"Monopolistic competition and trade: Does the theory carry any empirical 'weight'?"*

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Introduction

In a recent paper, Cho, Sheldon and McCorriston (2002), using a panel of bilateral trade flows across ten developed countries between 1974 and 1995 explored the effects of exchange rate uncertainty on the growth of food and agricultural trade as compared to other sectors such as manufacturing, machinery, and chemicals. Based on the use of a standard gravity model controlling for other factors likely to determine bilateral trade, the results of their analysis showed that real exchange rate uncertainty had a significant negative effect on food and agricultural trade over this period. In terms of the standard gravity model, a puzzling result of this research though is that when all countries were included in the analysis, the impact of country-pair incomes on bilateral trade was significant for all sectors except food and agriculture. In contrast, when the panel was split into separate samples of members of the European Monetary System (EMS), and all other non-EMS countries including the United States, the income variable was found to be statistically significant for the food and agriculture sector in the EMS sample, but not in the non-EMS sample.

One possible reason for this result is that the underlying model of trade may differ depending on the sector and sample of countries involved, and hence the expected size of the income variable. A recent study by Feenstra, Markusen and Rose (2001) used the gravity equation to focus on this issue. They found that there is a 'home-market' effect whereby an exporting country's income has more of an effect on its net exports of differentiated products than the importing country's income. In contrast, this effect is reversed for the case of homogeneous goods, whereby there is a reverse 'home-market' effect, although the average effects of both countries' incomes are higher for differentiated than homogeneous products. In the context of Feenstra *et al.*'s (2001) categorization of trade into homogeneous and differentiated goods, it should be noted that countries in the EMS have generally exported processed food and agricultural goods while the United States and Canada, major non-EMS countries, have exported bulk agricultural commodities (McCorriston and Sheldon, 1991), which may explain the differences in the income parameter between these two samples in the Cho *et al*. study.

In addition, McCorriston and Sheldon, Hirschberg, Sheldon and Dayton (1994), and Hirschberg and Dayton (1996) have all noted high levels of intra-industry trade for processed food and agricultural products, particularly involving European Union (EU) countries, intra-industry trade being defined as the simultaneous import and export of products that are very close substitutes in terms of factor inputs and consumption (Tharakan, 1985). The existence of intra-industry trade is typically associated with increasing returns to scale, product differentiation and monopolistic competition (Helpman and Krugman, 1985), and the volume of such trade is expected to be higher the greater the equality of trading partners' GDP per capita (Helpman, 1987). Helpman (1987) has also argued that the volume of trade among a group of countries as a percentage of their aggregate income, should be larger the more similar the countries' income levels. Using a gravity-type equation, Helpman (1987) found support for this hypothesis using data for a sample of OECD countries, noting that such a result is consistent with a model where specialization is a function of the connection between economies of scale and brand proliferation (Helpman, 1999). Hummels and Levinsohn (1995), however, in repeating Helpman's (1987) analysis for a sample of non-OECD countries, found that the gravity model still worked well for a group of countries whose bilateral trade was more likely characterized by homogeneous goods.

In analyzing bilateral trade data, there appears to be a model identification problem: the gravity equation works well empirically for both differentiated and homogeneous goods.

Evenett and Keller (2002) have argued that the gravity model can nest both the increasing returns/product differentiation story as well as a more conventional homogeneous goods/relative factor abundance story. With appropriate theoretical restrictions on the income parameter, it is possible to use the gravity model of bilateral trade to discriminate between different theories of international trade. In addition, following Feenstra *et al*. (2001), one can place further restrictions on the home and foreign income parameters in order to assess the 'home-market' effect and also allowing identification of the correct trade model.

In this context, the overall objective of this paper is to revisit the basic theory of trade in the presence of product differentiation and economies of scale, and to lay out how such a theory can and has been tested for empirically. The paper proceeds as follows: first, the empirical phenomenon of intra-industry trade is discussed; second, the standard monopolistic explanation for intra-industry trade is briefly laid out, along with a discussion of how this is embedded in a general equilibrium trade model; third, the apparent contradiction between the findings of Helpman (1987), and Hummels and Levinsohn is resolved through a discussion of the theoretical foundations for the gravity equation; and finally, the empirical strategy for testing the increasing returns/product differentiation story is outlined, indicating ways in which it could be applied to processed food and agricultural trade.

1. The empirical phenomenon of intra-industry trade

Measurement

Neo-classical trade theory predicts that trade between two countries will take place on the basis of comparative advantage generated by differences in some primitive such as technology and/or relative factor endowments. As a result, it is expected that the pattern of trade will be of an inter-industry nature. However, empirical work on the evolution of the European Economic Community by Verdoorn (1960), Drèze (1960, 1961) and Balassa (1965), and later work by Grubel and Lloyd (1975), indicates that a considerable part of the growth in world trade in the post-war period, particularly between developed countries, has been of an intra-industry nature, i.e., the simultaneous export and import of products which are very close substitutes for each other in terms of factor inputs and consumption (Tharakan, 1985).[1]

The early work on intra-industry trade essentially focused on its measurement. As the various indices of intra-industry trade have been carefully reviewed in Tharakan (1983) and Greenaway and Milner (1986), only the main indices are outlined here. Following Kol and Mennes (1986), measures of intra-industry trade can be grouped under two main headings; the first and most common type of index includes both imports and exports for a given country at an industry/sector/country level, hence the concept being assessed is overlap in trade flows. The second type of index compares patterns of imports and exports separately, focusing on a single country relative to a group of countries for an industry/sector/country.[2] This type of measure can also be used to assess the degree of intra-industry specialization, i.e., the extent to which factors of production are being used to produce specific products within an industry at the expense of other products.

The focus here is on the most-commonly used measure of overlap in trade flows, the Grubel and Lloyd (*GL*) index, which can be written as:

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[1] Helpman (1999) reports that trade overlap within industries has remained high, e.g., the share of intra-industry trade in the UK was 53 percent in 1970, increasing to 85 percent in 1980, and for Germany the equivalent shares were 56 percent and 72 percent respectively.

[2] The most common index of this type is that suggested by Glejser, Goosens and Vanden Eede (1982). Their index is one of either export or import specialization, based on measuring changes in an individual country's trade relative to changes in total trade of a group of countries. For example, if a country's exports increase at a rate equal to or less than that for the group, this represents intra-industry specialization in supply. However, if exports change at a faster rate than that for the group, this is inter-industry specialization. This index has been applied to food and agricultural trade by McCorriston and Sheldon.

$$GL^j = \frac{(X^j + M^j) - \left|X^j - M^j\right|}{(X^j + M^j)}, \tag{1}$$

and re-arranging:

$$GL^j = 1 - \frac{\left|X^j - M^j\right|}{(X^j + M^j)}\ , \qquad\qquad 0 \le GL^j \le 1 \tag{2}$$

X^j and M^j being a country's exports and imports respectively, j is a given level of aggregation, and GL^j takes a value of unity for pure intra-industry trade.[3] In aggregating across goods/industries/sectors, it is important to note the weighting characteristics of the index, particularly if it is used as a summary measure of intra-industry trade at a country-level. Suppose j is an aggregate across two industries i = 1 and 2, (2) can be re-written as:

$$GL^j = 1 - \left[\frac{\left|X_1 + X_2 - M_1 - M_2\right|}{(X_1 + X_2 + M_1 + M_2)}\right]. \tag{3}$$

If each industry i has the same sign on its trade balance, then GL^j is a weighted average of the two industries. If, however, the two industries have opposite signs on their trade balances, this weighting effect is lost. In order to guarantee the weighting property, GL^j should be adjusted to:

$$GL^{j\prime} = 1 - \frac{\sum_{i=1}^{n}\left|X_i^j - M_i^j\right|}{(X_i^j + M_i^j)}. \tag{4}$$

Given this index, it is important to recognize three technical problems that arise in the measurement of intra-industry trade. The first concerns the adjustment for aggregate trade imbalance. Given that products/industries/sectors can be chosen at a particular level of aggregation, it may be the case that there is no overall trade balance such that, $\sum_{i=1}^{n} X_i^j \ne \sum_{i=1}^{n} M_i^j$,

[3] Prior to Grubel and Lloyd, Balassa (1966) derived a similar index, $B^j = \left|X^j - M^j\right| / (X^j + M^j)$, $0 \le B^j \le 1$, which is simply the analogue of GL^j, where B^j is equal to zero for pure intra-industry trade.

which implies that, $\sum_{i=1}^{n}\left|X_i^j - M_i^j\right| > 0$. Looking at $GL^{j\prime}$, it means that it must take a value less than one.

This characteristic of the index has raised the question as to whether it is a fundamentally biased measure of intra-industry trade. Both Grubel and Lloyd and Aquino (1978) argue that there is a bias and have suggested adjustments. Focusing on Grubel and Lloyd, they argue that intra-industry trade should be derived as a proportion of total trade imbalance:

$$GL^{j\prime\prime} = \frac{(X^j + M^j) - \sum_{i=1}^{n}\left|X_i^j - M_k^j\right|}{(X^j + M^j) - \left|\sum_{i=1}^{n} X_i^j - \sum_{i=1}^{n} M_i^j\right|}, \tag{5}$$

which can be re-written as, $GL^{j\prime\prime} = GL^{j\prime}/(1-\omega)$, $0 \le GL^{j\prime\prime} \le 1$, where: $\omega = \left|\sum_{i=1}^{n} X_i^j + \sum_{i=1}^{n} M_i^j\right| / (X^j + M^j)$. Hence the value of the adjusted $GL^{j\prime\prime}$ index increases as ω increases and it indicates what would have been the level of intra-industry trade in the absence of a trade imbalance. Greenaway and Milner (1981, 1986) have questioned whether such an adjustment is actually necessary. In particular, the adjustment presumes *a priori* that the observed trade imbalance reflects trade disequilibrium. However, for a particular group of industries, trade imbalance is not necessarily inconsistent with macro-equilibrium. Therefore, some care should be taken when making the above type of adjustment.

The second technical problem that arises is known as categorical aggregation.[4] This occurs when products are aggregated together in inappropriate trade groups and is essentially the same problem that occurs in applied industrial organization, i.e., what is the correct way of defining an

[4] For example, Finger (1975) argues that goods of heterogeneous factor proportions are placed in a single industry. Davis and Weinstein (2001) recently concluded that, "…Much of what we call intra-industry trade is simply a data problem that reflects the failure of our industrial classification system to capture the fact that very different goods are being lumped together…" (p. 12)

industry? Given that intra-industry trade is defined as trade in similar but differentiated products, the researcher needs to be sure that is what is being measured, as opposed to industry misspecification.

Essentially two procedures have been adopted to deal with the problem. First, researchers have re-grouped trade data into their own concepts of an industry. For example Balassa (1966) grouped third and fourth-digit SITC data into 91 industries. Clearly such a method is open to subjective bias. Second, researchers have selected a particular level of statistical aggregation in the published data that best conforms to their concept of an industry. In principle, such a technique should make use of external evidence on factor inputs and elasticities of substitution. Greenaway and Milner (1983, 1985) note that there appears to be a fair degree of consensus over which level of SITC category to use, most researchers adopting the 3-digit classification. Although consensus does not imply correctness, casual tests indicate that the choice of the 3-digit level is not unreasonable. For example, Greenaway and Milner (1983) regrouped 3, 4 and 5-digit SITC data into SIC Minimum List Headings for the UK and found, for the Grubel and Lloyd index, a high degree of correlation between the two classifications. They also indicate that in moving from the 3 to the 4-digit level of the SITC, while there is a decline in the recorded values of intra-industry trade, it is not a substantial decrease. The general conclusion drawn by Davis (1995) is that, "…While all observers acknowledge that actual industrial classification does not mesh neatly with the theoretical demarcations of industries, most would argue that this does not eliminate the puzzle since intra-industry trade is important down to quite fine levels of disaggregation…" (p. 205)

The third problem relates to the fact that the *GL* index is essentially a static measure based on trade data for one year only (Brülhart, 2000). Hamilton and Kneist (1991) have argued that even if the *GL* index increases between periods, it may actually hide an uneven change in trade flows which is characterized more by inter-industry than intra-industry adjustment. Brülhart (1994) has suggested the following adjustment to the *GL* index designed to capture the concept of marginal intra-industry trade:

$$A_I = 1 - \left[\frac{|\Delta_I X_t - \Delta_I M_t|}{(\Delta_I X_t + \Delta_I M_t)} \right], \qquad 0 \le A_I \le 1 \qquad (6)$$

where for a given industry, Δ denotes changes in *X* and *M* in constant prices, *t* is the base year, and *I* denotes the time period between the base and end years. A_I varies between zero for marginal trade that is exclusively inter-industry and one for marginal trade that is exclusively intra-industry. Importantly, Brülhart (2000) has shown that A_I is not correlated with levels and first-differences in the *GL* index, so that the distinction between marginal intra-industry trade and intra-industry trade is empirically meaningful.

This adjustment of the *GL* index has some bearing on evaluation of the so-called 'smooth adjustment hypothesis', whereby it is claimed that if industries are characterized by intra-industry trade, then adjustment to competitive forces will be easier than if it were inter-industry in nature (Greenaway and Milner, 1986). Specifically, if industries are characterized by product differentiation, then it is easier to adjust product lines than it is to undertake the restructuring implied by inter-industry trade. In addition, the labor economics literature indicates that the cost of adjustment is substantially higher under inter-industry adjustment, due to the fact that accumulated human capital is portable between firms in a sector but not across sectors (Lovely and Nelson, 2000). Brülhart (2000) has tested the 'smooth adjustment hypothesis' using a panel data set for 64 Irish industries over the period 1977 to 1990, finding that, intra-industry job turnover, a proxy for labor market adjustment, was positively and significantly related to A_I, but was unrelated to the *GL* index.

Evidence of intra-industry trade in food and agriculture

Most empirical work on intra-industry trade has focused almost entirely on manufactured goods. For example, Balassa and Bauwens (1987) explicitly excluded food products from their sample. However, empirical work by McCorriston and Sheldon, Christodolou (1992), Hart and McDonald (1992), and Hirschberg *et al*. has shown that intra-industry trade does exist in this sector, and that the level has been growing over time. While Carter and Yilmaz (1998) do a nice job of summarizing these studies, it is worth noting the key findings reported in McCorriston and Sheldon, and Hirschberg *et al*.

In the latter study, an unadjusted version of the *GL* index was used to generate sectoral values of intra-industry trade for a sample 30 countries over the period 1964-85 based on 4-digit SIC data.[5] Over the sample period, average values of the index for bilateral trade with all partners varied from 0.19 for the UK to 0.03 for Taiwan, the countries exhibiting higher levels intra-industry trade being developed. In the former study, the authors used an adjusted version of the *GL* index to analyze trade patterns in a sample of processed food products for the US and nine members of the European Community (EC). Using 3-digit SITC data for 1986, the average value of the index across the sample of processed food products was 0.42 for the US compared to 0.87 in the EC9, although a good deal of the EC's trade was accounted for by trade among the EC member countries. Importantly though, where the results indicate intra-industry trade, they are of a similar order of magnitude to other industrial goods and higher than values recorded for agricultural products. This emphasizes the importance of choosing suitably disaggregated data when measuring intra-industry trade, since aggregated product groups such as 'food and live animals' may hide the existence of intra-industry trade at a more disaggregated product definition.

[5] The sectoral values of the *GL* index were derived following a method suggested by Bergstrand (1990)

2. Monopolistic competition and trade

Leamer (1992) has argued that other than the Leontief (1953) paradox, Grubel and Lloyd's work is the only empirical finding presenting an important and substantive challenge to the neoclassical orthodoxy, and in his view has been, "…at least partially responsible for the large theoretical literature on models with increasing returns to scale and product differentiation…" (pp. 5-6)[6] Essentially, the traditional model of comparative advantage, based on the assumptions of homogeneous goods, constant returns to scale and perfect competition, was not thought capable of rationalizing intra-industry trade, whereas scale economies provides a motivation for specialization and hence, two-way trade in differentiated goods, where the market structure is one of monopolistic competition.

Two types of monopolistic competition model have evolved. Krugman (1979, 1980, 1981), following Dixit and Stiglitz (1977), assumes individuals derive utility from variety *per se* and therefore consume all differentiated goods being offered in a particular group. Consequently, product differentiation takes the form of producing a variety not yet in supply, although scale economies at the firm level, constrains the number of goods that can be produced in equilibrium. In contrast, Lancaster (1980) and Helpman (1981) assume that individuals demand goods that embody bundles of characteristics and they are assumed to have an ideal bundle. Consequently, only one type of differentiated good is purchased by consumers, but given diversity of tastes, there is an aggregate demand for variety. Therefore, product differentiation in this case takes the form of a firm offering a variety of good with a different bundle of characteristics to those already on offer.

[6] The monopolistic competition model has been widely used in computable general equilibrium (CGE) trade modeling, e.g., Francois, van Meijl, and van Tongeren (2005), and has been used in a variety of other settings, including, amongst others, innovation and endogenous growth models, e.g,, Grossman and Helpman (1992), and spatial models, e.g., Fujita, Krugman and Venables (1999).

Again, scale economies limit the number of products in equilibrium. Importantly, both types of model generate intra-industry trade.

Basic monopolistic competition model

Following Krugman (1980), the initial focus is on the autarky equilibrium. An economy consists of one industry which produces a variety of goods from a continuum of potential goods. On the demand side, the goods produced enter each consumer's utility function symmetrically and all consumers have the same homothetic utility function of the form:

$$U = \sum c_i^{\theta}, \qquad 0 < \theta < 1 \qquad i = 1,...,n \tag{7}$$

where c_i is the consumption of the i^{th} good, the elasticity of substitution between any two goods being equal to a constant $\sigma = 1/(1-\theta)$. If w is income, consumers maximize utility subject to a budget constraint, $w = \sum_{i=1}^{n} p_i x_i$, the first-order condition being:

$$\theta c_i^{\theta-1} = \lambda p_i, \qquad i = 1,...,n \tag{8}$$

where λ is the shadow price on the budget constraint.

Labor is the only factor, all goods being produced with the same cost function:

$$l_i = \alpha + \beta x_i, \qquad \alpha, \beta > 0 \qquad i = 1,...,n \tag{9}$$

where l_i is labor used in production of the i^{th} good and x_i is output of the i^{th} good. This function implies a fixed cost element α, constant marginal costs β and hence decreasing average costs.

The output of any good x_i must equal consumption in equilibrium, so assuming consumers are also workers, output of any good is simply the consumption of one individual multiplied by the labor force L:

$$x_i = Lc_i, \qquad i = 1,...,n \tag{10}$$

and assuming full employment:

$$L = \sum (\alpha + \beta x_i)\,, \qquad\qquad i = 1, ..., n \qquad (11)$$

Under autarky, equilibrium in the economy is derived by assuming monopolistic competition where no two firms produce the same good and free entry drives profits to zero. In addition, assume equilibrium is symmetric with prices and quantities being identical across goods. Dropping subscripts and using (8) and (10), the inverse demand curve facing any firm is:

$$p = \theta \lambda^{-1} (x / L)^{\theta - 1}\,, \qquad (12)$$

Given a sufficiently large number of goods are produced in equilibrium, the pricing decision of one firm has no impact on the marginal utility of income λ, consequently the elasticity of demand is $\varepsilon = 1/(1-\theta) = \sigma$. Profit-maximization implies:

$$mc = mr = p(1 - 1/\varepsilon)\,, \qquad (13)$$

so that the profit maximizing price for any firm will be:

$$p = \theta^{-1} \beta w\,, \qquad (14)$$

firms' profits being:

$$\pi = px - (\alpha + \beta x) w\,, \qquad (15)$$

Using (14), (15) can be solved out for *x*:

$$x = \alpha / (p / w - \beta) = \alpha \theta / \beta (1 - \theta)\,. \qquad (16)$$

From the full employment condition (11) and (16), the equilibrium number of goods is:

$$n = L / (\alpha + \beta x) = L(1 - \theta) / \alpha \qquad (17)$$

i.e., the number of goods is a function of the size of the labor force *L*, the level of fixed costs α and the value of θ from the utility function.

Suppose there is another economy identical to the one just described such that there is no reason for conventional trade to occur. From (17), it can be seen that the number of goods produced in equilibrium will be $2n$ because effectively the labor force L has doubled. Trade occurs because of the production technology, i.e., each good will only be produced by one firm in one country but is sold in both countries, generating pure intra-industry trade. Consequently, the gains from trade are greater diversity for consumers as they spread their incomes over twice as many goods, which, given the symmetry in the model, implies that in equilibrium each firm's output is the same as under autarky, i.e., (16) holds before and after trade.[7] Also, in the trading equilibrium, the prices of any good in either country are the same, and real wages are the same, i.e., there is factor-price equalization. The volume of trade in the model is determinate in that each country exports half of the output of its products, however the direction of trade is not determinate, i.e., it is arbitrary which country produces which goods.

General equilibrium and monopolistic competition

With these micro foundations in place, it is possible to lay out a general equilibrium trade model due to Helpman and Krugman (1985). Assume two countries, j and k; two factors, capital K and labor L; two industries, one perfectly competitive producing a homogeneous good Z under constant returns to scale, the other monopolistically competitive producing a range of differentiated goods X, n_x under increasing returns.

First define the set of world resource allocations that generate a trade outcome similar to an integrated equilibrium, i.e., the outcome that would arise if all factors were perfectly mobile.[8] Following a figure popularized by Dixit and Norman (1980), the dimensions of figure 1 show the combined factor endowments of the two countries. With full employment, this endowment $\bar{V}$ will

[7] In Krugman (1979), a different specification of the utility function is used, and the elasticity of demand facing each firm is assumed to vary negatively with consumption. Consequently, with trade, consumers spread their expenditure over a wider range of goods, which in turn lowers the elasticity of demand for any specific good, reducing equilibrium prices, and raising real wages. In addition, while the total number of goods increases with trade, each country produces fewer than under autarky, implying that each firm's output increases and greater scale economies are realized.

[8] See Krugman (1995) for a good discussion of the integrated equilibrium and its relation to Samuelson's so-called 'angel'.

be fully utilized in the two industries: *OQ* will be the vector of resources used in the differentiated goods sector, assumed to be capital-intensive in production, and *OQ** will be the vector of resources used in the homogeneous good sector, which is labor-intensive in production. In addition, the vector *OO** represents aggregate employment, and with appropriate units of measurement, it can be interpreted as world gross domestic product (GDP), denoted as Y^w.

Assuming common knowledge of technologies and identical, homothetic preferences, trade can generate the full employment, integrated equilibrium. Suppose that country *j* is evaluated from the origin *O* and country *k* from the origin *O**, and define the area *OQO*Q** as the factor price equalization set. If the allocation of factors is given by the endowment point *E*, country *j* will devote On_x^j resources to the production of *n* varieties of the differentiated good and *OZ* to the production of the homogeneous good. This solution is derived by constructing a parallelogram between *O* and *E*, where a line parallel to *OQ** is drawn through *E* and a line parallel to *OQ* is also drawn through *E*. A similar process is followed to derive country *k*'s production levels.

In order to describe the pattern of trade, a negatively sloped function *BB* is drawn through point *E*, the slope of which is relative factor prices, *w*/*r*. This line passes through the diagonal *OO**, giving the home and foreign countries' income levels of Y^j=*OC* and Y^k =*CO** respectively; all income being paid to the factors of production and all income being spent. Constructing a parallelogram between *O* and *C*, the consumption level of country *j* can be derived, with country *j* consuming OC_X of the differentiated goods and OC_Z of the homogeneous good. By a similar process, the consumption levels of country *k* can also be shown. In this particular equilibrium there is simultaneous inter-industry trade and intra-industry trade. Country *j* imports the homogeneous good, and is a net exporter $(n_x^j - C_X)$ of differentiated goods, while country *k* is an exporter of the homogeneous good and a net importer of differentiated goods. The concept of net trade flows in the differentiated goods sector follows from the fact that country j produces and exports n_x^j varieties, and imports n_x^k varieties from the foreign country, where $n_x^j > n_x^k$.

The trading equilibrium described in figure 1 is of course just a re-statement of the Heckscher-Ohlin (H-O) theorem, i.e., the capital-abundant country j is a net exporter of the capital-intensive good X, while the labor-abundant country k exports the labor-intensive good Z. This can also be re-interpreted in terms of the net factor content of trade. With identical homothetic preferences, the composition of the factor content of consumption is the same for both countries, and is identical to the world endowment $\overline{V}$. Consequently, vector OC is country j's factor content of consumption, while the vector EC, the difference between the endowment E and the consumption of factor services, is the factor content of net trade flows, i.e., country j is a net exporter of capital services and an importer of labor services, while country k is an exporter of labor services and a net importer of capital services.[9]

Empirical Analysis

A key empirical prediction of the Helpman and Krugman (1985) model is that the share of intra-industry trade is expected to be larger between countries that are similar in terms of their factor endowments and also their relative size. Helpman (1987) evaluated the empirical validity of these predictions using 4-digit SITC data for a cross-section of 14 OECD countries over the period 1970 to 1981, estimating a regression of the form for each year:

$$GL^{jk} = \alpha + \beta_1 \log\left[\frac{Y^j}{N^j}\right] - \left[\frac{Y^k}{N^k}\right] + \beta_2 \min(\log Y^j, \log Y^k)$$
$$+\beta_3 \max(\log Y^j, \log Y^k) + \mu^{jk}, \tag{18}$$

[9] An interesting empirical literature has evolved testing for the factor-content of trade theorem, important contributions being by Trefler (1995), Davis and Weinstein (2001), and Debaere (2003).

where GL^{jk} is the Grubel and Lloyd index for each country pair j and k, Y^j and Y^k are their respective GDPs, and N^j and N^k are their respective populations. The results provide support for the predictions that that $\beta_1 < 0, \beta_2 > 0$, and $\beta_3 < 0$, although the negative correlation between intra-industry trade and dissimilarity of GDP per capita weakens over time.

Hummels and Levinsohn note two key problems with Helpman's (1987) empirical analysis: first, there are potential problems with using GDP per capita as a proxy for relative factor endowments, and second, the empirical methodology ignores the panel characteristics of the data. In terms of the former, GDP per capita is only a reasonable proxy if, the number of factors is limited to two[10]; and, second, there is a possibility that GDP per capita captures differences in demand structure rather than relative factor endowments. To address these concerns, Hummels and Levinsohn initially ran (18) for the same sample of OECD countries for each year in the period 1962-1983, replacing GDP per capita with GDP per worker. Their results replicate those of Helpman (1987), the negative correlation between intra-industry trade and dissimilarity of GDP per worker weakens over the sample period, and the parameters on the minimum GDP and maximum GDP variables are consistent with the theory. They then re-ran (18) with actual factor data, replacing GDP per worker with capital per worker and land per worker. The results indicate land per worker is negative and significant throughout the period, while capital per worker is initially negative and significant, but then turns positive and significant. Hummels and Levinsohn suggest that the sign on land per worker is picking up the possibility that there is little intra-industry trade in agricultural products, i.e., countries that are relatively well-endowed with land trade agricultural products for manufactured goods.

[10] Helpman and Krugman (1985) show for any country j that, $Y^j = \pi(p, L^j, K^j)$, where π, p, L^j, and K^j are profits, prices, labor and capital respectively. Re-arranging gives, $Y^j / L^j = \pi(p, K^j / L^j)$.

Hummels and Levinsohn also estimated (18) by pooling all 22 years of their sample, using either GDP per worker or capital per worker, and also country-pair fixed effects to pick up idiosyncratic differences across country-pairs such as geography and language that do not change much over time. Their results suggest that Helpman's (1987) earlier findings may not be robust. In particular, use of country fixed effects reverses the negative sign on both GDP per capita and capital per worker and the explanatory power of the regressions increases substantially, i.e., country fixed effects produce results exactly opposite to what theory predicts.[11] Hummels and Levinsohn are led to conclude, "…If much intra-industry trade is specific to country-pairs, we can only be skeptical about the prospects for developing any general theory to explain it…" (p. 828)

Interestingly, Hummels and Levinsohn did try to decompose the country-pair effects into land and distance effects, finding that a distance effect is quite important in understanding intra-industry trade. In this context, Hirschberg *et al.* in their study of intra-industry in the food processing sector for a sample of countries over the period 1964-1985, conducted a test of the Helpman and Krugman (1985) model using several other variables, including distance, exchange rate uncertainty, and dummies for country-pairs having common membership of a customs union/free trade area, and a common border. In addition, country-pair fixed effects were used to capture any remaining unobserved factors, as well as time fixed effects. Based on a weighted tobit model estimation, the results indicated that although the relative size of trading partners' GDP was statistically insignificant[12], dissimilarity in their GDP per capita has a negative impact on intra-

[11] Hummels and Levisohn get similar results using a random effects model

[12] Following Noland (1989), Hirschberg *et al.* measure relative size of countries j and k by the variable $GDPSIZE^{jk} = \left(\frac{GDC^k - GDC^j}{GDC^k + GDC^j}\right) . \left(\frac{GDP^j}{GDP^k}\right)$, where GDC is GDP per capita. If $GDC^j > GDC^k$, then the ratio $GDPSIZE^{jk} < 0$, and the larger the difference in size between j and k, the smaller the level of intra-industry trade.

industry trade in the food processing sector[13], while exchange rate uncertainty, distance, membership of a customs union/free trade area, and a common border all have significant and correctly signed effects on the level of intra-industry trade. These findings provide some support for Helpman's (1999) contention in commenting on the Hummels and Levinsohn results that there is, "…an obvious need to broaden the theory to arrive at a better empirical specification…" (p. 136) [14]

Competing explanations for intra-industry trade

While the focus of this paper is on the monopolistic competition explanation for intra-industry trade, it is worth briefly mentioning some competing theories. Perhaps the most convincing alternative to the monopolistic competition model is that of Davis, who introduces elements of Ricardian theory into a Heckscher-Ohlin setting. In this model, preferences are assumed identical and homothetic across countries; there are two factors of production, capital and labor; and there are three goods, X_1, X_2, and Z, where goods X_1 and X_2 have identical factor intensities, but are more capital-intensive in production than good Z.[15] Importantly, there are technological differences across countries such that for country j, the production function for good X_1 is $X_1^j = Af(K_{X1}, L_{X1})$, and for country k it is $X_1^k = f(K_{X1}, L_{X1})$, where A>1 represents a Hicks-neutral shift in the production isoquants of country j. In equilibrium, country j produces the entire supply of good X_1 in which it is has an absolute advantage, and the structure of trade then depends on the location of relative endowments

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[13] Following Balassa and Bauwens (1987), Hirschberg *et al.* measure dissimilarity in GDP per capita between partner countries j and k via the index $INEQGDC^{jk} = 1 + \frac{\left[w^{jk}\ln(w^{jk}) + (1-w^{jk})\ln(1-w^{jk})\right]}{\ln 2}$, where $w^{jk} = GDC^j/(GDC^j + GDC^k)$, and $INEQGDC_{jk}$ varies over the range 0 to 1. The larger is $INEQGDC^{jk}$, the smaller the level of intra-industry trade.

[14] Prior to Helpman's (1987) work, a body of empirical work had evolved analyzing factors affecting intra-industry trade. Typically these studies estimated an industry cross-section regression, with an index of intra-industry trade as the dependent variable, and the explanatory variables consisting of proxies for the level of scale economies and product differentiation in specific industries, e.g., Loertscher and Wolter (1980). This work has met with fairly trenchant criticism on the grounds that, "…the linkage of the theory and the data analyses of necessity is often casual…" (Leamer, 1992, p.33)

[15] Under these assumptions, goods X_1 and X_2 are 'perfectly intra-industry', i.e., for all factor price ratios, they are produced under identical factor intensity.

in the factor price equalization set, with four possibilities: (i) pure inter-industry trade where country k imports goods X_1 and X_2 from j in exchange for exports of good Z (j is capital abundant); (ii) partial inter-industry trade where country k is self-sufficient in X_2, and exports Z to j in exchange for X_1 (j is capital-abundant); (iii) pure intra-industry trade where country j exports X_1 to k in exchange for X_2, and each country is self-sufficient in Z (identical capital-labor ratios); (iv) heterogeneous trade where country k produces only X_2 which it trades in exchange for its entire consumption of X_1 and Z (j is labor-abundant). The key to this model then is the interaction between technology differences and factor endowments in explaining the structure of trade.

There are also models that assume small numbers of firms: Brander (1981) and Brander and Krugman (1983) show that where the free trade market structure is Cournot-Nash duopoly, cross-hauling of homogeneous goods can occur, a phenomenon they describe as "reciprocal dumping". Shaked and Sutton (1994), develop a model where under autarky, the equilibrium number of firms producing vertically differentiated goods in a Nash-Bertrand oligopoly is a function of the extent of fixed costs of increasing product quality and the distribution of income. They then show that if countries trade with each other, firms will have to exit, and depending on the location of the remaining firms, there may be intra-industry trade in goods of differing quality. The problem with the latter types of model is that they lack the general equilibrium context of Davis' model.

3. Gravity and monopolistic competition

Volume of trade and country size

Perhaps the most fundamental prediction that comes out of the work of Helpman and Krugman (1985) concerns the relationship between relative country size and the volume of trade. Suppose in the model outlined earlier that goods X and Z are both differentiated and produced under increasing returns, monopolistic competition prevails, all trade between the two countries being intra-industry. In this set up, a key result is that as countries become more similar in size, the volume of trade between them as a proportion of their aggregate GDP should increase (Helpman, 1987; Hummels and Levinsohn). Specifically, Helpman (1987) shows that if countries have identical homothetic preferences and trade is balanced, then the following structural equation holds:

$$\frac{V^A}{Y^A} = e_A\left[1 - \sum_{j \in A} (e_A^j)^2\right] \tag{19}$$

where V^A is the volume of trade between a group of countries A, Y^A is the aggregate GDP of the group of countries, e^A is the share of group A in world GDP, and e_A^j is the share of country j's GDP in group GDP. The right-hand side of (19) is a measure of size dispersion that increases as countries become more similar in size.

Helpman (1987) defined A to be a group of 14 OECD countries, computing the left and right-hand sides of (19) for every year from 1956 to 1981. When graphed, these data points showed a strong positive correlation between the two variables, Helpman (1999) concluding that, "…This co-movement is consistent with models of product differentiation in which specialization in production is driven by brand proliferation…" (p. 137) [16]

Hummels and Levinsohn re-examined this result using data for the same 14 OECD countries over the period 1962 to 1983, but focusing instead on bilateral trade flows, and also using panel data econometric methods to estimate (19). Rearranging (19), and taking logs, Hummels and Levinsohn estimated:

$$\ln(V_t^{jk}) = \alpha^{jk} + \beta_1 \ln[Y_t^{jk}(1-(e_t^j)^2 - (e_t^k)^2)] + \mu_t^{jk}, \tag{20}$$

[16] As noted by Leamer (1992), and later Leamer and Levinsohn (1995), equation (19) can also be derived in a setting where each good is produced in one country under an Armington assumption about preferences.

where the superscript jk denotes a country-pair, and α^{jk} is a country-pair fixed effect that includes the country-pair's share of world GDP, e^{jk}, assumed constant over time. Their results confirm Helpman's (1987) original finding. However, when they estimate the same equation in levels for a sample of 14 non-OECD countries over the period 1962 to 1977, they found the same relationship performed well, even though bilateral trade in this sample is unlikely to be characterized by differentiated goods.

More recently, Debaere (2005) has revisited this issue for the period 1970 to 1989, using Helpman's (1987) original sample of 14 OECD countries, and 12 of Hummels and Levinsohn's sample of non-OECD countries. Debaere (2005) estimates the following equation:

$$\ln(V_t^{jk}) - \ln Y_t^{jk} = \alpha^{jk} + \beta_1 \ln e_t^{jk} + \beta_2 \ln[(1-(e_t^j)^2 - (e_t^k)^2] + \mu_t^{jk}, \qquad (21)$$

arguing that Hummels and Levinsohn's transformation of (19) is not "innocuous", multiplication of the joint GDPs, Y_t^{jk}, and the size dispersion index, $[(1-(e_t^j)^2 - (e_t^k)^2]$, allowing size to impact the estimation due to the fact that the covariance between them is positive. In addition, the share of world GDP, e_t^{jk} is allowed to vary over time, and is evaluated separately from the size dispersion index, $[(1-(e_t^j)^2 - (e_t^k)^2]$. Debaere's (2005) results indicate that for the OECD sample of countries, increased trade to GDP ratios for this sample of countries are positively related to their share of world GDP and to their similarity in terms of size, confirming Helpman's (1987) previous result. In contrast, for the non-OECD sample, while the sign on share of world GDP is positive, the sign on the index of size dispersion is negative. Consequently, these results, along with those of Hummels and Levinsohn, would seem to raise significant doubts about the ability of the monopolistic competition model to consistently explain trade patterns at the country-level.

The gravity equation

As both Helpman (1987) and Hummels and Levisohn note, (19) fits the general form of the gravity equation. However, based on Evenett and Keller's (2002) observation, there appears to be a model identification problem: the gravity equation works well empirically for both differentiated and homogeneous goods. In addition, Feenstra (2004) argues that maybe one should not be too surprised by Debaere's (2005) results, due to the fact non-OECD countries are less likely to trade differentiated goods. The empirical issue then becomes one of determining which theoretical model generates 'gravity-like' trade volumes in a given sample of data (Evenett and Keller, 1998, p.1).

The so-called gravity equation of trade predicts that the volume of trade between two countries will be proportional to their GDPs and inversely related to any trade barriers between them. Typically, bilateral trade flows between country j and country k have been explained by the following specification:

$$V^{jk} = \beta_0 (Y^j)^{\beta_1} (Y^k)^{\beta_2} (D^{jk})^{\beta_3} (A^{jk})^{\beta_4} u^{jk} \qquad (22)$$

where V^{jk} is the value of exports (imports) by country j to k (j from k) Y^j (Y^k) is the value of nominal GDP in $j(k)$, D^{jk} is the distance from j to k, A^{jk} is a vector of other factors that may positively or negatively impact trade between j and k, and u^{jk} is a log-normally distributed error term with $E(\ln u_{jk}) = 0$. This particular specification was originally used by Tinbergen (1962). The gravity equation, in fact, is probably one of the great success stories in economics, many studies being able to account for variation in the volume of trade across country pairs and over time (Leamer and Levinsohn, 1995). However, until fairly recently, the theoretical foundations for the gravity model were considerably less well understood.

Feenstra *et al*. (2001) note the gravity equation is not implied by the many-country, H-O model. However, with perfect specialization an equation of this sort does arise, and can be derived from quite different theoretical models. This specialization can be due to an Armington demand structure (Anderson, 1979; Bergstrand 1985), increasing returns (Helpman, 1987; Bergstrand, 1989), technological and geographical differences (Davis; Eaton and Kortum, 2002), and factor endowment differences (Deardorff, 1998; Evenett and Keller, 2002). Grossman (1998) notes, "…Specialization – and not new trade theory or old trade theory – generates the force of gravity…" (p. 29)

Due to the emergence of a theoretical literature developing the micro-foundations for the gravity model, its application to explaining bilateral trade patterns has become popular again in recent years. It has been used extensively in analysis of the effects of exchange rate uncertainty in country panel data sets, e.g., Rose (2000), De Grauwe and Skudelny (2000), Dell'Ariccia (2000), Rose and Wincoop (2001), and Glick and Rose (2001). In addition, tests of the different theoretical models underlying the gravity equation have become quite common, e.g., Helpman, 1987, Hummels and Levinsohn, Rauch (1999), Head and Ries (2001), Baier and Bergstrand (2001), Feenstra *et al*. (2001), Chen (2002), Evenett and Keller (2002), and Rose (2004).

Derivation of the gravity equation

The results presented in Feenstra *et al*. (2001) and Evenett and Keller (1998; 2002) are probably the most developed in terms of attempting to embed different theories of international trade into the gravity equation, and as a result generating restrictions on the country income parameter(s) that form the basis for hypothesis testing. In order to derive these restrictions, Evenett and Keller (1998; 2002), are followed to initially derive the gravity equation in the case where there is perfect good specialization, based on increasing returns/product differentiation.

Similar to the Helpman and Krugman (1985) model outlined previously, suppose there are two countries, *j* and *k*, two goods, *X* and *Z*, and two factors of production, *K* and *L*. The goods *X* and *Z* come in many varieties, and are produced by the same increasing returns to scale technology. The two countries have identical, homothetic preferences, consumers having CES utility functions where all varieties of each good enter symmetrically. Due to increasing returns, each variety is produced by only one firm in equilibrium, the equilibrium number of varieties being determined by free entry and firms behaving monopolistically competitively. n_g^c is the number varieties, $g = X,Z$, produced in country $c = j$, k, s^c is country *c*'s share of world spending, and x^c (z^c) is the equilibrium quantity of a variety of good *X*(*Z*). Let Y^c be a country's GDP, and world GDP is $Y^w = Y^j + Y^k$. Also assume good Z is the numeraire, and p_x is the relative price of a variety of good *X*.

Assuming balanced trade, where $s^c = Y^c / Y^w$, $\forall c$, and there are zero transport costs, then in an increasing returns/product differentiation world, both countries will demand all varieties according to the countries' GDP as a share of world GDP. As a result, any variety produced in country *k* and consumed in *j* must be imported. As a result, country *j*'s (*k*'s) imports from country *k*(*j*) are given as:

$$M^{jk} = s^j[p_x n_x^k x^k + n_z^k z^k], \tag{23}$$

$$M^{kj} = s^k[p_x n_x^j x^j + n_z^j z^j]. \tag{24}$$

The terms in brackets in (23) and (24) are equal to the GDP of country *k* and country *j* respectively, so substitution of Y^j and Y^k into (23) and (24) yields:

$$M^{jk} = s^j Y^k = \frac{Y^j Y^k}{Y^w} = s^k Y^j = M^{kj}. \tag{25}$$

Equation (25) is the gravity equation, based on an increasing returns/product differentiation structure, where imports are strictly proportional to GDPs.

Following Helpman and Krugman (1985), it easy to show that (25) holds whenever there is perfect product specialization, all consumers are faced with the same goods prices and have identical homothetic preferences, and trade balances. Suppose that goods *X* and *Z* are both homogeneous and produced under constant returns to scale. Assume that good *X* is capital-intensive in production, while good *Z* is labor-intensive, and also that country *j*(*k*) is sufficiently relatively well-endowed in capital (labor) that country *j*(*k*) specializes in producing good *X*(*Z*). If X^c is production of good *X*, and Z^c is production of good *Z*, then $X^j = X^w$, and $Z^k = Z^w$, production of good *X* equals country *j*'s GDP, $p_x X^j$, and production of good *Z* equals country *k*'s GDP, Y^k. As a result, the following can be written:

$$M^{jk} = s^j Z^k = s^j Y^k = \frac{Y^j Y^k}{Y^w}, \text{ and } M^{kj} = s^k p_x X^j = s^k Y^j = \frac{Y^j Y^k}{Y^w}, \qquad (26)$$

This is identical to the gravity equation (25), and is termed the multi-cone H-O model (Leamer, 1987; Feenstra, 2004).

These two versions of the gravity model can be illustrated via figure 2, constructed in the same fashion as figure 1. Suppose country *j* is evaluated from the *O* origin, and country *k* from the *O** origin, and that the endowment for the increasing returns/product differentiation case is given by point *E* on the diagonal vector *OO**, i.e., relative factor endowments are the same in both countries, so product specialization is based entirely on increasing returns to scale. Country *j*(*k*) will devote resources to producing $n_x^j\,(n_x^k)$ varieties of good *X* and resources to producing $n_z^j\,(n_z^k)$varieties of good *Z*. In turn, the consumption level of country *j*(*k*) is OC_X (O^*C_X) for varieties of *X*, and OC_Z (O^*C_Z)for varieties of *Z*. This results in a pattern of trade that is pure intra-industry, i.e., country j(k) specializes in producing specific varieties $n_x^j(n_x^k)$ of good X and specific varieties $n_z^j(n_z^k)$ of good Z which are then consumed in both countries.

Suppose instead for the multi-cone H-O model that the endowment of factors is given by point E'=Q. Now country j(k) specializes in producing homogeneous good X (Z) at point Q, while the pattern of consumption is still given by the parallelogram drawn from point C on the diagonal $OO*$. The pattern of trade is now pure inter-industry, with country j(k) exporting (importing) good X and importing (exporting) good Z.

The gravity equation(s) derived above is overly restrictive as it relies on perfect specialization, in terms of either increasing returns/differentiated goods or constant returns/homogeneous goods. Evenett and Keller (1998; 2002) also allow for the possibility of imperfect specialization. Suppose X is a differentiated goods sector, with increasing returns and a technology that is capital-intensive, while Z is a homogeneous good sector with constant returns and a technology that is labor-intensive, known as the increasing returns/uni-cone H-O model. For endowments inside the factor price equalization set, the volume of bilateral trade is given as:

$$T^{jk} = s^k p_x X^j + s^j p_x X^k + (Z^k - s^k Z^w), \tag{27}$$

where the first term on the right hand side of (27) is country j's exports (M^{kj}), and the other two terms are its imports of other varieties of X and good Z (M^{jk}). Suppose then that $\gamma^j = \dfrac{Z^j}{p_x X^j + Z^j}$ is the share of good Z in country j's GDP, then with balanced trade, $M^{jk} = M^{kj}$, so that $M^{kj} = s^k p_x X^j$, and given the definition of γ^j, then $M^{kj} = s^k(1-\gamma^j)Y^j$, and the following adjusted gravity equation can be written:

$$M^{jk} = (1-\gamma^{j})\frac{Y^{j}Y^{k}}{Y^{w}}. \tag{28}$$

In comparison to (25), this gravity equation implies that for any value of γ^{j}>0, the level of bilateral imports is lower than the case where both *X* and *Z* are differentiated. In addition, as the share of *Z* in GDP declines, the level of imports rises, and in the limit, as $\gamma^{j} \to 0$, then (28) reverts back to (25). Therefore, the volume of trade is higher the lower is the share of the homogeneous good in GDP.

Suppose now that there is imperfect specialization in the case where both goods *X* and *Z* are homogeneous and produced under constant returns, a case known as the uni-cone H-O model. The volume of bilateral trade is given by:

$$T^{jk} = p_{x}(X^{j} - s^{j}X^{w}) + (Z^{k} - s^{k}Z^{w}). \tag{29}$$

From the H-O theorem, if country *i* is relatively capital-abundant it exports the relatively capital-intensive good *X*, and imports the relatively labor-intensive good *Z*, and vice-versa for country *j*. From this, the following gravity equation can be written:

$$M^{jk} = (\gamma^{k} - \gamma^{j})\frac{Y^{j}Y^{k}}{Y^{w}}. \tag{30}$$

As the capital-labor ratios of the two countries converge, so $\gamma^{k} \to \gamma^{j}$, and in the limit when $\gamma^{k} = \gamma^{j}$, there is no trade. In addition, the multi-cone H-O model is a special case of (30) when $\gamma^{j} = 0$ and $\gamma^{k} = 1$.

These two cases of imperfect specialization are illustrated in figure 3. For an endowment point *E*, in the increasing returns/uni-cone H-O model, country *j* produces n_{x}^{j} and consumes C_X varieties of the differentiated good *X*, and produces *Z* and consumes C_Z of the homogeneous good *Z*, and vice-versa for country *k*. The pattern of trade, therefore, is simultaneous intra-industry trade in varieties of good *X*, and inter-industry trade in goods *X* and *Z*, country *j*(*k*) being a net exporter (importer) of varieties of *X* and an importer (exporter) of *Z*. Likewise in the uni-cone H-O model, country *j* produces O*X* and consumes C_X of good *X*, and produces *Z* and consumes C_Z of good *Z*, and vice-versa for country *k*. The pattern of trade, therefore, is inter-industry trade in goods *X* and *Z*, country *j*(*k*) being an exporter(importer) of *X* and an importer (exporter) of *Z*. It should also be noted that as the endowment point moves along *BB* to *E''*, the volume of trade is maximized in *OQO**. In the increasing returns/uni-cone H-O case, this corresponds to $\gamma^j \to 0$, while in the uni-cone H-O case it corresponds to $\gamma^j \to 0$, and $\gamma^k \to 1$.

4. Empirical analysis of the gravity equation

Given this analysis, it is useful to outline the recent empirical work by Evenett and Keller (2002) and Feenstra *et al*. (2001), which presents a potential strategy for analyzing trade in the food and agricultural sector, and a means for addressing the empirical puzzle noted by Cho *et al*. concerning the differential effect of income on bilateral food and agricultural trade for EMS versus non-EMS countries.

Perfect versus imperfect specialization

Focusing first on Evenett and Keller (2002), they work with a cross-sectional data set for 58 countries in 1985, generating a possible 3,306 bilateral import relations. To test the gravity models outlined in the previous section, they first calculated the GL^{jk} index for each country pair using 4-digit SITC data on all goods trade, creating a sample of 2,870 observations, some country pairs having no positive amounts of trade between them. They then split this sample into two sub-samples based on an arbitrarily chosen level of the GL^{jk} index, $\overline{GL} = 0.05$ where, if $GL^{jk} > \overline{GL}$, it is expected that trade would be more likely based on product differentiation and scale economies. This resulted in 630 observations in the high GL^{jk} sample, which was then split into V=5 classes, where GL^{jk} increases by class, $v=1,\ldots,V$. For each v, the following version of (25) was estimated:

$$M_v^{jk} = \alpha_v \frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{31}$$

where for perfect specialization based on increasing returns, the predicted value of $\alpha_v = 1$. The results show the estimated values of α_v range from 0.016 to 0.139, which falls well short of the predicted value, and when the whole sample is used, $\alpha_v = 0.087$. This model clearly over-predicts the level of bilateral trade between countries.

Turning to the 2,240 observations where $GL^{jk} < \overline{GL}$, Evenett and Keller (2002) split this sample into V=5 classes, where factor proportions increase by class, $v=1,\ldots,V$. For each v, the following version of (25) was estimated:

$$M_v^{jk} = \alpha_v \frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{32}$$

where in the multi-cone H-O model, with perfect specialization in homogeneous products, the predicted value of $\alpha_v = 1$. The results show the estimated values of α_v range from 0.039 to 0.111, which again falls well short of the predicted value, and when the whole sample is used, $\alpha_v = 0.052$. Again, this model over-predicts the level of bilateral trade between countries.

Given these results, Evenett and Keller (2002) also allow for imperfect specialization. Focusing first on the increasing returns/uni-cone H-O model, they re-estimate (31) for cases where country $j(k)$ is capital-abundant, given that X is assumed capital–intensive, and for each v:

$$M_v^{jk} = (1-\gamma_v^j) \frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{33}$$

$$M_v^{jk} = (1-\gamma_v^k)\frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{34}$$

where the predicted values of $(1-\gamma_v^j)$ and $(1-\gamma_v^k) < 1$. Given the number of estimated values of $(1-\gamma_v^j)$ and $(1-\gamma_v^k)$ varies by and within each class *v*, the median estimated values range from 0.053 to 0.128, increasing non-monotonically in the level of GL^{jk}, and the median estimated value for the whole sample is 0.086. In addition, the simple correlation between $(1-\gamma_v^j)$ and K^j / L^j is found to be negative, i.e., the share of differentiated products in GDP does not increase with the relative abundance of capital to labor.[17] From this, Evenett and Keller (2002) conclude that these results provide mixed support for the increasing returns/uni-cone H-O model, i.e., it correctly predicts more production of differentiated goods with higher intra-industry trade, but the link to factor proportions is weak.

Finally, Evenett and Keller analyzed the uni-cone H-O model by re-estimating (32) for cases where *j*(*k*) is capital-abundant, and for each *v*:

$$M_v^{jk} = (\gamma_v^k - \gamma_v^j)\frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{35}$$

$$M_v^{jk} = (\gamma_v^j - \gamma_v^k)\frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \tag{36}$$

where the predicted values of $(\gamma_v^k - \gamma_v^j)$ and $(\gamma_v^j - \gamma_v^k) < 1$. The median estimated values range from 0.021 to 0.080, increasing non-monotonically with differences in factor proportions, and the median estimated value for the whole sample is 0.04. In addition, the simple correlation between γ_v^j and K^j / L^j is found to be negative, i.e., the share of the labor-intensive good *Z* in GDP does not increase with the relative abundance of capital to labor. Evenett and Keller (2002)

[17] Testing the model under the assumption that the homogeneous good is capital-intensive also fails to provide support for the increasing returns/uni-cone H-O model.

conclude that the uni-cone H-O model works well, even when factor proportion differences are large. Overall, they conclude that both factor endowments and scale economies can explain different components of variations in production and trade. [18]

'Home-market' effect

Turning to the Feenstra *et al*. (2001) study, a key feature of their work is that they focus explicitly on using the gravity equation to test for the 'home-market' effect. As noted in the introduction, it is possible that if countries differ in their relative size as measured by GDP, then there may be a 'home-market' effect which is expected to result in a larger income elasticity effect on bilateral trade for the home country (Krugman, 1980; Feenstra *et al*., 2001). In the increasing returns/uni-cone H-O model, the 'home market' effect occurs if the relative size of, say country j, is increased, resulting in an increase in the net exports of varieties of good X. As country j's GDP increases with size, demand for varieties of good X in j increases, this raises profits of existing firms in country j, causing entry of new firms, so that in equilibrium, country j specializes in and exports more varieties of the differentiated good.

As noted by Feenstra *et al*. (2001), the 'home-market' effect is actually quite sensitive to the extent of free entry into the differentiated goods sector, so that there might be a reverse 'home market' effect if there are barriers to entry to producing new varieties. Therefore, to provide an alternative to the monopolistic competition model with free entry, Feenstra *et al*. (2001) follow Head and Ries (2001) by assuming an Armington-type structure. In this case, there is perfect competition, goods are differentiated by country of origin, and the number of goods is fixed at one in each country. As each country produces its good in proportion to its size, the price of country j's good is the same as the price of country k's good, and each country

[18] Evenett and Keller (2002) also evaluated the robustness of their results by lowering the critical value of $\overline{GL}$ to 0.033. Essentially they found a similar pattern of results for both the perfect and imperfect specialization models. In addition, their results prove to be robust to allowing for the effects of distance.

will demand the two varieties in the same ratio. If country j is larger than country k, then country j's exports of the good are lower than its imports, i.e., there is a reverse 'home-market' effect. Essentially, this structure assumes that location of production is exogenous, so that an increase in income, and hence demand, in one country, is met by additional output by firms in both countries, so that there is a less than one-for-one relationship between the increase in demand share of the larger country and the change in its output share.[19,20]

Feenstra *et al*. (1998; 2001) also propose a setting where goods are homogeneous rather than differentiated, drawing on the 'reciprocal dumping' model of Brander, and Brander and Krugman outlined earlier. Given Cournot-Nash behavior and free entry, if country j is larger than country k, the zero profit condition implies that more firms enter the market in j, resulting in prices being lower in j than k, so that j is a net exporter of the homogeneous good, despite the increase in demand in j, i.e., there is a 'home-market' effect. Alternatively, given a Cournot-Nash duopoly in homogeneous goods, the model predicts that the relative shares of the two firms are the same in both export markets. Consequently, if country j is larger than country k, given constant relative export market shares, then the smaller country k will have larger exports than the larger country j. In other words there will be a reverse 'home-market' effect.

Re-writing the gravity equation in logarithmic form,

$$\ln M^{jk} = -\beta_0 \ln Y^w + \beta_1 \ln Y^j + \beta_2 \ln Y^k \,, \tag{37}$$

where M^{jk} is the value of imports by country j from k, and the income elasticity parameters for countries j and k are β_1 and β_2 respectively. In the case of perfect specialization and zero

[19] Head and Ries note that the Armington structure is also consistent with a short-run version of the monopolistic competition model where the number of firms is fixed. In addition, in reference to Davis's model of intra-industry trade, they argue that the Armington model, "…may be viewed as representative of a broader class of models where a larger market does not induce reallocation of the location of firms and product varieties…" (pp. 859-860)

[20] Head and Ries' empirical results for tariff reductions following implementation of the 1988 US-Canadian free trade agreement indicate support for the Armington structure as opposed to the monopolistic competition model.

transport costs, the term $-\beta_0 \ln Y^w$ is a constant in a cross-sectional regression, while $\beta_1 = \beta_2 = 1$. If initially both countries are of the same size, and then there is a small transfer of GDP from *k* to *j*, this can result in the 'home market' effect whereby $\beta_1 > \beta_2$, i.e., a country's net exports of the differentiated good are more sensitive to own income than their partner's income. Depending on the specific data set, this result is consistent either with the monopolistic competition story or the 'reciprocal dumping' story with free entry. In contrast, if initially both countries are of the same size, and again there is small transfer of GDP from *k* to *j*, this can result in the reverse 'home market' effect whereby $\beta_1 < \beta_2$, i.e., a country's net exports are more sensitive to their partner's income than their own income. Again, depending on the specific data set, this result is consistent either with the Armington story or the 'reciprocal dumping' story with no entry.

Feenstra *et al*. (2001) work with a 110 country data set for five cross-sections: 1970, 1975, 1980, 1985, and 1990, and rather than use the *GL* index, they separate goods into differentiated and homogeneous following Rauch's (1999) classification based on 5-digit level SITC data aggregated to the 4-digit level. Rauch defines homogeneous goods as those traded in an organized exchange, while differentiated goods are neither traded in an organized exchange, and nor do they have a reference price. The version of (37) they estimate allows for other control variables such as distance, common language, and membership of a free trade customs union/agreement that are typically included in a gravity equation, e.g., see Cho *et al*. The results for the complete sample of countries show that in the case of differentiated goods, the average estimated value of β_1 is 1.09, and for β_2 it is 0.65, while in the case of homogeneous goods, the average estimated value of β_1 is 0.51, and for β_2 it is 0.82. Feenstra *et al*. (2001) conclude that these results are consistent with there being a 'home market' effect in the case of differentiated goods under monopolistic competition, and a reverse 'home market' in the case of homogeneous goods with duopoly and 'reciprocal dumping'. They also find these results hold when they split the sample into OECD countries and OPEC to non-OPEC countries. Their overall conclusion is that, "…the theoretical foundations for the gravity equation are actually quite general, but the empirical performance is quite specific…" (p.446)

Application to food and agricultural trade

The previous discussion leads to one basic prediction: depending on whether goods in a particular sample are differentiated or homogeneous, one type of model is expected to do a better job of explaining trade in that sample than another. All this suggests that using the appropriate data and econometric methods, it ought to be possible to test which trade theories best explain bilateral trade in food and agricultural products. As noted earlier, observed intra-industry trade in this sector appears to differ substantially between agricultural commodities and processed food products and by country (McCorriston and Sheldon), and some success has already been had in applying gravity-type models to the sector (Hirschberg *et al*; Cho *et al.*). By separating bilateral trade flows into differentiated and homogeneous goods, using either of the classification schemes outlined above, it should be possible to identify whether the increasing returns/product differentiation story can explain processed food trade, and whether the homogeneous goods/relative factor abundance story can explain trade in agricultural commodities.

On balance, the Feenstra *et al*. (2001) approach seems most attractive in several respects. First, adaptation of Rauch's approach to classifying food and agricultural goods into homogeneous and differentiated groups is quite appealing given his definition of homogenous goods, and avoids the type of problems associated with measuring intra-industry trade. Second, in estimating (37), the Evenett and Keller (2002) approach can be nested by appropriate restrictions being placed on the parameters β_1 and β_2. Third, other models of trade can be captured through restrictions on these same parameters implied by the 'home market' effect. Table 1 contains a summary of these parameter restrictions that might be tested for in food and agricultural trade data.

5. Summary

This paper has focused on what is recognized as the most commonly used, theoretical alternative to the neoclassical trade model – one based on product differentiation, scale economies, and monopolistic competition. The evolution of this model came out of the empirical challenge that observed intra-industry trade presented to the way international economists think about trade. Even though there are some well-known problems associated with measuring intra-industry trade, the monopolistic competition model has become the dominant theoretical alternative to the neoclassical model, and has also become very popular in computable general equilibrium approaches to trade modeling. So does the theory carry any empirical weight?

While Helpman's (1987) initial work seemed to present fairly strong evidence for the theory, the later empirical analysis of Hummels and Levinsohn did raise significant doubts about its validity. However, the follow-up work by Gebaere (2005) on the original Helpman (1987) structural equation, and the recent theoretical and empirical work using the gravity model, suggests that evidence for the increasing returns/product differentiation story may be found in the appropriate trade data sets. Given that intra-industry trade has been found to exist in the food and agricultural sector, there is no obvious reason why the type of methodology developed by Evenett and Keller (2002), and Feenstra *et al*. (2001) should not be adapted and applied to the sector.

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Table 1: Summary of parameter restrictions on gravity model

Trade model	Income parameter restriction	Good type
Increasing returns/ Multi-cone H-O model	$\beta_1 = \beta_2 = 1$	Differentiated/homogeneous
Increasing returns/ Uni-cone H-O model	$\beta_1 = \beta_2 = (1 - \gamma^i) < 1$	Differentiated/homogeneous
Uni-cone H-O model	$\beta_1 = \beta_2 = (\gamma^j - \gamma^i) < 1$	Homogeneous
Increasing returns/ 'Home-market'	$1 \geq \beta_1 > \beta_2$	Differentiated
Armington/ Reverse 'home-market'	$\beta_2 > \beta_1$	Differentiated
Oligopoly/ 'Home-market'	$\beta_1 > \beta_2$	Homogeneous
Duopoly Reverse 'home-market'	$\beta_2 > \beta_1$	Homogeneous

Figure 1: Trade Equilibrium

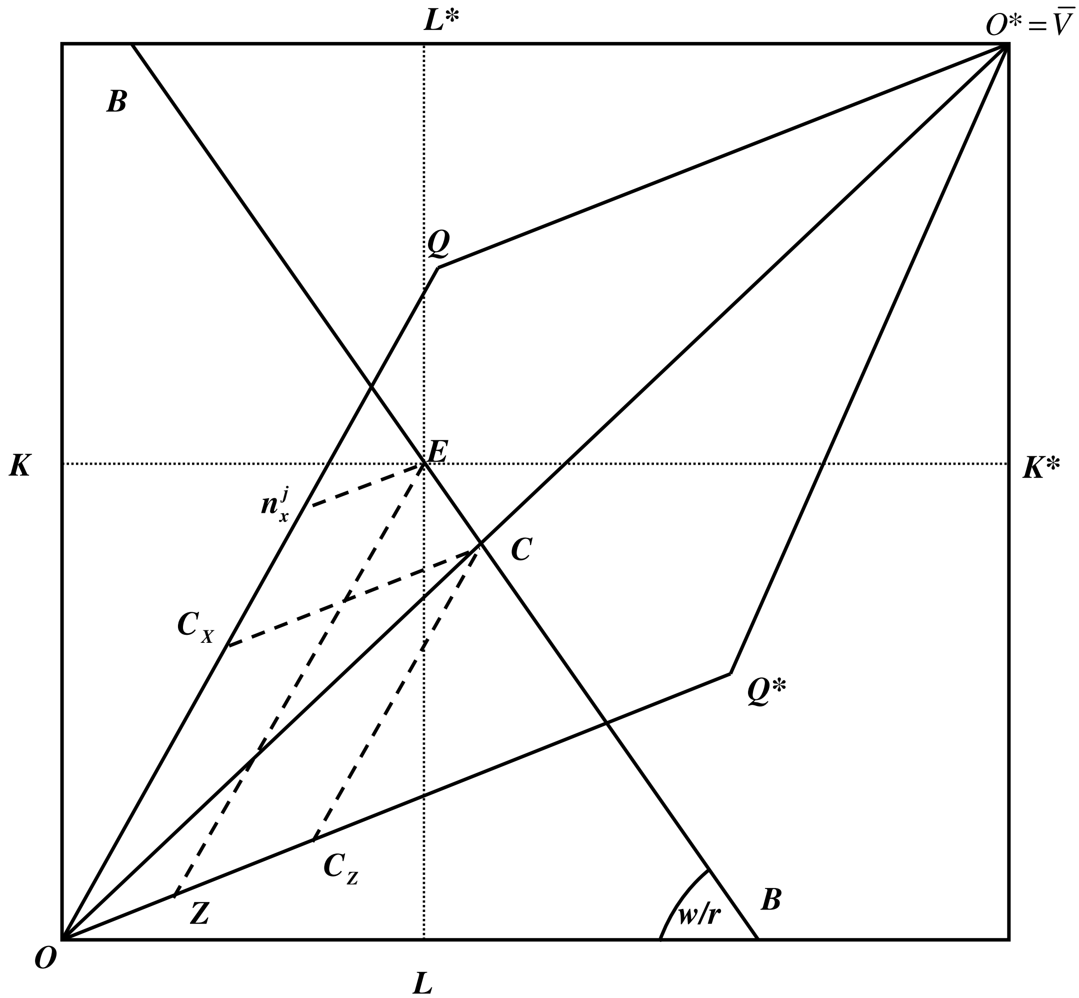

Figure 2: Perfect Specialization

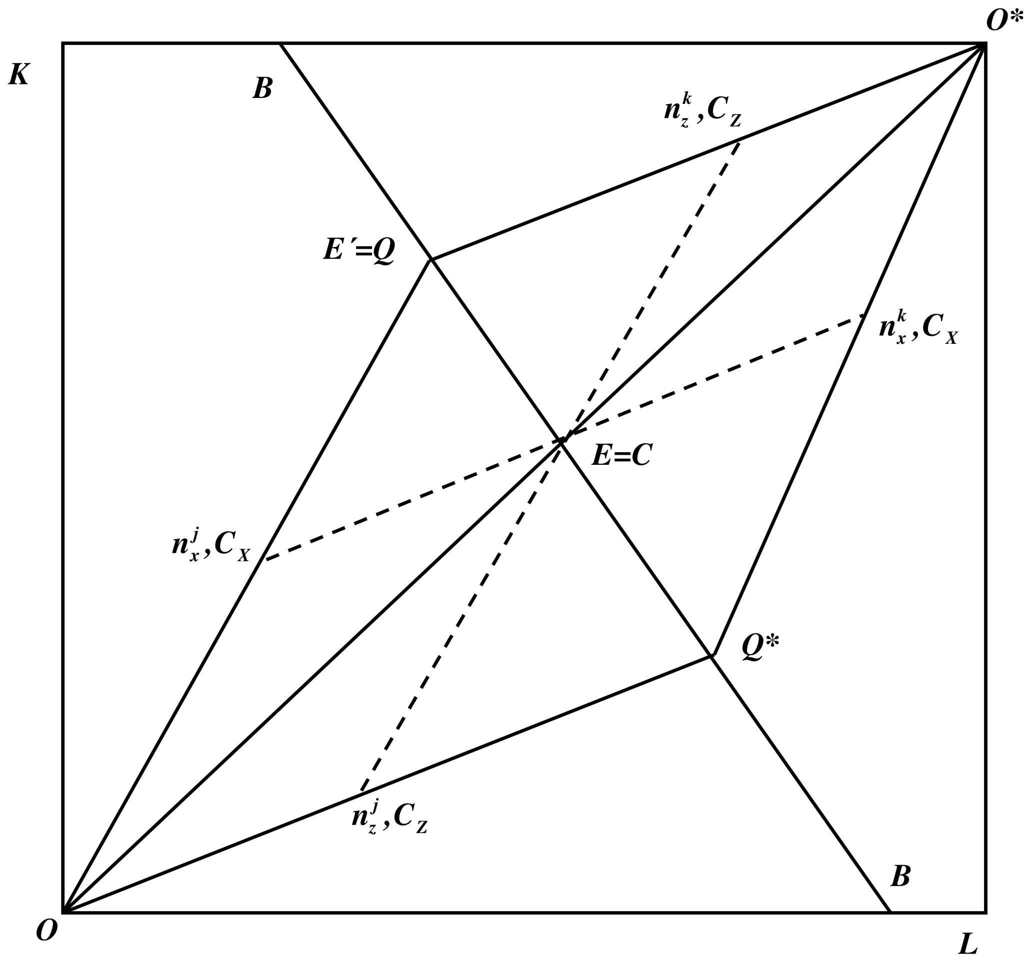

Figure 3: Imperfect Specialization