *j*'s importable goods production in its GDP. With the assumption of homothetic preferences across countries, if exporting based on comparative advantage occurs, it must be true that $\left(\frac{\theta^i}{1-\theta^i}-\frac{\theta^j}{1-\theta^j}\right)>0$. On the other hand, if country *i*'s exportable good is labor intensive, a similar argument will show that $\left(\frac{\theta^i}{1-\theta^i}-\frac{\theta^j}{1-\theta^j}\right)<0$.

regarded as coming from Regime 2.[30]

The first stage model generates I^*. The criterion function (an index function) for "choosing" one from the two trade generating mechanisms (comparative advantage or scale economies with product differentiation) involves such variables as the differences in the capital-labor ratios and the number of varieties locally supplied relative to the total number of varieties demanded by the trading partners. The former represents the relative strength of comparative advantage or Regime 1, and the latter represents the strength of scale economies with product differentiation or Regime 2.

In the second stage, after the regime selection probability is determined, both Regime 1 and Regime 2 are simultaneously estimated for nonlimit observations. The combined equation is expressed as

$$E\left(\ln X^{ij}\right) = \alpha' x_1 \Phi + \beta' x_0 (1 - \Phi) + (\sigma_{1\varepsilon} - \sigma_{0\varepsilon})\phi \quad (24')$$

Here Φ, ϕ, $\sigma_{0\varepsilon}$, and $\sigma_{1\varepsilon}$ denote the cumulative distribution function, the probability density function, and the covariance functions respectively. Regressing the dependent variable $\ln X^{ij}$ on the exogenous variables $x_1\hat{\Phi}$, $x_0\left(1-\hat{\Phi}\right)$, and $\hat{\phi}$ will yield estimates of α', β' and $\left(\sigma_{1\varepsilon} - \sigma_{0\varepsilon}\right)$. The variables that are included in both regimes must have identical coefficients.

IV. The Data

Data have been taken from various sources such as *World Economic Outlook 2002*, *International Financial Statistics*, *World International Trade Statistics*, and the *Penn World Table* 5.6 and 6.1. The bilateral export flows X^{ij} are from the *World Bank Trade and Production Database* for 67 countries over the period 1976-99. Each country's data set covers different time periods: the end year is 1999, but the beginning year is different. The panel data sets are not balanced. Moreover, the number of observations for each country does not always equal the product of time periods and the number of its trading partners due to omissions. The bilateral export flows X^{ij} are reported in current U.S. dollars at three-digit International Standard Industrial Classification (ISIC) industries (28 industries), and are available for 67 countries. The *World Bank Trade and Production Database* also contains data on value added, which are used to calculate the share of exportable good production in each country's GDP. The IMF *World Economic Outlook Database*

---

[30] If a homogeneous goods model works at all, a differentiated goods model must stop working and *vice versa*. In a switching regression model, an observation on export flows may come from either comparative advantage or scale economies, but not from both.

2002 provides data on cross-country differences in the price levels with its base in 1985 and on gross domestic product in U.S. dollars. The *Penn World Table* version 5.6 is the source of data on capital-labor ratios (K/L).[31] Jon Haveman's *Useful Gravity Model Data* set provides the bilateral distance between the capital cities measured in kilometers (*DISTANCE*), which proxies transportation costs, the ratio of *c.i.f.*(cost, insurance and freight) to *f.o.b.*(free on board). Table 1 presents averages of the explanatory variables used in the model.

Table 1

The number of varieties produced in country *j* $N^j = (Y^j/qp_X^j)$ is a hypothetical construct to be put into the probit equation as an explanatory variable. It is defined as the ratio of country *j* GDP to the value of a typical differentiated good produced in country *j*. A large value for this number relative to the total number of tradable varieties in the world implies that country *j* can sufficiently satisfy its demand for differentiated goods from the local suppliers. The number of local varieties will increase with the value of GDP in country *j* and decrease with the value of the equilibrium quantity, qp_X^j, of the "supposedly identical" differentiated goods. The larger the number of varieties locally produced, the smaller is the demand for intra-industry imports. The total value-added of each three-digit ISIC industry in the *World Bank Trade and Production Data Set* is used as a proxy for the value of equilibrium quantity demanded for a typical differentiated good, qp_X^j. In the monopolistic competition model with the identical country size, the amount of each variety produced in each country should be identical. Also, with identical homothetic preferences, the amount of each variety demanded should be identical if each country's income is identical.[32] However, according to the *World Bank Trade and Production Data Set*, the value-added per firm even within the same industry is far from being identical across countries. There are two possible explanations for this anomaly. First, unlike in a theoretical model, those countries in the data set are not identical in terms of their country size, factor endowments, and so forth. So the quantity supplied by each firm need not be identical across countries. Second, in a model of symmetrical countries, the share of each variety produced and exported in each country should be identical. Yet, in reality, the demand for each variety in every country is met by both domestic production and imports, so their production shares do not have to be symmetrical across countries. Since the value-added per firm in the data set accounts for domestic production only, the country with a smaller value-added per firm may have to import differentiated goods proportionally more than the country with a

[31] Capital stock per worker in 1985 international prices is available only until 1992. Capital stock data have to be extrapolated from the past data set. For that purpose, the GDP data set has been used as an independent variable.

[32] The amount of each variety demanded is less than the amount of each variety produced in each country.

larger value-added per firm in order to satisfy the condition that the demand for each variety is identical across countries. In that case, the value-added per firm for a smaller country can be less than that of a larger country.

V. Empirical Results: Evidence from the Experiences of Korea and Taiwan

A. The Grubel-Lloyd Indices

The bilateral GL indices are calculated from the data on all manufactured goods traded at the four-digit and three-digit SITC for country pairs with positive amounts of trade. Each of these countries has up to 66 bilateral trade relations against its respective trading partners, and each of them buys up to 82 four-digit SITC or 28 three-digit items from every economy in the data set. The time period of the bilateral data sets ranges from nineteen to twenty four years.

The average GL indices for Korea and Taiwan against each of their respective trading partners are given in Table 2 for the period of 1976-1999. The indices based on three-digit classification are larger than those based on four-digit classification. Obviously, the level of aggregation significantly influences the magnitude of the indices. The number of trading partners in the data set also influences the magnitude of the GL indices. For example, compared with those indices calculated by Evenett and Keller (2002) for the group of 58 countries in the year 1985, the indices for Korea and Taiwan based on 51 and 49 countries are much larger. The GL indices for Taiwan and Korea in Evenett and Keller (2002) are 0.0569 and 0.0644 respectively, but the same indices calculated at the four-digit level in this paper are 0.099 and 0.113 respectively as shown in Table 2.[33]

Table 2

The GL index measures the extent of intra-industry trade as an indicator of trade due to product differentiation with scale economies. The high values of the GL index imply that product differentiation and economies of scale play a more influential role than comparative advantage in explaining the pattern of trade, while the low values imply the other way around. Yet, as many researchers have pointed out, inconsistency in industrial classification and the presence of intermediate goods trade may inhibit the exact measuring of the trade shares attributable to product differentiation with scale economies.[34]

B. Model Estimates

---

[33] Yet direct comparison is not warranted, because not only the number of countries and their composition, but also the coverage of industries is different between the two data sets.

[34] Evenett and Keller (2002, p288)

The sample selection probability is less susceptible to arbitrariness. It relates each observation to one of the two trade flow generating mechanisms, either comparative advantage or product differentiation with scale economies. The sample selection probability is estimated from a sample selection model[35] using all the possible bilateral export relations among the trading partners by two stage least squares with the constant term. Thirty-four sets of cross-section data are used: for each of the two countries (Korea and Taiwan), seventeen sets of data (1976-1992) are chosen.

All the estimated coefficients of the probit equation are consistent with theory and are statistically significant at less than 1 percent level. Two explanatory variables enter the probit equation: product differentiation and factor proportions. Positive signs on the 'relative' variety term, N^j/N^W ,[36] bear out theoretical expectations. The extent of intra-industry trade shrinks if the demand for differentiated goods met by local suppliers becomes larger. Thus the likelihood of a certain observation to come from the comparative advantage regime increases with the capabilities of local producers to meet the local demand for differentiated goods. Conversely, a decrease in their capabilities will increase the extent of potential intra-industry trade and reduce that of inter-industry trade. Similarly, regarding the extent of comparative advantage, positive signs on the relative capital-labor ratio, $\left(K^j/L^j\right)/\left(K^i/L^i\right)$, are also consistent with theory. Inter-industry trade is more likely to be observed if the difference in factor proportions between the trading partners increases. Coefficients of both terms are volatile for Korea, but relatively stable for Taiwan. The ratio of the partial effects for $\left(N^j/N^W\right)$ and $\left(K/L\right)_{IJ}$ terms for both Korea and Taiwan remained above one except for 76-78 (Korea) and 76-77 (Taiwan), implying that the role of product differentiation was greater that of comparative advantage in explaining the likelihood of inter-industry trade. That is, the positive effect of factor proportions on the probability of inter-industry is more than fully eclipsed by the negative effect of product differentiation. One implication of this is that the inter-industry trade becomes less important than intra-industry trade in explaining the increase in trade flows. (See table 3-A,B.)

Transition probabilities p11 and p01 denote conditional probabilities $\Pr[w=1 \mid I=1]$ and $\Pr[w=1 \mid I=0]$ respectively where w is a dichotomous indicator or a measure of I with error. The transition probability p11 for Korea ranges from 0.964(1991) to 1.000(1976), meaning that w, the measure of I, represents correctly the dichotomous variable I ninety-six to a hundred percent of the data points. The transition probability p11 for Taiwan ranges from 0.945(1977) to

---

35 The sample selection model is equivalent to the switching regression model with imperfect sample separation information (or "endogenous switching").

36 $N^j = Y^j/q^j p_X^j$ and $N^W = 2\left(Y^i + Y^j\right)/\left(q^i p_X^i + q^j p_X^j\right)$

0.983(1979). On the other hand, the transition probability p01 indicates the probability that w misrepresents the dichotomous variable I as in "regime 1" when the latter is indeed in "regime 2." The transition probability p01 for Korea ranges from 0.271(1988) to 0.520(1984), while that for Taiwan from 0.276(1992) to 0.625(1982). What these numbers imply is that the probability of misclassifying an observation from regime 2 into one from regime 1 is substantial: the average probability of misclassification is 0.433 for Korea and 0.423 for Taiwan. The present sample selection model performs well in classifying data from regime 1 correctly, but it does not when it comes to classifying data from regime 2. The overall probability of correct prediction is a weighted average of the probability correctly predicted for regime 1 and the percent correctly predicted for regime 2. The overall probability that the predicted value matches the actual value is 0.923 for Korea and 0.895 for Taiwan respectively.

The coefficients of the combined equation estimated in the second stage are consistent with what theory stipulates. Coefficients of the combined market effect $\left(Y^i + Y^j\right)$ for Korea range from 1.99 (1979) to 2.86 (1976), implying that exports elastically respond to market expansion. For Taiwan, they range from 1.43 (1979) to 2.19 (1976). However, if theory is correct, these coefficients should approach one. In this regard, the combined market effect (or the market expansion effect) term may have been overestimated. Overestimation is apparently more serious for Korea (average 2.34) than for Taiwan (average 1.76).

Coefficients of the "size dispersion" effect term $\left(S^i S^j\right)$ are expected to be smaller than those on the market expansion effect term. Unlike the market expansion effect, the size dispersion effect is supposed to be absent in the exchange of diversified homogeneous goods. So the weighted average of the size dispersion effects associated with the two different regimes must be smaller than the size dispersion effect associated with the product differentiation regime alone. For both Korea and Taiwan, the coefficients of the size dispersion effect term are indeed less than those of the combined market effect (or the market expansion effect) term.

The comparative advantage term, $\left(\theta^i - \theta^j\right)$, has negative coefficients, which range from -0.60 (1992) to -1.93 (1976) for Korea and from -0.43 (1979) to -1.41 (1976) for Taiwan. Yet 1979 result for Taiwan is not statistically significant. The negative sign of the comparative advantage term implies that export growth diminishes as comparative advantage improves. This seemingly inconsistent outcome needs further explanation. In the presence of the product differentiation term, the influence of comparative advantage on exports cannot be independently determined. If comparative advantage improves, those sectors specializing in affected goods will want to increase their exports. If the exports of comparative advantage goods are to increase, these sectors have to snatch resources away from the other activities. For example, resources that might have gone to differentiated goods production must be reallocated to homogeneous goods. If that happens, the exporting of differentiated goods may be reduced down to such an extent that the reduction in differentiated goods export may exceed the increase in homogenous goods export, and the net amount of exports is actually decreased. The negative comparative advantage term implies that this conjecture might be the case. On average, the reduction in export growth in response to changes in comparative advantage is slightly more elastic in Korea (-1.07) than in Taiwan (-0.80). As both Korea and Taiwan continue to deepen their capital-labor ratios, they seem to have been able to make their respective industrial structure more suitable for differentiated goods production. As a result, the negative impact of expanding inter-industry trade has been moderated.

The negative sign on the comparative advantage term is consistent with the prediction of Evenett and Keller (2002, p287) that the bilateral volume of exports (imports) increases with the extent of product differentiation. In the perfectly specializing product differentiation model, bilateral exports (imports) are proportional to the product of GDPs as shown in equation (14). In the unicone Heckscher-Ohlin model, however, bilateral exports (imports) are less than proportional to this product as shown in equation (2). The fact that the comparative advantage term becomes larger means a change in the composition of two forces, product differentiation and comparative advantage, in favor of comparative advantage. The increase in the importance of comparative advantage relative to product differentiation means the trade share explained by the former becomes larger, so that the volume of trade that is a weighted average of trade explained by both forces should decline.

The negative coefficient of the product differentiation term, $\frac{T^{ij}}{P^i P^j}$, is consistent with theoretical expectations.[37] With a negative coefficient, exports will increase if the product of prices indices increases. The degree of product differentiation depends on how similar the prices of these goods are. Moreover, the more similar the price indices are, the greater their product becomes. The similarity of price indices will therefore enhance export growth due to increased product differentiation. Unlike the case with the negative comparative advantage term, reallocation to differentiated goods production should not reduce the total amount of exports. Scale economies due to an increase in differentiated goods production preclude the actual reduction in export growth.

Apparently, comparing the coefficients of the comparative advantage and product differentiation terms shows that the product differentiation term is relatively more important to Taiwan in explaining the export growth than to Korea. The coefficient of the product differentiation term is always greater than that of the comparative advantage term in absolute value for Taiwan except the years 1976 and 1991. Yet it is not the case for Korea until the year

[37] Since $\beta_5 = 1 - \beta$, $\beta_5 < 0$ implies that $\beta > 1$, which is what theory presumes.

1982 provided that the case of the year 1979 is ruled out.

Coefficients of the probability density function term, $\phi(\gamma' z)$, and the inverse Mills ratio (the hazard rate), $\lambda = \frac{\phi(\gamma' z)}{\Phi(\gamma' z)}$, can be calculated. The coefficient of the estimated probability density term, $\hat{\phi}$, is the estimate of $(\sigma_{1\varepsilon} - \sigma_{0\varepsilon})$, which ranges from -0.186(1979) to 0.529 (1976) for Korea and from -0.196 (1977) to 0.187 (1984) for Taiwan.[38] Yet the estimates of $\hat{\phi}$ are not statistically significant except for the years 1976, 1978, and 1983 for Korea and 1978 for Taiwan.[39]

Table 3

C. Sample Selection Probabilities

The regime selection probability that each observation is on Regime 1 (or on Regime 2) is calculated from the estimated parameters of the model. Its average is reported in Table 4 on the row showing the values of Φ. As for Korea, the average selection probability for Regime 1, Φ, ranges from 0.797 (1991) to 0.946 (1976), which implies that the selection probability for Regime 2, the supposed extent of intra-industry trade, ranges from 0.054 to 0.203. The extent of intra-industry trade inferred from the sample selection model is less than that assessed from the GL index. It approaches only 87.7 percent of the GL index on average during the sample period, which is an underestimation of the GL index by 12.3 percent. In case of Taiwan, however, an overestimation is the case. Taiwan's selection probability for Regime 2 ranges from 0.120 (1976) to 0.261 (1991), and its GL index ranges from 0.09 (1977) to 0.200 (1992). The sample selection model overestimates the GL index by 16.3 percent.

Table 4

Besides the discrepancy between the regime selection probability and the GL index, different correlations between them also are characteristic of the experiences of Korea and Taiwan. While the correlation coefficient is relatively high for Korea, it is not so for Taiwan. The correlation coefficients are 0.894 (Korea) and 0.622 (Taiwan) respectively. Apparently, a stronger linear relationship between the regime selection probability and the GL index exists in case of Korea.

What has caused these imbalances in the indices and the correlation coefficients? Three factors seem to be at work. The first factor is the discrepancy in the number of observations. For both Korea and Taiwan, the data points plugged into the formula in the calculation of the GL index are always greater than those used in the estimation of the sample selection model.[40] The

[38] The estimates of $\hat{\phi}$ are not reported in Table 2.

[39] They are significant at the 5 percent level.

[40] Compare the numbers at 3-digits in Table 2 with those in Table 1.

GL index can be calculated for any country pairs exchanging positive amount of trade. On the other hand, the sample selection model needs a balanced-set of explanatory variables before it can be estimated. Thus, unlike in the case of the GL index, the availability of trade data is not sufficient for the selection model to be estimated. The information about capital per worker and industry value-added is so indispensable elements that it actually plays a crucial role in determining the availability of the relevant data-set. The second factor is related to the treatment of the zero values of trade. When the amount of exports (imports) is zero, it does not influence the magnitude of the GL index. Zero values do not enter the formula. In case of the sample selection model, however, zero amounts make difference to the extent of intra-industry trade, since they are classified into the inter-industry trade regime. One related point to the second factor is the fact that in the calculation of the GL index both exports and imports data are needed. Yet in the estimation of the sample selection model either import or export data, but not both, are required. The third factor is the performance of the separation indicator used, which can be inferred from the transition probabilities in Table 3. When it comes to the separation of observations associated with inter-industry trade, the separation indicator used in the present model performs satisfactorily. This indicator, however, is not so good at identifying intra-industry trade observations when these data are actually from the intra-industry trade regime. It is not easy to see what impacts the inequality in the number of observations, the different treatment of zero values, and the performance of the separation indicator have made on the regime selection probability. Yet the discrepancy between the GL indices and regime selection probabilities or that in the correlation coefficients between Korea and Taiwan would have been smaller in their absence.

VI. Discussion

A. Regime Selection Probabilities and Intra-industry Trade Indices

With only a few supporting cases in hand, one cannot make even a cautious generalization on the relationship between the regime selection probabilities and intra-industry trade indices. Yet, however scant evidence the above analysis provides, the way the model is set up is rigorous enough to justify choosing the regime selection probability in preference to the intra-industry trade index. The regime selection model combines two contrasting sub-models. The gravity equation constitutes the foundation on which these two sub-models for explaining bilateral trade flows are built. The first sub-model comes from Evenett and Keller (2002),[41] a unicone

[41] They are IRS-based perfect specialization (IRS/IRS Goods), IRS-unicone Heckscher-Ohlin-based imperfect specialization (IRS/CRS Goods), multicone Heckscher-Ohlin-based perfect

Heckscher-Ohlin model with two goods produced by constant returns to scale (CRS) technology, and the second one is a monopolistic competition model with two goods produced by increasing returns to scale (IRS) technology. The Heckscher-Ohlin model does not allow perfect specialization in the production of goods with factor price equalization. The monopolistic competition model allows perfect specialization in each variety of differentiated goods. These two sub-models are combined to expand three trade models,[42] so that every observation on bilateral trade flows can be regarded as having come from any one of them. Then the selection probability determines whether a certain observation belongs to the comparative advantage sub-model or the product differentiation sub-model.

Obviously, the regime selection probability is not identical to the GL index. Yet, the regime selection probability may replace the GL index as an appropriate indicator to assess the extent of intra-industry trade. The regime selection probability can be empirically justified, but the GL index lacks both theoretical and empirical justification. In the calculation of the GL index, its selection criterion posits on the condition that the absolute value of the difference between exports and imports is not zero. The GL selection criterion only makes sure that there is two-way trade in the bilateral trade flows. This criterion is not well founded on theory and lacks empirical regularities. On the other hand, the regime selection probability is a more relevant method to separate intra-industry trade from inter-industry trade, and it will make a better indicator of intra-industry trade. The sample selection probability can improve upon the GL index.

The modeling method of this paper follows common practice in the literature, assuming perfect specialization for product differentiation with scale economies, but imperfect specialization for Heckscher-Ohlin type comparative advantage. In contrast, Evenett and Keller (2002) arbitrarily separate the "low-Grubel-Lloyd" sample from the "high-Grubel-Lloyd" sample and classify each sample into five sub-groups according to the level of product differentiation or differences in factor proportions. They show that both the multicone Heckscher-Ohlin model (that is, without factor price equalization) and the scale economies model with perfect specialization grossly over-predict the level of bilateral trade flows across countries. In so doing, they reject the feasibility of perfect specialization versions for the reason of over-prediction, and find evidence in support of the imperfect specialization versions,

---

specialization (CRS/CRS Goods), and unicone Heckscher-Ohlin-based imperfect specialization (CRS/CRS) models. The first two belong to the "high Grubel-Lloyd" sample and the remaining two to the "low Grubel-Lloyd" sample.

[42] They are two-homogeneous-goods-model (comparative advantage model), homogeneous-and-differentiated-goods-model (comparative advantage / product differentiation model), and two-differentiated-goods-model (product differentiation model).

namely the IRS / unicone Heckscher-Ohlin model and the unicone Heckscher-Ohlin model.

B. Transition from Comparative Advantage to Product Differentiation

Some authors have looked at the changes in the GL index to infer transition in trade patterns.[43] Provided that the equivalence between the GL index and the selection probability is secured, one can infer transition in trade patterns from the changes in the regime selection probability. A regression equation that is constant over the observation period does not fit well with data on trade flows over time. If the export pattern of a particular sector changes, the volume of exports in that sector cannot be explained by a model that remains constant over time. Two different regimes of the gravity equation that have been used to measure the extent of intra-industry trade can be used to ascertain the existence of transition in export patterns from the one based on comparative advantage to the other based on product differentiation with scale economies. A switching regression model is appropriate for such study on transition in trade patterns in which a shifting from comparative advantage to product differentiation occurs. A change in the regime selection probability indicates that a transition in trade patterns is taking place in the sense that the bilateral trade flows have come to be better explained by product differentiation with scale economies than by comparative advantage.

The product differentiation with scale economies and comparative advantage terms should be inversely related to each other in explaining bilateral trade flows, consider the following.[44] While an increase in the demand for variety in the foreign country is likely to increase exports, an increase in production costs (exporter's price) reduces exports. The larger the equilibrium number of varieties is, the lower is the price of each variety. If the size of the market becomes larger, the number of varieties that can be produced increases. However, the net increase in the number of varieties due to market expansion in a country with a larger local market is less than that in a smaller one, because the former has already been producing more varieties than the latter. As a result, the larger the number of locally produced varieties is, the smaller is the additional reduction in the local equilibrium price. If imports due to product differentiation in a larger market decrease, then imports due to comparative advantage (relative price differences) will increase. Or, if the force of "product-differentiation-based" trade prevails, the force of "comparative-advantage-based" trade will diminish. Since these two forces are to work in the opposite direction, trade due to comparative advantage should get smaller when trade due to product differentiation prevails.

---

[43] See for example Rodrik (1994) and Scitovsky (1986).

[44] This does not mean their coefficients should have opposite signs. See V. C. for the reason why.

VII. Conclusion

This paper suggests that the GL index can be interpreted as a regime selection probability. For a given set of bilateral trade flow data, the GL index is equivalent to a trade-weighted average of “selection probabilities” by which any actual observation on trade flows is attributed either to comparative advantage or to product differentiation with scale economies. The reason why the GL index must be equivalent to the weighted average of selection probabilities is that it posits on the similar selection mechanism as found in the usual sample selection model. According to sample selection, the regime selection probability can be obtained as an average of sample selection probabilities that combine hypothetically distinctive trade regimes to replicate the actual data. It interprets a given set of observations on trade flows as a construct composed of mixed inter-industry and intra-industry trade elements.

The sample selection probabilities are affected by the level of aggregation in classifying the product groups or categorizing the industries. At one extreme where the degree of aggregation is “too low,” the magnitude of intra-industry trade based on scale economies is likely to be small, but pure inter-industry trade based on comparative advantage is likely to be large. At the other extreme where the level of aggregation is “too high” so that all the “oranges and apples” are classified under the same category, the extent of inter-industry trade will decrease, leading to greater intra-industry trade. Any observation on export flows is not “pure” in the sense that both of these trade regimes present themselves in causing the observation of those data. Besides the level of aggregation, the selection criterion plays a crucial role in determining the value of the intra-industry trade index. If a different criterion other than the difference between exports and imports is adopted, the GL index will change accordingly. The selection criterion used in this paper stipulates three conditions under which a particular observation is classified as coming from the inter-industry trade regime. A dichotomous variable is employed as a sample separation indicator that equals one if the conditions for inter-industry trade are satisfied and zero otherwise.

This paper justifies estimating the extent of intra-industry trade with the sample selection model or the switching regression model. Two points can be called forth for its justification. First of all, this method accords well with theoretical foundations and provides empirical robustness, so that the average regime selection probability thus estimated will serve as a more relevant indicator of intra-industry trade. Second, it can provide information on transition in trade patterns, since a change in the average regime selection probability may indicate a transition in trade patterns in which a shifting of explanatory power from comparative advantage to product differentiation occurs.

References

Anderson, James E. and Eric van Wincoop, "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, March 2003, 93(1), 170-192

Dixit, Avinash and Victor Norman, *Theory of International Trade*, Cambridge: Cambridge University Press, 1980

Evenett, Simon J. and Wolfgang Keller, "On Theories Explaining the Success of the Gravity Equation," *Journal of Political Economy*, April 2002, 110(2), 281-316

Grubel, Herbert G., and Peter J. Lloyd, *Intra-industry Trade: The Theory and Measurement of International Trade in Differentiated Products*, London: Macmillan, 1975

Helpman, Elhanan, "Imperfect Competition and International Trade: Evidence from Fourteen Industrialized Countries," *Journal of the Japanese and International Economies*, March 1987, 1(March), 62-81

Helpman, Elhanan and Paul M. Krugman, *Market Structure and Foreign Trade*, Cambridge: MIT Press, 1985

Hummels, David and James Levinsohn, "Monopolistic Competition and International Trade: Reconsidering the Evidence, *Quarterly Journal of Economics*, August 1995, 110(3), 799-836

Leamer, Edward E. and James Levinsohn, "International Trade Theory: The Evidence," in Gene M. Grossman and Kenneth Rogoff (eds), *Handbook of International Economics*: vol. III, Amsterdam: Elsevier, 1995

Lee, Lung-Fei and Robert H. Porter, "Switching Regression Models with Imperfect Sample Separation Information – With an Application on Cartel Stability," *Econometrica*, March 1984, 52(2), 391-418

Maddala, G.S., *Limited-Dependent and Qualitative Variables in Econometrics*, Cambridge: Cambridge University Press, 1983

Quandt, Richard E., *The Econometrics of Disequilibrium*, New York: Basil Blackwell, 1988

Rodrik, Dani, "Industrial Organization and Product Quality: Evidence from South Korean and Taiwanese Exports," in Paul M. Krugman and Alasdair Smith (eds) *Empirical Studies of Strategic Trade Policy*, Chicago: University of Chicago Press, 1994

Scitovsky, Tibor, "Economic Development in Taiwan and Korea, 1965-81," in Lawrence J. Lau (ed) *Models of Development: A Comparative Study of Economic Growth in South Korea and Taiwan*, San Francisco: ICR Press, 1986

Table 1: Summary Statistics

Korea			*dependent variable*	*independent variables (average)*								
year	bilateral relations	no obs.	exports (average)	θ^i	θ^j	home income	foreign income	distance (km)	home price	foreign price	foreign K/L	home K/L
1976	14	249	7398	0.036	0.036	28921000	92312076	5989	48.53	92.48	20452	7105
1977	18	332	7453	0.036	0.036	37077000	105598807	6329	53.44	85.02	18392	7770
1978	29	582	15036	0.036	0.036	50069000	257436931	8212	61.47	91.09	20110	8207
1979	37	723	14557	0.036	0.036	64124000	245064617	8483	68.38	90.64	19818	8950
1980	39	694	16110	0.036	0.036	62210000	289005248	8180	63.88	94.79	20823	9759
1981	49	820	17059	0.036	0.037	69575000	265263859	9069	62.30	82.99	19658	10172
1982	52	875	16777	0.036	0.037	74453000	247074040	9127	57.88	73.25	19272	10486
1983	51	903	18567	0.036	0.037	82317000	251128373	9861	54.14	67.93	19524	10857
1984	52	966	22698	0.036	0.036	82317000	250925052	9541	52.30	61.50	18540	11367
1985	51	919	23997	0.036	0.037	93460000	271096657	9886	48.45	60.79	19216	12036
1986	54	996	27234	0.036	0.037	107620000	302758652	9606	47.46	65.86	18788	12723
1987	55	957	38696	0.036	0.038	135184000	359481458	9589	51.16	73.73	19685	13586
1988	54	995	48806	0.036	0.037	180612000	391878202	9577	59.25	76.20	19637	14705
1989	55	983	49608	0.036	0.038	220710000	411503631	9876	66.47	73.38	20206	16287
1990	55	964	50007	0.036	0.038	252622000	465223083	9874	67.03	79.91	20990	17995
1991	58	1013	50200	0.036	0.038	295234000	470550503	9287	69.28	75.70	20620	18859*
1992	58	934	55122	0.036	0.037	314737000	537866258	9614	69.01	81.76	22452	19510*

Note: Exports, income, and capital per worker in thousand US$

* Estimated

Taiwan			*dependent variable*	*independent variables (average)*								
year	bilateral relations	no obs.	exports (average)	θ^i	θ^j	home income	foreign income	distance (km)	home price	foreign price	foreign K/L	home K/L
1976	14	277	4047	0.036	0.036	18623000	84990625	7044	54.56	87.04	18350	9540
1977	21	358	3678	0.036	0.036	21816000	99322285	7591	55.71	81.29	17325	10531
1978	29	582	14909	0.036	0.036	26761000	258558278	8910	56.52	91.33	19951	11502
1979	39	751	15151	0.036	0.036	33199000	237118671	9067	58.56	89.10	18965	12507
1980	39	723	18780	0.036	0.036	41423000	277726185	9047	64.76	92.44	20050	13664
1981	42	746	21327	0.036	0.036	48141000	279075174	9268	66.59	81.98	19918	15036
1982	44	802	20024	0.036	0.036	48563000	263400227	9230	60.30	74.18	19890	16293
1983	45	830	22548	0.036	0.036	52415000	268560417	10098	57.19	69.32	20100	17415
1984	47	884	27421	0.036	0.036	59173000	267868425	9842	55.68	63.23	19272	18303
1985	49	921	26690	0.036	0.037	62080000	271235507	10283	53.44	59.74	19134	*19194*
1986	52	985	32571	0.036	0.038	75287000	303692136	10054	55.24	65.98	18461	*20019*
1987	52	960	45586	0.036	0.038	101651000	355762432	10532	63.83	74.11	19626	*21061*
1988	51	966	51705	0.036	0.037	123239000	401998245	10078	70.37	77.86	20032	*22395*
1989	51	879	60069	0.036	0.038	149159000	449974129	10266	77.02	76.16	21554	*24067*
1990	54	949	54912	0.036	0.038	160393000	465486712	10331	75.83	80.22	21050	*25722*
1991	57	963	62551	0.036	0.038	179405000	496877121	9755	75.58	77.87	21119	*28184*
1992	57	908	69602	0.036	0.037	212166000	546018986	10208	81.51	81.95	22504	*30708*

Note: Exports, income, and capital stock per worker in thousand US$

Table 2: Grubel-Lloyd Indices

	3-digit				4-digit			
	Korea	**no. obs**	**Taiwan**	**no. obs**	**Korea**	**no. obs**	**Taiwan**	**no. obs**
1976	0.083	392	0.120	392	0.062	1148	0.079	1148
1977	0.098	504	0.098	588	0.072	1476	0.062	1722
1978	0.134	812	0.161	812	0.087	2378	0.104	2378
1979	0.138	1036	0.162	1092	0.100	3034	0.115	3198
1980	0.133	1092	0.168	1092	0.096	3198	0.114	3198
1981	0.115	1372	0.147	1176	0.080	4018	0.101	3444
1982	0.111	1456	0.159	1232	0.081	4264	0.108	3608
1983	0.127	1428	0.160	1260	0.096	4182	0.107	3690
1984	0.143	1456	0.154	1316	0.106	4264	0.112	3854
1985	0.144	1428	0.155	1372	0.099	4182	0.113	4018
1986	0.161	1512	0.161	1456	0.119	4428	0.115	4264
1987	0.161	1540	0.177	1456	0.118	4510	0.129	4264
1988	0.175	1512	0.199	1428	0.130	4428	0.137	4182
1989	0.184	1540	0.189	1428	0.133	4510	0.136	4182
1990	0.192	1540	0.184	1512	0.141	4510	0.129	4428
1991	0.188	1624	0.187	1596	0.141	4756	0.135	4674
1992	0.193	1624	0.200	1596	0.144	4756	0.140	4674

Table 3-A: 2SLS Regressions Explaining Korea's Exports

	76	*77*	*78*	*79*	*80*	*81*	*82*	*83*	*84*
Explanatory Variables					**Probit**				
ONE	2.442	2.160	1.541	1.750	2.475	2.134	1.969	2.151	1.794
	(0.506)	(0.329)	(0.164)	(0.152)	(0.245)	(0.175)	(0.143)	(0.159)	(0.107)
$(K/L)_{IJ}$	1.524	2.024	2.209	1.789	1.773	1.870	1.667	1.754	1.087
	(0.320)	(0.334)	(0.265)	(0.175)	(0.196)	(0.163)	(0.137)	(0.152)	(0.080)
(N_I/N_W)	1.887	1.183	1.245	1.516	2.060	2.083	1.920	2.011	1.629
	(0.599)	(0.262)	(0.246)	(0.223)	(0.331)	(0.254)	(0.216)	(0.227)	(0.166)
					Transition Probabilities				
p01(w=1,I=0)	0.385	0.441	0.289	0.452	0.500	0.500	0.516	0.476	0.520
p11(w=1,I=1)	1.000	0.966	0.983	0.974	0.980	0.980	0.978	0.981	0.975
Explanatory Variables					**Sample Selection**				
ONE	-37.00	-27.47	-26.07	-23.23	-25.83	-27.68	-25.33	-29.66	-29.89
	(7.163)	(4.035)	(2.663)	(2.112)	(2.450)	(2.264)	(2.110)	(2.174)	(2.043)
Y_{IJ}	2.863	2.254	2.126	1.994	2.143	2.227	2.130	2.396	2.454
	(0.493)	(0.264)	(0.164)	(0.134)	(0.153)	(0.139)	(0.130)	(0.130)	(0.124)
S_{IJ}	*0.891*	*0.445*	0.682	0.761	0.836	0.666	0.729	0.921	0.885
	(0.580)	*(0.313)*	(0.167)	(0.152)	(0.196)	(0.146)	(0.133)	(0.117)	(0.104)
θ_{IJ}	-1.926	-1.127	-1.103	-0.886	-1.072	-1.151	-1.036	-1.276	-1.161
	(0.567)	(0.317)	(0.209)	(0.164)	(0.196)	(0.174)	(0.159)	(0.161)	(0.148)
TP_{IJ}	-1.607	-1.056	-0.962	-0.916	-0.915	-1.011	-1.166	-1.315	-1.599
	(0.438)	(0.254)	(0.209)	(0.174)	(0.176)	(0.164)	(0.155)	(0.155)	(0.149)
λ	9.799	*-0.266*	4.417	*-2.142*	*0.286*	*-0.487*	*-0.779*	-1.338	*0.332*
	(4.050)	*(0.923)*	(1.873)	*(1.277)*	*(0.852)*	*(0.520)*	*(0.538)*	(0.601)	*(0.432)*
$\bar{R}^2$	0.356	0.294	0.295	0.289	0.287	0.292	0.292	0.335	0.374
F[k,n]	27.02	25.76	46.36	54.53	53.14	61.88	65.47	83.61	101.54
Log-L	-580	-743	-1378	-1678	-1643	-1885	-1967	-2062	-2105

Note: Standard errors in parentheses. All variables are log-transformed. Italicized and underlined numbers are statistically insignificant at any levels.

Table 3-A: 2SLS Regressions Explaining Korea's Exports (continued)

	85	***86***	***87***	***88***	***89***	***90***	***91***	***92***
Explanatory Variables					**Probit**			
ONE	2.268	2.076	1.742	2.322	1.371	1.583	1.333	1.512
	(0.162)	(0.132)	(0.104)	(0.152)	(0.075)	(0.090)	(0.072)	(0.086)
$(K/L)_{IJ}$	1.780	1.663	1.180	1.839	0.853	1.250	0.792	1.132
	(0.146)	(0.119)	(0.079)	(0.132)	(0.060)	(0.086)	(0.056)	(0.084)
(N_I/N_W)	2.243	2.321	1.861	2.794	1.223	1.747	1.292	1.662
	(0.227)	(0.200)	(0.162)	(0.228)	(0.109)	(0.140)	(0.105)	(0.138)
					Transition Probabilities			
p01(w=1,I=0)	0.441	0.388	0.476	0.271	0.464	0.361	0.483	0.399
p11(w=1,I=1)	0.974	0.970	0.977	0.968	0.975	0.965	0.964	0.966
Explanatory Variables					**Sample Selection**			
ONE	-30.66	-29.30	-28.45	-26.83	-29.85	-30.75	-31.24	-26.62
	(2.122)	(2.044)	(2.112)	(2.219)	(2.423)	(3.100)	(2.775)	(2.546)
Y_{IJ}	2.509	2.454	2.371	2.272	2.387	2.455	2.449	2.236
	(0.126)	(0.119)	(0.121)	(0.124)	(0.134)	(0.163)	(0.148)	(0.140)
S_{IJ}	0.762	0.757	0.592	0.700	0.726	0.870	0.800	0.809
	(0.103)	(0.085)	(0.090)	(0.078)	(0.085)	(0.080)	(0.077)	(0.087)
θ_{IJ}	-1.155	-1.017	-0.916	-0.760	-0.928	-0.984	-1.021	-0.596
	(0.156)	(0.147)	(0.148)	(0.148)	(0.157)	(0.193)	(0.169)	(0.153)
TP_{IJ}	-1.454	-1.472	-1.394	-1.217	-1.475	-1.639	-1.476	-1.350
	(0.148)	(0.132)	(0.143)	(0.131)	(0.144)	(0.140)	(0.140)	(0.157)
λ	*-0.768*	*-0.203*	*0.415*	*0.213*	*0.780*	*0.012*	*0.495*	*0.524*
	(0.611)	*(0.462)*	*(0.718)*	*(0.494)*	*(0.691)*	*(0.390)*	*(0.459)*	*(0.551)*
$\overline{R}^2$	0.385	0.409	0.421	0.396	0.403	0.424	0.426	0.392
F[k,n]	102.18	117.72	115.90	108.34	109.28	114.38	120.15	98.37
Log-L	-2000	-2056	-1921	-2011	-1987	-1856	-1930	-1869

Note: Standard errors in parentheses. All variables are log-transformed. Italicized and underlined numbers are statistically insignificant at any levels.

Table 3-B: 2SLS Regressions Explaining Taiwan's Exports

	76	***77***	***78***	***79***	***80***	***81***	***82***	***83***	***84***
Explanatory Variables					**Probit**				
ONE	3.667	1.539	1.877	2.158	2.850	1.826	1.841	1.981	1.953
	(0.675)	(0.156)	(0.170)	(0.157)	(0.237)	(0.121)	(0.112)	(0.126)	(0.116)
$(K/L)_{IJ}$	2.572	1.509	2.420	1.191	1.246	0.877	0.861	0.957	0.952
	(0.467)	(0.158)	(0.220)	(0.092)	(0.107)	(0.074)	(0.070)	(0.074)	(0.071)
(N_I/N_W)	3.712	1.058	2.047	2.013	2.927	1.537	1.450	1.876	1.776
	(0.780)	(0.185)	(0.266)	(0.236)	(0.343)	(0.177)	(0.162)	(0.180)	(0.159)
					Transition Probabilities				
p01(*w*=1,*I*=0)	0.324	0.338	0.282	0.533	0.522	0.586	0.625	0.531	0.485
p11(*w*=1,*I*=1)	0.971	0.945	0.964	0.983	0.975	0.975	0.972	0.972	0.965
Explanatory Variables					**Sample Selection**				
ONE	-26.47	-21.31	-17.14	-13.44	-16.70	-16.18	-15.94	-18.03	-16.64
	(3.759)	(3.094)	(2.429)	(1.826)	(2.150)	(1.948)	(1.871)	(1.967)	(1.846)
Y_{IJ}	2.190	1.840	1.601	1.434	1.593	1.566	1.557	1.675	1.607
	(0.255)	(0.200)	(0.157)	(0.120)	(0.133)	(0.122)	(0.119)	(0.123)	(0.116)
S_{IJ}	0.504	0.391	0.322	0.512	0.563	0.532	0.531	0.599	0.567
	(0.287)	(0.175)	(0.165)	(0.135)	(0.140)	(0.120)	(0.125)	(0.124)	(0.117)
θ_{IJ}	-1.410	-1.054	-0.701	-0.434	-0.694	-0.617	-0.683	-0.825	-0.684
	(0.309)	(0.247)	(0.203)	(0.155)	(0.176)	(0.156)	(0.148)	(0.158)	(0.147)
TP_{IJ}	-1.396	-1.060	-0.935	-0.876	-0.968	-0.873	-0.953	-1.029	-0.976
	(0.242)	(0.203)	(0.188)	(0.160)	(0.160)	(0.155)	(0.144)	(0.148)	(0.150)
λ	*-1.227*	-1.089	-1.348	*0.832*	*0.880*	*0.921*	*0.787*	*0.781*	*0.991*
	(1.199)	(0.607)	(0.664)	*(0.928)*	*(0.712)*	*(0.645)*	*(0.585)*	*(0.647)*	*(0.722)*
$\overline{R}^2$	0.366	0.280	0.254	0.254	0.267	0.276	0.257	0.280	0.269
F[k, n]	28.95	23.71	35.26	44.83	46.90	48.90	48.08	53.91	53.49
Log-L	-568	-697	-1263	-1624	-1587	-1568	-1687	-1694	-1794

Note: Standard errors in parentheses. All variables are log-transformed. Italicized and underlined numbers are statistically insignificant at any levels.

Table 3-B: 2SLS Regressions Explaining Taiwan's Exports (continued)

	85	***86***	***87***	***88***	***89***	***90***	***91***	***92***
Explanatory Variables					**Probit**			
ONE	1.819	1.712	1.593	1.908	1.839	1.944	1.936	2.465
	(0.105)	(0.095)	(0.091)	(0.109)	(0.108)	(0.110)	(0.114)	(0.150)
$(K/L)_{IJ}$	1.010	1.033	0.994	1.009	0.945	0.914	0.826	1.246
	(0.070)	(0.068)	(0.067)	(0.068)	(0.068)	(0.063)	(0.060)	(0.091)
(N_I/N_W)	1.657	1.704	1.589	2.054	1.852	1.942	1.928	2.529
	(0.143)	(0.131)	(0.127)	(0.154)	(0.152)	(0.148)	(0.145)	(0.190)
					Transition Probabilities			
p01(w=1,I=0)	0.462	0.385	0.417	0.321	0.379	0.345	0.374	0.276
p11(w=1,I=1)	0.966	0.968	0.962	0.980	0.978	0.974	0.956	0.957
Explanatory Variables					**Sample Selection**			
ONE	-19.23	-18.96	-17.03	-18.13	-24.40	-23.79	-24.90	-19.40
	(1.935)	(1.927)	(2.051)	(2.110)	(2.425)	(2.477)	(2.194)	(2.179)
Y_{IJ}	1.775	1.783	1.614	1.677	2.062	2.016	2.066	1.783
	(0.119)	(0.116)	(0.122)	(0.125)	(0.137)	(0.139)	(0.123)	(0.124)
S_{IJ}	0.658	0.743	0.447	0.387	0.869	0.670	0.808	0.678
	(0.102)	(0.092)	(0.099)	(0.106)	(0.102)	(0.091)	(0.089)	(0.093)
θ_{IJ}	-0.794	-0.760	-0.600	-0.584	-1.020	-0.896	-1.134	-0.657
	(0.152)	(0.146)	(0.150)	(0.150)	(0.168)	(0.168)	(0.146)	(0.140)
TP_{IJ}	-0.982	-1.015	-0.726	-0.778	-1.061	-1.099	-1.029	-0.736
	(0.146)	(0.139)	(0.150)	(0.157)	(0.157)	(0.154)	(0.142)	(0.152)
λ	*0.656*	*0.473*	*0.522*	*0.740*	*0.348*	*0.373*	*0.215*	*-0.119*
	(0.785)	*(0.679)*	*(0.821)*	*(1.037)*	*(0.523)*	*(0.480)*	*(0.294)*	*(0.431)*
$\overline{R}^2$	0.306	0.328	0.277	0.300	0.342	0.332	0.362	0.320
F[k, n]	65.60	74.96	56.80	63.66	71.07	72.45	81.47	64.62
Log-L	-1833	-1882	-1837	-1831	-1691	-1791	-1712	-1635

Note: Standard errors in parentheses. All variables are log-transformed. Italicized and underlined numbers are statistically insignificant at any levels.

Table 4: Regime Selection Probabilities and Grubel-Lloyd Indices (Averages)

	Korea				Taiwan			
	Φ	**GLI**	**1-Φ**	**1-Φ/ GLI**	**Φ**	**GLI**	**1-Φ**	**1-Φ/ GLI**
1976	0.946	0.083	0.054	0.650	0.880	0.120	0.120	1.001
1977	0.900	0.098	0.100	1.021	0.820	0.098	0.180	1.840
1978	0.933	0.134	0.067	0.501	0.867	0.161	0.133	0.828
1979	0.913	0.138	0.087	0.630	0.869	0.162	0.131	0.808
1980	0.935	0.133	0.065	0.489	0.878	0.168	0.122	0.728
1981	0.904	0.115	0.096	0.837	0.847	0.147	0.153	1.042
1982	0.896	0.111	0.104	0.933	0.853	0.159	0.147	0.925
1983	0.912	0.127	0.088	0.694	0.826	0.160	0.174	1.089
1984	0.876	0.143	0.124	0.872	0.812	0.154	0.188	1.226
1985	0.881	0.144	0.119	0.830	0.803	0.155	0.197	1.268
1986	0.850	0.161	0.150	0.930	0.776	0.161	0.224	1.394
1987	0.835	0.161	0.165	1.024	0.766	0.177	0.234	1.325
1988	0.823	0.175	0.177	1.011	0.759	0.199	0.241	1.210
1989	0.820	0.184	0.180	0.980	0.771	0.189	0.229	1.213
1990	0.798	0.192	0.202	1.055	0.759	0.184	0.241	1.309
1991	0.797	0.188	0.203	1.080	0.739	0.187	0.261	1.394
1992	0.808	0.193	0.192	0.992	0.742	0.200	0.258	1.291
average	**0.872**	**0.146**	**0.128**	**0.877**	**0.810**	**0.164**	**0.190**	**1.163**
ρ	**0.894**				**0.622**			

Note: **Φ:** Regime 1 probability; **1-Φ:** Regime 2 probability; **GLI:** the Grubel-Lloyd index; ρ **:** the correlation coefficient between GL indices and regime selection probabilities