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DOES ECONOMIC GEOGRAPHY MATTER FOR INTERNATIONAL SPECIALIZATION?

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ABSTRACT

There are two principal theories of why countries trade: comparative advantage and increasing returns to scale. Yet there is no empirical work that assesses the relative importance of these two theories in accounting for production structure and trade. We use a framework that nests an increasing returns model of economic geography featuring "home market" effects with that of Heckscher-Ohlin-Vanek. We employ these trade models to account for the structure of OECD manufacturing production. The data militate against the economic geography framework. Moreover, even in the specification most generous to economic geography, endowments account for 90 percent of the explainable variance, economic geography but 10 percent.

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1 Introduction

Why do countries trade? What determines the pattern of trade? It is difficult to conceive of more fundamental problems for international trade economists. Two broad theories of international trade patterns have been devised. One is comparative advantage and the other is increasing returns. In reviewing the empirics of new trade theory, Krugman asks:

> "How much of world trade is explained by increasing returns as opposed to comparative advantage? That may not be a question with a precise answer. What is quite clear is that if a precise answer is possible, we do not know it." (1994, p. 23).

This is a deeply unsatisfactory state. Our paper will make progress in two directions. The first is that we implement tests designed to distinguish a trading world of increasing returns from one of comparative advantage. The second is that we estimate the relative contribution of each to the explanatory power of our model.

While our model is of a trading world, the direct object of estimation is the structure of manufacturing production in the OECD. We chose this focus as it is commonly argued that it is precisely there that increasing returns plays its most important role. Thus this provides the most promising setting for identifying the effects of increasing returns.

Of course, comparative advantage and increasing returns represent two classes of trade models. To make progress on the question, one is forced to select a model to represent each class. For comparative advantage we will rely on a variant of the Heckscher-Ohlin-Vanek (HOV) model. For increasing returns, one is forced immediately to confront a fundamental divide within these models. On one side is the set of zero transport cost models surveyed in Helpman and Krugman (1985). We do not pursue this avenue since, as we argue below, it is difficult to identify features of production or trade structure that distinguish these models from a variety of comparative advantage models. The second set interacts increasing returns with transport costs to create what Krugman (1991) has dubbed models of "economic geography."

Even the latter represents a set of models, rather than a specific alternative. In selecting among the set of potential representative models for economic geography, we had three aims in mind. First, we wanted it to be a model that has featured prominently in discussions of the role of increasing returns in trade. Second, we needed its central theoretical result to be robust to the departures required to take a theory from blackboard to data. Finally, we needed it to present a clear contrast in its predictions relative to those of comparative advantage theories. These criteria yield a clear candidate, drawn from the classic paper of Krugman (1980).[1] This model features what has long been termed the "home market effect." This element of economic geography is then nested with a Heckscher-Ohlin-Vanek model to ready it for empirical tests.

Our empirical results do not support the idea that this model of increasing returns contributes to an understanding of the structure of OECD manufacturing. One specification of our model does provide a glimmer of hope of finding these home market effects. However, the result is not robust to inclusion of endowments as explanatory variables at a fine level of production structure. Moreover, even in the specification most favorable to economic geography, the home market effects are of very muted importance in understanding OECD production. Of the explainable variance, 90 per cent is accounted for by differences in factor endowments, and but 10 per cent by economic geography.

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[1] It should be emphasized that this is *one* model of economic geography, and so cannot represent the full breadth of this work. Nonetheless, it is a particularly prominent and influential version. For a broader cross-section of the theory, see Krugman (1991). Our focus on this model was strongly influenced by its amenability to empirical implementation on cross country data.

Our results do not provide a complete answer to Krugman's question of the relative importance of comparative advantage and increasing returns for trade. The first reason is simply that our dependent variable is not trade but production. The second reason is that we have examined only one increasing returns model, and this with a variety of strong identifying assumptions. Nonetheless, the absence of a significant contribution by increasing returns in explaining the OECD manufacturing production structure should be troubling for those who believe that increasing returns are pervasive there. And the excellent ability of the Heckscher-Ohlin-Vanek framework to account for that structure is very promising for the comparative advantage theories.

2 Increasing Returns and Comparative Advantage: Separating the Models

2.1 Theory

In the last fifteen years, the analysis of international trade has undergone what Krugman (1990) describes as a "quiet revolution." This denotes the challenge of theories based on increasing returns to scale to the previously dominant paradigm of trade relations, that of comparative advantage.

From the start, the increasing returns theory has promised to account for a number of important observed phenomena that had seemed puzzling based on models of comparative advantage. It offered a simple account of intraindustry trade, the simultaneous import and export of goods of similar factor intensity. It promised to help us understand why so much of world trade is among countries with relatively similar endowment proportions, apparently at odds with the Heckscher-Ohlin theory. And it promised to provide a transparent theoretical underpinning for the gravity model, perhaps the empirical trade model with the greatest success. Each of these has been held up as an important advantage of the increasing returns models over those based on comparative advantage [see Helpman and Krugman (1985)].

These claims have been questioned, both theoretically and empirically. Work by Chipman (1992), Davis (1995, 1996), and Deardorff (1995) challenges the theoretical exclusivity of the increasing returns model in accounting for these phenomena. In a variety of settings, they demonstrate how each of these observations can arise quite naturally in a world of comparative advantage. This suggests a common feature that links these trade patterns in the two theoretical frameworks. In a word, it is specialization. Anything that gives rise to a high degree of specialization will generate these trade patterns. It can be increasing returns, Ricardian technical differences, Rybczynski-like "magnification" effects, or Armington preferences. The sense of this is appreciated by considering the simplest monopolistic competition trade models: what role does increasing returns play, apart from specialization, in giving rise to the characteristic trade patterns? The answer is none. In effect, the recent theoretical work demonstrates that the simple increasing returns models are observationally equivalent to a variety of models based on comparative advantage featuring a high degree of specialization.[2]

This cumulation of theoretical and empirical studies has underscored a perverse success of the increasing returns theory. The work of Helpman (1981), showing how to integrate the increasing

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[2] The reader should bear in mind that this observational equivalence cuts both ways. Our evidence that Heckscher-Ohlin does an excellent job in accounting for the structure of OECD production cannot be read as a rejection of the zero transport cost increasing returns model. In fact, this is exactly what one might expect from models such as that of Helpman (1981), where Heckscher-Ohlin explains the broad industrial structure and increasing returns accounts for intraindustry exchange.

returns theory with the more traditional models, was a milestone in winning broad acceptance for the new work. Yet the integration of the theories is now so complete that there seem to be no empirical elements that can separate them. If this were the end of the story, one would have to be profoundly disappointed that a theory with such apparently revolutionary implications has come to so little. Yet we believe that this dejection is unwarranted.

We have to agree with Krugman (1991) that the truly revolutionary element in the increasing returns framework lies in the work which he has dubbed the new "economic geography." The distinctive element of this work is the interaction of increasing returns with transport costs across countries (or regions).[3] In such a world, a fundamental contrast emerges with respect to models of comparative advantage. This concerns the role of demand in determining trade patterns. In a model of comparative advantage, *ceteris paribus*, unusually strong demand for a class of goods will turn those goods into importables. Transport costs may diminish the trade volume, but will never lead the good to be exported. This result differs importantly with that which emerges in a world of increasing returns. The scale economies lead producers of individual goods to concentrate their production in a single location. If a country has an unusually strong demand for a class of goods, that country becomes a good choice as a site for production, and so it is likely to export the goods in question. [See Krugman (1980)]

International transport costs play a crucial role here in allowing us to separate comparative advantage from increasing returns. Yet we know that shipping and communications costs have fallen sharply in recent decades. Nonetheless, we would assert that costs of trading between nations may

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[3] Although we will speak of transport costs, the reader should interpret this broadly as any per-unit costs that exist for transactions between but not within countries.

yet substantially exceed that of trade within nations. Important evidence of this appears in McCallum (1995), which shows that the international border matters a great deal, as seen in the contrast between the volume of Canadian inter-provincial trade versus trade with similarly distant US states. We believe that this justifies our focus on an increasing returns model with transport costs.

In sum, when there are costs of trade, unusually strong demand for a good yields opposing predictions in a comparative advantage vs. an increasing returns world. Comparative advantage suggests you will import that good; increasing returns suggests that you will export it. It is this basic contrast that we will exploit to separate the models in our empirical work.

2.2 Empirics

Are increasing returns empirically important for explaining trade patterns? A natural first approach to answering this question is to ask whether they are of measurable importance at the plant, firm, and industry level. This has been a major empirical research question in industrial organization. The literature has tended to reject the idea that economies of scale are crucial for industrial market structure, with the exception of electrical power, telecommunications, and products with very high transportation costs. [See excellent surveys in Jorgenson (1986) and Scherer and Ross (1990)].

However this direct evidence is in any case unlikely to settle the issue of the importance of scale economies for understanding trade patterns. From a theoretical perspective, it is the existence of economies of scale rather than their degree that is crucial in determining trade patterns. The results of economic geography could be driven by economies of scale too small to be detected by econometric techniques. Even if there are no economies of scale at the industry level, or economies of scope at the firm level, small economies at the level of the individual product suffice for the theoretical framework. On the other hand, if the alternative hypothesis is a world of constant returns to scale, the fact that any error bounds will always include a region of increasing returns means that direct evidence in principal cannot refute the increasing returns hypothesis. Finally, even if one were convinced that increasing returns is important at some levels, it does not follow that it matters for trade patterns. For example, if average cost curves declined over some region, so that constant returns to scale is literally incorrect, they may yet become flat or U-shaped at a level of output small enough to admit entrants that lead us to a competitive world. In effect, direct evidence on scale economies is unlikely to be decisive in settling their importance for trade patterns.

This suggests looking for the effects of scale economies in terms of their implications for trade patterns. A voluminous literature has sought to do this by examining the way that a variety of proxies for scale economies help to account for intraindustry trade. Our discussion of the theory above suggests that such studies cannot provide evidence that helps us to separate the theories.[4] As well, an uncertain match between the theoretical categories and the division of industries in the data provides additional cautions to this line of inquiry.[5]

Another effort to confirm the importance of scale economies in giving rise to trade has concerned the volume of bilateral trade. Again, we have outlined above the theoretical objections to using evidence on bilateral trade volumes as a way to separate increasing returns and comparative

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[4] For example, Harrigan (1994) notes that "A major difficulty in interpreting statistical models to explain the Grubel-Lloyd [intraindustry trade] indices is that the monopolistic competition model has very little to say about the cross-country and cross-industry variability of the Grubel-Lloyd index."

[5] Based on such considerations, Krugman (1994, p. 19) concluded: "Conceptually, then, the data on intra-industry trade are a very ambiguous tool for investigating economies of scale and trade." See also Davis and Bhagwati (1995).

advantage theories. Here we take the studies on their own terms. Relatively simple gravity models have long been known to do a good job of accounting for the volume of bilateral trade. Helpman (1988) employed a variant of a gravity model based on an underlying monopolistic competition framework to examine time series data for fourteen industrial countries. Generally the model worked well, and Helpman viewed the results as evidence in favor of the scale economies framework. Hummels and Levinsohn (1995) approached these results with a clever twist. They applied a variant of Helpman's approach to a data set consisting mostly of developing countries for which the monopolistic competition model was *ex ante* not expected to work. Their results showed that the model "worked" almost as well as in the study of Helpman. Evidently something more than just increasing returns was at work.

Only a few years ago, chastisement of the increasing returns account of trade patterns for a paucity of empirical support would have been tendentious. After all, empirical work on the comparative advantage theories hardly inspired confidence. The studies of Leontief (1953), and Bowen, Leamer, and Sveikauskas (1987), suggested deep problems. Yet the last several years have witnessed a revival of empirical work on comparative advantage. This includes the work of Trefler (1993, 1996), Davis, Weinstein, et al. (1996), Brecher and Choudhri (1993), and Harrigan (1996). To be sure, all of these have departed from the simplest factor price equalization models of Samuelson and Vanek. Yet the deviations have been very simple, and in the spirit of traditional comparative advantage, such as Ricardian technical differences, failures of factor price equalization, and consideration of cross-country differences in demand patterns. And they have shown that with sensible alterations, the simple comparative advantage models seem to do quite well.

3 A Theoretical Framework for Empirical Tests

3.1 Introduction

The aim of this section is to provide a theoretical framework for empirical examination of the structure of production across the OECD countries. The null hypothesis will be that the structure of production is determined entirely according to the multi-factor Heckscher-Ohlin theory. The alternative considered is that Heckscher-Ohlin must be augmented with a simple model of economic geography.

There are no prior tests for a very good reason. To be empirically implementable, a complete economic geography theory must allow for increasing returns and transport costs. It must allow for many countries, and for these to vary in endowment proportions, economic size, and demand patterns. Finally, it must allow for differences across industries in input proportions and size. Yet, there is no theoretical model that incorporates all of these elements. We do not fully remedy this shortcoming – our aim is more modest. We propose to explore these variations separately to reveal the logic governing production patterns. Where necessary, we are willing to make strong maintained assumptions on the structure of the technology. And then -- cognizant of the potential pitfalls -- we will specify an estimating equation that embodies what we view as the robust core of these models. We believe that the necessity to initiate empirical work that places these elements in a common framework justifies the approach we take.

Our theoretical work proceeds in two broad stages. The first is to explore the role of idiosyncratic elements of demand in determining production patterns both in models of economic geography and comparative advantage. We then proceed to show how to nest the two frameworks in a manner amenable to empirical testing.

3.2 Economic Geography and the Home Market Effect

In this section, we employ a model of economic geography to develop a number of results that form the foundation for our empirical work. The model draws strongly on the pioneering paper of Krugman (1980). We summarize one elaboration of this framework due to Weder (1995). And we extend the basic model to check the robustness of the results for problems that become important when we turn to empirical implementation.

The model is developed with very strong symmetry conditions that provide a basis for factor price equalization. Consider a world of two countries endowed in equal amounts with the single factor labor, so that $L = L^*$. In this world, there are two monopolistically competitive industries, indexed by X_1 and X_2. Production of a variety in either industry takes place under increasing returns to scale with identical production functions across both varieties and industries. The labor usage in the production of an individual good j is given as $l^g = a + b\, x^g$, for $g = 1, 2$. The aggregate labor constraint, for example in the home country, requires $L = \Sigma_g l^g$.

There are two types of consumers in the world, those who consume only good X_1, and those who consume only good X_2. A key assumption of the model is that the former type are more prevalent in the home country, and the latter in the foreign country -- in fact that the two are mirror images. A typical consumer with a preference for the type X_1 goods will maximize a utility function of the Dixit-Stiglitz kind, Max $V = [\Sigma_{g \in X1} D_g{}^{\rho}]^{1/\rho}$ subject to the available labor income.

An extremely convenient feature of Krugman's model is that even in the presence of transport costs output per firm in equilibrium is at the same level in each of the countries. Along with the symmetries in demand and production, this implies that the production patterns of the two countries can be fully described by the number of varieties produced in each of the industries. Let μ be the number of varieties of good g produced at Home relative to those produced abroad. Let $\sigma < 1$ be the ratio of demand for a typical import relative to a domestically produced variety. Let λ represent the ratio of demanders for good g at Home relative to the number in Foreign. Krugman shows that in the range of incomplete specialization, the relative production levels μ can be described as:

$$\mu = \frac{\lambda - \sigma}{1 - \lambda \sigma}$$

When $\lambda = 1$ demand patterns are identical and the countries produce the same number of varieties in each industry, leaving a zero net balance. This will play an important role when we turn to our empirical implementation as it suggests that predictions of production structure, *ceteris paribus*, should be centered around an even distribution of the industries across the countries. Idiosyncratic demand components will then explain deviations from this neutral production structure.

Moreover, we need to consider closely the way in which idiosyncratic demand components will translate into alterations in production structure. From above, and for the range of incomplete specialization for which these relations are valid,

$$\frac{\partial \mu}{\partial \lambda} = \frac{1-\sigma^2}{(1-\sigma\lambda)^2} > 1$$

Krugman emphasized that this will imply that countries with a large "home market" for a good will be net exporters of that good. For our purposes it is convenient to focus directly on the implications for production. That is, idiosyncratic demand patterns (indexed by λ) have a *magnified* impact on production patterns. This will play a crucial role in our empirical implementation, helping to separate the influences of economic geography from that of comparative advantage. These relations appear in Figure 1 in schematic form.

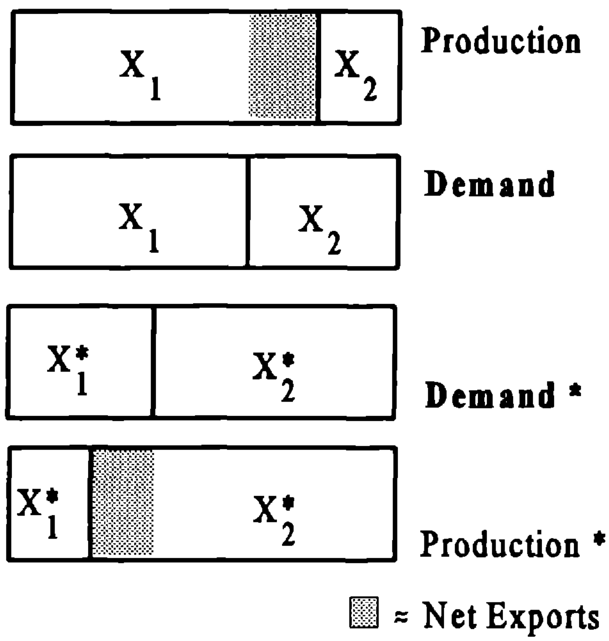

Figure 1 Demand Idiosyncracies have a Magnified Impact on Production

Krugman (1980) briefly considers a case in which the countries differ not only in demand patterns, but also in population. One version of this case is considered at length in Weder (1995). In the latter, the "mirror image" of the two countries is preserved in the sense that the *share* of individuals of each type is exactly opposite for the two goods and countries. However it is also assumed that one country is larger, so may even have an *absolutely* larger demand for all varieties of both goods.

Weder shows that there are in principle three influences on the pattern of production in his model: relative wages, w/w^*; relative country size, L/L^*; and relative spending patterns, h/f, where h is the proportion of consumers of the X_1 good at home, and f is the corresponding proportion for the foreign country. Weder shows that the first two influences in effect net out. His main result appears as Proposition 3: "In the open-economy equilibrium, each country is a net exporter of that group of differentiated goods where it has a comparative home-market advantage." And a country is said to have a comparative home-market advantage just when it has a higher *proportion* of demanders of one type relative to the other.

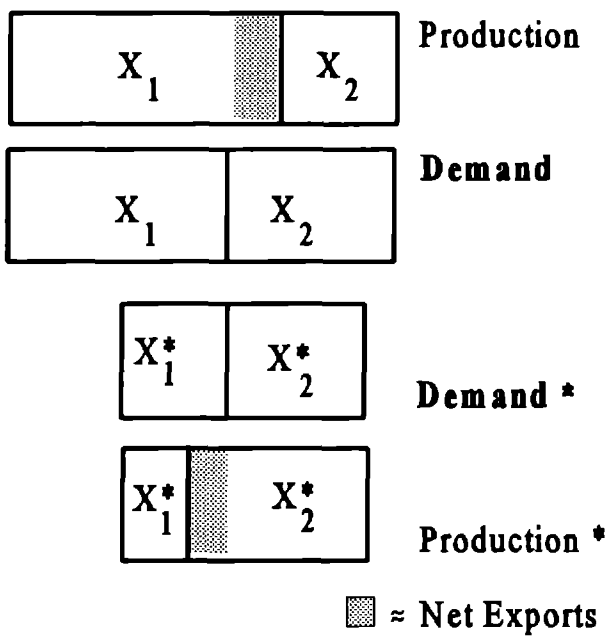

Figure 2 Production Patterns when Country Size Differs

Thus the country with the relatively high share of X_1 demanders will be the net exporter of the X_1 type goods. This remains true even when one country has an absolutely larger market for all varieties in both industries. Ultimately, this is not surprising for an economist trained in the theory of comparative advantage. The aggregate resource constraint for each country is going to force some ordering on the location of production. It is intuitively pleasing that this is decided, as above, by the comparative strength of the demand patterns. This result is depicted schematically in Figure 2.

There are two other directions in which generalizations are warranted. The first is to consider what happens when there are more than two industries. The second is to consider what happens when there are more than two countries. A brief acquaintance with the simpler cases of Krugman (1980) and Weder (1995) will convince the reader that such extensions threaten to become mired in a dense jumble of algebra. Hence we eschew brute force. Rather, we will seek to capitalize on the beauty of Krugman's symmetry assumptions to explore these problems. One element of this symmetry that will be key to the results that we examine is the fact that it results in factor price equalization among countries in spite of being separated by transport costs, facing different vectors of goods prices, and having quite distinct production and consumption patterns.

We will now examine the problem of trade in the goods of more than two industries. We approach this indirectly. Let there be two trading blocs isolated from each other, each bloc formed of two countries. Each pair of countries is in a trading equilibrium similar to that of Krugman described above (equal size, etc.). There are only two differences. One is that the goods being traded differ between the blocs. As before, the countries in Bloc One are trading in the industries X_1 and X_2. In Bloc Two, the countries instead are trading in industries Y_1 and Y_2, with their populations divided between those who consume the respective goods. The second difference is that the strength of the demand idiosyncracies may vary across the two blocs. We assume that the demand differences are greater with respect to Bloc Two goods. Now consider what would happen if each of the countries in one bloc merged with one of the countries in the other bloc. This would have no implications for the real economy, although there would now be recorded trade between the two enlarged countries in all four goods. Assuming that there was initially incomplete specialization in both blocs, this will continue to be true in the two enlarged countries. Because of the symmetry, the two enlarged countries will have exactly opposite rankings in degree of demand specialization. The key result for our purposes is that the degree of production specialization will be greater for the goods with stronger demand specialization.

A similar approach can be used to investigate trade patterns in a three country, three industry world. Let the industries be indexed by X_1, X_2, and X_3. We will consider a case in which each country has only two types of consumers: Country One has consumers who demand only goods from industries X_1 and X_2 ; Country Two has consumers who demand only goods from industries X_2 and X_3; and Country Three has has consumers who demand only goods from industries X_3 and X_1. Assume again that the countries are the same size, and that the proportion of the consumers that demand the respective goods are f and $(1 - f)$ in each country, with $f > 1/2$. It is clear from the symmetry that the equilibrium will again feature factor price equalization. Moreover, given that the cost conditions are unchanged, and the local demand conditions in the two markets that demand a particular good are effectively the same as in the two country model, producers will face the same tradeoffs, and so we will observe the same division of production between the markets with positive demand. Thus, while the move to more countries makes the story marginally more intricate, the exact same kind of home market effects can be observed in a world of many countries (and goods).

3.3 Production and Idiosyncratic Demand under Comparative Advantage

We have already examined the relation between patterns of idiosyncratic demand and production in a model of economic geography. We now consider the same problem in models of comparative advantage. A useful benchmark case is that with zero transport costs. For simplicity, consider a conventional freely-trading Heckscher-Ohlin world with two goods, X and Y, and two factors, capital and labor (each consumer supplying a unit of labor). Assume that we meet the conventional requirements for factor price equalization. Let there also be two types of consumers -- those who consume only X and those who consume only Y. Assume that the two types are initially distributed uniformly across the countries. Then trade patterns will be determined precisely according to the standard Heckscher-Ohlin determinants of deviations from an average production pattern. Now consider a redistribution of the consumer types across countries that leaves the aggregate labor force in each unaffected. This will yield the same equilibrium relative goods price [see Dixit-Norman (1980)], but the countries now have an idiosyncratic component of demand. Our concern is whether the idiosyncratic demand pattern affects production. It does not. The reason is that with a fixed production set, the equilibrium goods prices are sufficient to determine production structure. The goods prices themselves depend on the structure of world demand (not directly its local component).

[See Figure Three]

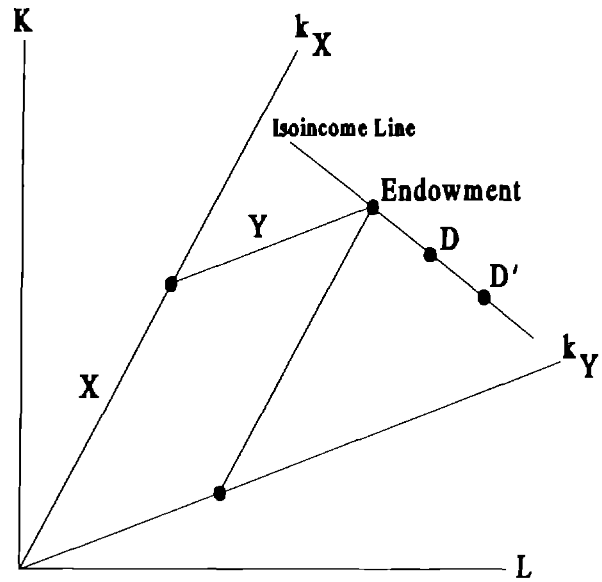

Figure 3

The problem is only slightly more complicated when we consider a competitive world with transport costs. Unfortunately, once we introduce transport costs it is no longer simple to conduct experiments that change the pattern of local demand while leaving world demand (so equilibrium goods prices) unaffected. Thus we turn to a slightly different experiment, that of considering shocks to the pattern of local demand (not compensated elsewhere). The intuition comes through simply enough in a partial equilibrium framework.[6]

Consider a world with N countries -- Home and $N - 1$ (potential) suppliers of the home importable. Let the home supply curve be given by $P = a + b X^H$. Each of the foreign suppliers has

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[6] One can derive essentially similar results in a general equilibrium framework, although it is more cumbersome. The partial equilibrium results nevertheless provide the intuition for the workings of a true comparative advantage model.

a parallel excess supply curve, $P = a + \tau + bX^{I}$, where $\tau > 0$ is a per-unit transport cost. This is illustrated in Figure 4 for the case of a single foreign supplier.

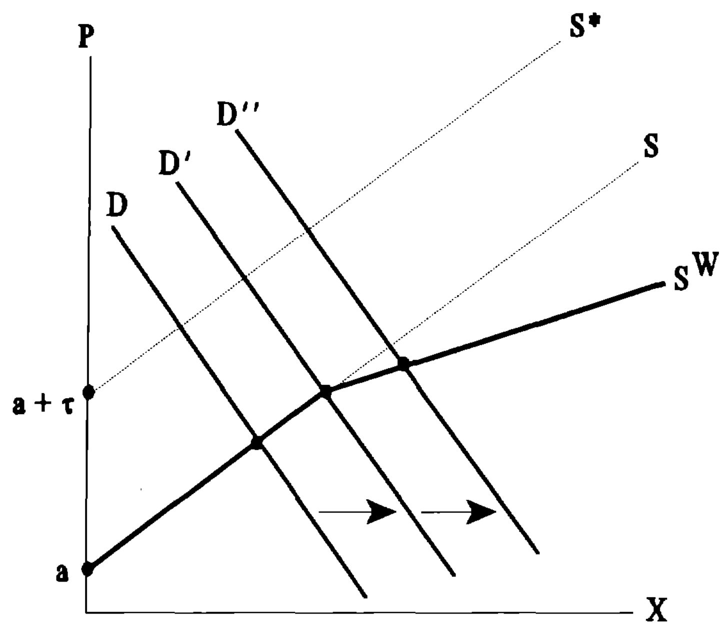

Figure 4 Idiosyncratic Demand in a Competitive World with Transport Costs

Our problem now can be broken down into two parts. When the equilibrium price falls in the range $[a, a + \tau]$ there are no imports. For local demand shifts that leave the equilibrium price in this range, all local demand (idiosyncratic or not) must be met by local production. Hence in this range, production and demand move one-for-one. However the good is not traded. If instead we consider a positive local demand shock that moves us between equilibria with trade, then there is a supply response from each of the countries. In fact, it is straightforward to see that in this simple case if the equilibrium change in quantity is dX, then only $dX^{H} = dX/N$ of it will be met through increased local supply. If N is large (so that the typical country is relatively small amidst the aggregate), then the local supply response at the margin will be close to zero.

We must ponder one final fillip. This is the case when the number of goods exceeds the number of factors. It is well known that in such a case the HOV model does not fully determine the cross-country distribution of production, although it still determines the net factor content of trade. In determining production, there are degrees of freedom equal to the excess number of goods relative to factors. *Ceteris paribus,* this implies that even small costs of trading some of the relevant goods could shift the full measure of trade onto the remaining goods. For the goods with positive costs of trade, local production and absoprtion may move one-for-one, even if these costs of trade are small.

Our conclusion, then, is that comparative advantage can account for relations between idiosyncratic demand and production that range from zero to one-to-one. The interpretations vary, though. The relation will be zero in the N-good, N-factor, frictionless trading world. In this same world, but with transport costs, there will be one range in which demand and production move one-to one, and a region in which the relation is close to zero. Thus, the measured relation could be anywhere between zero and one, depending on how the level of transport costs affects the weight that should be placed on each of these regions. Finally, we saw that in a simple world in which the number of goods exceeds the number of factors, it is possible that even small transport costs could lead production and idiosyncratic demand to move one for one. In no case, though, would there ever be a more than one-to-one relation in a comparative advantage world.

3.4 Nesting Heckscher-Ohlin and Economic Geography

In this section, we turn to the problem of nesting the models in a framework that will be suitable for our empirical work. We begin with a simple model of the structure of production in a Heckscher-Ohlin world. The basics of this model are well known, so we review them only briefly. Consider a world in which all relevant countries share identical, constant returns to scale technologies. It will prove convenient throughout our exercise to consider a model in which the input coefficients are fixed technologically. We assume throughout that production in the countries of interest is at least weakly diversified across all goods of interest. For the case of two goods and two factors, the determination of production patterns for one of the countries can be depicted as in Figure 3.

When we consider placing the economic geography model in this setting, we must distinguish between industries, goods within an industry, and varieties of each of the goods. The approach that we work with follows that of Helpman (1981). The broad structure of production at the industry level is determined by Heckscher-Ohlin. However, production of goods within each of the industries is determined according to the influences identified in the models of economic geography above. Given the output level, we can compute directly the commitment of resources to an industry by each country. Countries differ in the scale of their industries but not in the factor composition within an industry. These differences in industry size will play a key role as an aggregate resource constraint that insures that it is the relative (not absolute) market sizes that matter for production patterns.

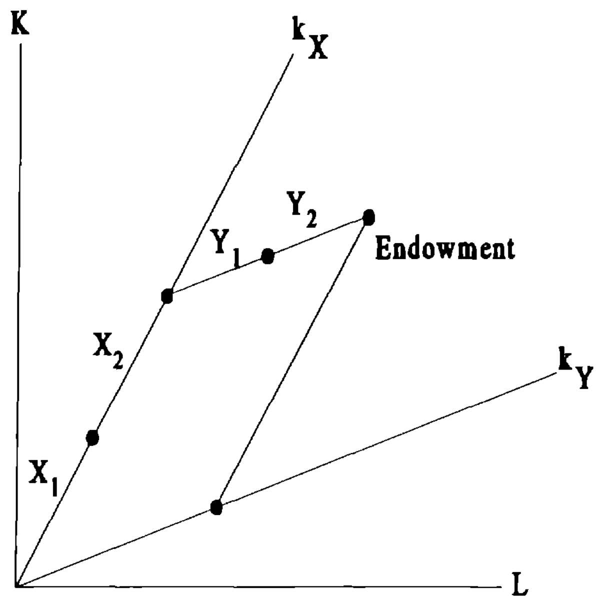

Figure 5

When we think about a single industry across countries, this comes close to exactly mimicking the simple economic geography models. The presence of many factors is not a problem, since the fixed coefficients effectively turn the many into one composite factor. The level of resources committed by each to the industry is fixed and works similarly to the fixed labor endowment in the simpler models. The one important difference between this more complex setting and the simpler economic geography models is that the relevant factor prices are determined in a model broader than the single four digit industry. Nonetheless, the fact that each country faces an aggregate resource constraint specific to the industry (under our maintained assumption of fixed coefficients) strongly suggests that relative demand will continue to figure prominently in the assignment of production of specific goods across countries.

4 Empirical Implementation

4.1 Formalizing the Hypotheses

Our formalization of the Heckscher-Ohlin production model is straightforward and mirrors that of a long line of empirical trade papers [See, Leamer and Levinsohn (1995)]. We start by assuming that the location of production can be determined by factor endowments according to the following formula:

$$X = \Omega V \tag{1}$$

where $\boldsymbol{X}$ is a N x C matrix of output, $\boldsymbol{V}$ is a M x C matrix of factor endowments, and $\boldsymbol{\Omega}$ is a N x M matrix of parameters that in the case of equal numbers of goods and factors equals the inverse of the Heckscher-Ohlin-Vanek technology matrix. In our implementation of (1), $N > M$, but following a long tradition in empirical trade, we will assume that the number of goods in the real world equals the number of factors and that missing factors are contained in the error term. Whether it is reasonable to think of world production as being driven by factor endowments can then be assessed by examining how well equation (1) fits the data.

Following our theoretical model, let's assume that there are $N = M$ industries that use factors in different proportions per unit output, and that technology is Leontief. Suppose that within an industry n, there are G_n goods that are produced using factors in the same proportions but enter into the utility function separately. Within an industry like textiles, these goods might correspond to spun textiles, knit fabrics, carpets and rugs, etc. Since all of these goods are produced using the same techniques, we can rewrite equation 1 as

(2) $$X^n = \sum_{g=1}^{G_n} X_g^n = \Omega^n V \ ,$$

for all industries n and goods g. Here Ω^n denotes the nth row of the Ω matrix. Our formulation allows us to have a very special type of indeterminacy. While the aggregate output of industries is assumed to be driven by factor endowments, the output shares of goods within the industry is assumed not to be driven by factor endowments. In other words, to draw an example from the economic geography literature, factor endowments may tell us something about which countries are large textile producers, but they may be very poor predictors of where goods like carpets are located.

Since a maintained assumption is that Heckscher-Ohlin models of production cannot explain production patterns below a certain level of aggregation, we need a theory to explain the location of production of goods within an industry. Let's suppose that each good is comprised of a number of varieties that are produced using increasing returns technology. To continue our example, we are assuming that within the industry "textiles" there is a good "carpets" that is comprised of monopolistically competitive varieties like "wall-to-wall carpets," "Persian carpets," "rugs," etc., each of which is produced with economies of scale. It is at the varieties level that we assume economies of scale drives specialization. This assumption of specialization for varieties at this level of disaggregation seems reasonable in light of Grubel and Lloyd's (1975) finding that at the SITC 5-digit level, intraindustry trade only accounts for only 14% of all trade.

Empirically, the challenge is to determine whether the assumption that economies of scale forces the specialization helps us understand production patterns at the goods level. Following Weder (1995), we model goods production as

(3)
$$X_g^{nW} = f\left(\frac{X_g^{nW}}{X^{nW}} X^{nc}, \left(\frac{D_g^{nc}}{D^{nc}} - \frac{D_g^{nW}}{D^{nW}} \right) X^{nc} \right)$$

where D denotes absorption in either the country or the world and the first derivatives are expected to be non-negative. The first term in f captures the tendency for each country to produce the same relative shares of each good. Absent any demand differences, the share of production of any good g in industry n should be approximately equal to the share in the world. The second term mirrors Weder's condition for being a net exporter of a commodity in a two country world where one country differs in size from the other. High relative demand for a good in one country causes more varieties to locate in that country and thus raises production of that good. In our specification we suggest that this insight linking relative demands in two countries should be extendable to comparisons between one country and the rest of the world. This specification captures the notion that production should locate in countries with idiosyncratically high relative demands. Using the fact that world production must equal world consumption, we can rewrite (3) as

(3')
$$X_g^{nW} = f\left(\frac{D_g^{nW}}{D^{nW}} X^{nc}, \left(\frac{D_g^{nc}}{D^{nc}} - \frac{D_g^{nW}}{D^{nW}} \right) X^{nc} \right)$$

Since in our sample all goods are produced in all countries, equation (3') should be differentiable. This enables us to employ the first order approximation of version of (3') presented below:

(4)
$$X_g^{nW} = \alpha_g^n + \beta_1 \frac{D_g^{nW}}{D^{nW}} X^{nc} + \beta_2 \left(\frac{D_g^{nc}}{D^{nc}} - \frac{D_g^{nW}}{D^{nW}} \right) X^{nc} + \epsilon_g^{nc}$$

or

(4') $$X_g^{nc} = \alpha_g + \beta_1 SHARE_g^{nc} + \beta_2 IDIODEM_g^{nc} + \epsilon_g^{nc}$$

where

$$SHARE_g^{nc} = \frac{D_g^{nc}}{D^{nc}} X^{nW}$$

and

$$IDIODEM_g^{nc} = \left(\frac{D_g^{nc}}{D^{nc}} - \frac{D_g^{nW}}{D^{nW}} \right) X^{nc}$$

The β's correspond to the first terms in a Taylor expansion and the error corresponds to the higher order terms. The structure that we have placed on the analysis enables us to directly test the hypothesis of whether economic geography can improve our understanding of production patterns at the 4-digit level relative to the alternative hypothesis that all production at that level is indeterminate.

A few more words are in order about the specification. If the absorption of goods within countries is proportional to world production of goods (i.e. consumption is homothetic), then SHARE will equal the average level of production of a sub-industry within a Heckscher-Ohlin industry. In general, one should expect the coefficient on SHARE to be one.

We can now move to formal hypothesis testing. The coefficient on IDIODEM captures the impact that idiosyncratic patterns of demand have on production. If we estimate equation (4'), we can evaluate three hypotheses. First if β_1 is zero, then we conclude that we are in a world in which transport costs do not matter. As we have seen in the theoretical section, however, even in a comparative advantage world transportation costs can cause output to move as much as one for one with demand. This is especially true in cases where there are more goods than factors -- a maintained assumption in our analysis.[7] We can test this hypothesis by examining if β_1 is between zero and one. If β_1 falls within this range, then we conclude that we are in a world in which transportation costs and demand patterns affect the location of production, but there are no economies of scale driving specialization. Finally, if β_1 exceeds one, then we conclude that the magnification or home market effects associated with economies of scale are playing some role in driving production. These hypotheses are summarized below:

	Interpretation of β_1
1) $\beta_1 = 0$:	Frictionless Comparative Advantage World
2) $\beta_1 \in (0, 1]$:	Comparative Advantage World with Transport Costs
3) $\beta_1 > 1$:	Economic Geography

There is a problem, however, with simply relying on estimates of equation (4') to test hypotheses. Remember that the maintained null hypothesis in all of these cases is that after industry output is determined, factor endowments play no role in determining the location of production at the goods level. An alternative approach would be assume that there are an equal number of goods and factors and test the specification outlined in equation (4') against a specification that postulates that factor endowments determine levels of production of goods within industries, i.e. we would like to test the specification suggested by equation (4') against the specification below:

$$X_g^n = \Omega_g^n V \tag{2'}$$

[7] While we assume that the number goods exceeds the number of factors, we also assume that the number of industries equals the number of factors.

The specification test would then consist of estimating a nested model,

$$X_g^{nc} = \alpha_g + \beta_1 SHARE_g^{nc} + \beta_2 IDIODEM_g^{nc} + \Omega_g^n V^c + \epsilon_g^{nc} \quad , \tag{4''}$$

and seeing if the coefficient on IDIODEM was robust to the inclusion of factor endowments.

There is also one additional theoretical issue that we need to address at this stage. Since we are considering a model with transport costs, even in a standard Heckscher-Ohlin framework, the FOB price is going to be lower than the CIF price. This implies that there may be a tendency for domestic absorption to be higher if a country is a net exporter of a good because domestic consumers pay the FOB price while consumers in countries that import the good must pay the CIF price plus the cost of transportation. In order words, absorption may covary with production because countries with higher production levels are more likely to be net exporters of goods and therefore have lower prices. One way to correct for this problem is to include a dummy variable that is one if the country is a net exporter of the good and zero otherwise. However, because the impact of this effect is likely to be proportional to the size of demand, we created EXPORTD which is the interaction of a net export dummy with domestic absorption.

4.2 Econometric Issues

Equations (2) and (4') can be estimated separately or as a system of seemingly unrelated regressions. The main problem with estimating each of the equations separately is missing observations at the 4-digit level. At the 3-digit level we have observations for each industry for 22 countries but at the 4-digit level we lose 9 countries. This greatly reduces the number of available degrees of freedom especially in specifications where we would like to nest the two hypotheses. We therefore opted to estimate all of the equations both individually and as a system of seemingly unrelated regressions where we imposed the restriction that the coefficients on the IDIODEM and SHARE had to be the same across equations.[8]

There are a series of econometric issues, however, that prevent direct estimation of these equations. First, in equation (4') there is a simultaneity problem arising from the fact that X_g^{nc} is an element of X^{nc}. This makes the estimated coefficients biased and inconsistent. However, if we assume that Heckscher-Ohlin is valid at higher levels of aggregation, then theory provides us with a good set of instruments. Namely, if we assume that equation (2) is valid, we can use factor endowments as instruments for the sectoral level of output.

Second, we also must deal with two types of heteroskedasticity. First, larger countries tend to produce more of everything and therefore the errors are likely to be correlated with country size. Second, when we estimate equations (4') and (4"), there is an additional element of heteroskedasticity that arises from the fact that industries that are larger are likely to have larger errors. We correct for this heteroskedasticity by assuming that errors across countries are determined by the following stochastic process:

(5) $$\epsilon_g^{nc} = \gamma_g GNP_c^{\theta_g} + \mu_{gc}$$

[8]Degrees of freedom considerations also forced us to impose a diagonal variance-covariance matrix on the residuals.

where γ_g and θ_g are parameters and μ_{gc} is assumed to be normally distributed across countries. Because equation (5) was estimated in logs, our heteroskedasticity corrected industry standard errors were close to unity but not exactly equal to one. In order to avoid spuriously weighting some industries more than others because of the log form of the regression, we forced all industry standard errors to equal one by dividing all observations by the heteroskedasticity corrected standard errors appropriate for that good.

Finally, one may wonder whether it is appropriate to assume spherical errors when our dependent variable is bounded below at zero. This is not just an econometric problem but a theoretical problem too. If a country does not produce a particular good, it could indicate that the country is no longer in the factor price equalization set and may be using different production techniques. Fortunately, in our sample, all countries produced positive amounts at all levels of disaggregation, so we feel that our assumption regarding the normality of the disturbances probably does not affect our results.

4.3 Data

Theory does not indicate how to find a level of disaggregation where factor endowments cease determining production structure and specialization is driven by increasing returns and demand patterns. Our strategy was to use the most detailed cross-national data we could find and then assume that industries at the most disaggregated levels were monopolistically competitive.

The data source most appropriate for our purposes was the OECD's Comparative Trade and Production (COMTAP) data set. This provides comparable trade and production data for 13 members of the OECD at the 4-digit level and 22 members of the OECD at the 3-digit classification level. These countries are listed in Table 1.

In principle, working at the 4-digit level enabled us to break manufacturing up into 82 4-digit sectors, but because in 13 cases there was only one 4-digit sector within a three digit sector, our sample was reduced to 69 4-digit and 27 3-digit sectors. In addition, we had to drop another 13 4-digit sectors due to missing observations for some countries. Domestic absorption was calculated by subtracting net exports from production. In two sectors (fur dressing and dyeing and manufacturing goods, not elsewhere classified), we obtained large negative numbers for domestic absorption for a number of countries so we dropped those industries. For a few out of the remaining 897 observations, imputed domestic absorption was negative but very small (1-2% of production), and we attributed these negatives to measurement error and reclassified these amounts as zeros. Table 2 reports the 54 4-digit industries that we eventually used in the analysis. As one can see from the table, many of the industries at the 4-digit level, such as carpets and rugs and motor vehicles, have been used as examples of monopolistically competitive industries. Indeed this level of disaggregation is basically the same as the one used by Krugman (1991) to support his hypothesis that geography matters for trade.

Because of data limitations we were forced to measure domestic absorption as a residual. Measuring domestic absorption by using a residual potentially introduces a bias into our sample through the mismeasurement of production. If production is recorded at too high a level for a particular year, that will also tend to cause measured absorption to rise. This creates a simultaneity problem if we use contemporaneous demand. Furthermore, since the spirit of economic geography models is to explore how long-run historical demand deviations affect production, we thought it inappropriate to regress current production on current demand. In order to deal with both of these issues, we decided to use average demand over the period 1970-1975 to identify idiosyncratic components of demand, while other variables in our regressions were values for 1985. We also ran all specifications with demand calculated over the time period 1976-1985 and just 1985 and obtained results qualitatively the same.[9]

Table 3 presents some sample statistics on the data. The first panel presents a correlation matrix of 4-digit output across our sample of countries. The striking feature of this table is that output is always positively correlated within our sample of countries and sometimes the correlation between countries is quite high. This table demonstrates the often expressed notion that OECD countries have a broadly similar production structure. Indeed, this absence of substantial variation in the relative sizes of sectors within countries is often viewed as a *prima facie* case against Heckscher-Ohlin.

Table 3 also reports sample statistics for our consumption variables. The data reveals that there are typically four 4-digit sectors within a 3-digit sector. Furthermore, it appears that absorption distortions are fairly symmetrically distributed around zero in our sample.

Our data on factor endowments came from a number of sources. Country capital stocks were calculated by using a perpetual inventory method using investment and price data from Summers and Heston (1988) and a depreciation rate of 0.133. The rate was chosen to be consistent with earlier studies such as Bowen, Leamer, and Sveikauskas (1987) and Davis, Weinstein *et. al.* (1996). World endowments of labor force by educational level were taken from the UNESCO *Statistical Yearbook*,

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[9] Avinash Dixit pointed out to us a second potential bias in favor of the geography model. One can imagine a variety of reasons why local demand and production structure may positively covary independent of the elements that define economic geography. This would tend to bias our estimates of the home market effect upwards.

and fuel production is equal to the sum of the production of solid fuels, liquid fuels, and natural gas in coal-equivalent units as recorded in United Nations' *Energy Statistics Yearbook*.

4.4 Estimating the Heckscher-Ohlin Production Model

We append an additive error term on the end of equation (2) in order to estimate the Heckscher-Ohlin production equation. Although many authors have regressed trade on a cross section of factor endowments, it is worth noting that as far as we know, no one has directly estimated equation (2) across countries. The closest work in this spirit is that of Harrigan (1995). Harrigan decided not to estimate 2 directly because he was concerned that with 20 countries and 4 factors (in our case we will use 22 countries and 5 factors), he would not have many degrees of freedom. Instead, he estimated equation (2) using time series data with a constant term for each industry and a procedure that allowed the coefficients to vary somewhat over time. Although the time series estimates all had R^2 in excess of 0.9, when he compared the relative magnitudes of the fitted values to the actual outputs, Harrigan found very large predictive errors. In other words, his estimates were largely driven by the time series variation, but had little to say about the between variation. Harrigan therefore concluded that "the [Heckscher-Ohlin] model does not do a particularly good job at explaining cross-country variation in output."

The results were not promising for the Heckscher-Ohlin model, but, as Harrigan noted, it is difficult to assess whether the failure was due to a failure of the theory or simply in the way in which $\boldsymbol{\Omega}$ was allowed to vary over time. Consider the following problem. Suppose productivity or price changes causes the technology matrix to move according to some well-behaved pattern, how would those changes appear in the $\boldsymbol{\Omega}$ matrix? Since the elements of the $\boldsymbol{\Omega}$ matrix are going to be a complex non-linear transformation of the elements of the technology matrix, it would be very surprising if movements in the Ω were also well behaved. We therefore should not be surprised if it is difficult to characterize movements in Ω over time.

Since rigorous application of the theory requires cross-sectional estimation, this is the path we will follow. Even so, we must bear in mind that the theory may fail an F-test and the regression may have a low adjusted R^2 because we are working with few degrees of freedom.

Table 4 presents the results of estimating equation (2) using 3-digit output data. Overall, output seems to be highly correlated with factor endowments with R^2 that are on average 0.90 and in most regressions the coefficients of several of the factors have significant t-statistics indicating that the coefficients can be measured with a reasonable amount of precision. We find the good fits of these regressions quite surprising, especially in light of Harrigan's results. Our results clearly suggest that production patterns are actually extremely highly correlated with factor endowments.

We do not report the coefficients because, beyond their sign, their values are dependent on both the size of the sector and the units used to measure the factor endowments. This makes it very difficult to interpret magnitudes. The coefficient on capital is almost always significant, which indicates that aggregate capital stocks play an important role in the level of manufacturing activity. There does not seem to be much of a pattern to the estimates of the other coefficients. At first glance, this might appear troubling, but a bit more thought suggests that one should not be concerned. First, even if we accept the strong maintained assumption that there are an equal number of industries and factors and hence that our coefficients are Rybczynski derivatives, the coefficients we estimated correspond to elements in the inverse of a technology matrix with a dimension of around thirty. Since it is impossible to infer the coefficients of a high dimension technology matrix from parts of its inverse, we feel that the coefficients cannot be interpreted. Second, if there are more industries than factors, then despite the indeterminacy of the system, it still may be the case that production patterns are correlated with factor endowments, but the coefficients will not necessarily correspond to technological parameters.

These production results are somewhat better than the results that typically obtain when net trade flows are regressed on factor endowments. Leamer (1984), for example, used ten factors and ten industries and obtained an average R^2 of 0.64 on 1975 data. One possible reason for our better fit is that in this sample we have restricted ourselves to only looking at the OECD while other authors, e.g. Leamer (1984), have typically used much broader samples of countries. Core assumptions of the Heckscher-Ohlin model such as identical technologies, factor price equalization, and the absence of barriers to trade are likely to be much closer to the truth for the OECD than for developing countries. Second, it may also be the case that factor endowments predict output better than consumption, causing the production side of the model to work better than the consumption side. Hunter and Markusen (1989) and Hunter (1991) have shown that non-homothetic preferences may be an important factor in explaining trade flows. Since differences in income are likely to be more pronounced in samples that include both the OECD and developing countries, it is possible that the relatively poorer fit in previous studies of trade are due to consumption distortions across countries with very different per capita incomes. On the other hand, the fact that Heckscher-Ohlin is often thought to explain North-South trade more than North-North trade because of the greater differences in factor endowments between developed and developing countries tends to run counter to this second argument.

Oddly enough, the more troubling feature of these results is the very high R^2. We did not expect the HO model to fit cross-sectional data for the OECD this well. The most obvious candidate for a spurious correlation is country size. Our data contains two sorts of variation. The first type of variation is due solely to size factors. Suppose two countries have identical factor proportions, but one country is simply larger than the other. In this case one might obtain very good fits of a regression of output on factor endowments because factor endowments are simply a proxy for country size and country size is proportional to output in each sector. The second type of variation arises solely from factor proportion differences. If two countries had the same GDP but differed only in their relative endowments, it also should be possible to predict output patterns knowing factor endowments. While theoretically both sources of variation should be related in the same way to factor endowments, it would be troubling if size were the only factor driving our results. Indeed, looking at the high correlations of output at the 4-digit level revealed in Table 3, it seems plausible that the first explanation could be driving our results.

Fortunately, this potential problem can be easily resolved. All of the size based variation can be eliminated by forcing θ to equal 2 in our heteroskedasticity correction. This deflates all output and factors by GDP and eliminates all of the size based variation leaving us with only the factor proportion based variation. Table 4A reports the results of industry by industry estimation making this correction. As one might suspect, the size based variation did tend to increase our R^2's, but not by that much. On average, our adjusted R^2's averaged 0.7, which is still quite respectable. We therefore conclude that even when looking only at the purely compositional component of output variation, factors endowments explain a very large share of output within the OECD.

4.5 Testing for the Home Market Effect

The relationships that we seek to test can be portrayed graphically, and it makes sense to look at the data before plunging into the econometrics. Obviously, it is impossible to display a multivariate relationship in a bivariate graph, but we can obtain some sense of the data through the following exercise. If we divide both sides of equation (4') by X^n and then set β_1 equal to 1 and bring the share term over to the left-hand-side, we obtain

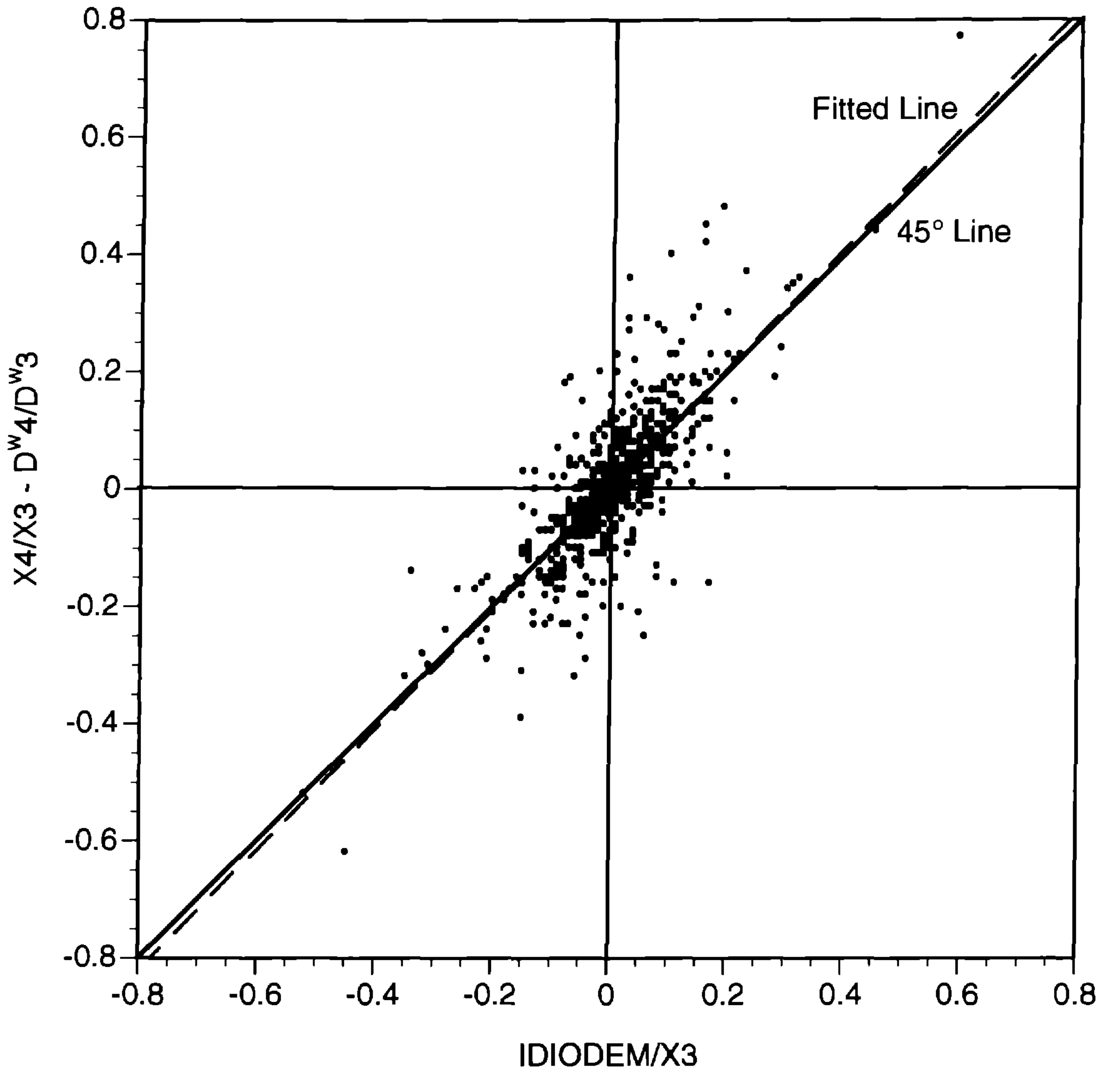
$$\frac{X_g^{nW}}{X^{nc}} - \frac{D_g^{nW}}{D^{nW}} = \frac{\alpha_g^n}{X^{nc}} + \beta_2 \left(\frac{D_g^{nc}}{D^{nc}} - \frac{D_g^{nW}}{D^{nW}} \right) + \epsilon_g^{nc}$$

The left-hand-side represents how much the share of a given 4-digit industry deviates relative to world levels while the term in parentheses tells us of the magnitude of the idiosyncratic demand distortion. Figure 6 presents the results of graphing the left-hand-side of the above equation against the term in parentheses. Plotting the data in this manner enables us to visually examine the various hypotheses that we have been considering. If transportation costs were zero and production was CRS, one would expect to see a scatter of points lying along the horizontal line through zero. In this case, demand distortions would have no impact on production distortions. If the world is CRS but there are transportation costs one would expect the scatter of points to lie somewhere in between the 45° degree line and the horizontal line through zero. Finally, in the world of economic geography, one would expect the points to be scattered along a line with a slope larger than 1 because idiosyncratic demand patterns should have magnified effects on production. The data clearly reject the hypothesis that we are in a frictionless comparative advantage world. The two series are highly

Figure 6

Production Deviation versus Idiosyncratic Demand

(3 and 4-Digit Data)



correlated ($\rho = 0.77$), and the data appears to be distributed along a line with a slope of about one.[10] This seems to suggest that either a weak home market effect or indeterminacy are apparent in these data. We also experimented by plotting the same variables for 2 and 3-digit industries instead of 3 and 4-digit ones. The results displayed in Figure 7 seem to lend support to the view that, at least at this level of aggregation, economic geography effects do not seem important.

Regression analysis confirms the general impression of the data we obtained in Figure 6. Table 6 presents the results of estimating equation 5 under a variety of specifications. In the first panel, we estimate a version of the model in which only geography effects are allowed to operate at the 4-digit level. In this specification, the coefficient on IDIODEM is precisely measured and significantly larger than one, indicating that historical idiosyncratic demand patterns are associated with even larger future production shares. In other words, at the mean, a country that had idiosyncratic demand that was 100% larger than the world share of a given 4-digit good will see its production of that good rise 120%. It is also comforting to note that the coefficient on SHARE is close to one, as one would expect.

We were concerned that this might be the result of FOB prices being lower than CIF prices, so we corrected for this by adding EXPORTD. While the results indicate that being a net exporter is highly correlated with production, it had almost no impact on any of the other point estimates in the regressions. This suggests that our results are not being driven by the fact that countries that produce a lot tend to have lower prices and therefore consume more.

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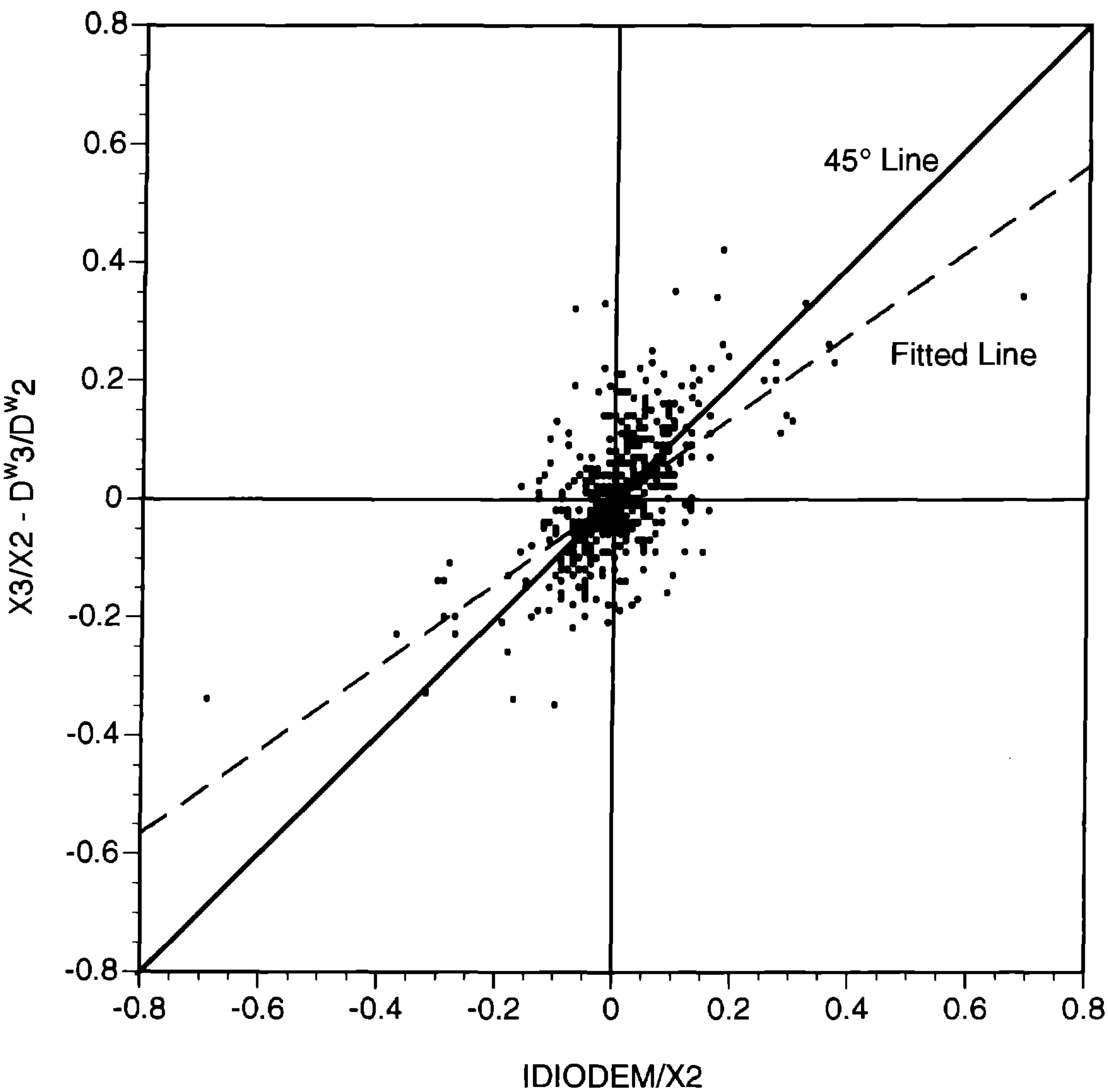
[10] The fitted line has a slope of 1.03 with a standard error of 0.03.

Figure 7

Production Deviation versus Idiosyncratic Demand

(2 and 3-digit Data)



As we have seen in figure 6 and our regression results, economic geography does very well against a null specifying that factor endowments matter at the 3-digit, but not the 4-digit level. However, there is reason to suspect that our results may be driven by an omitted variables bias. Suppose that one's view of the world was that factor endowments mattered at the 4-digit level, i.e. that equation (2'), not equation (2), was the true description of international production. If this were the case, absorption, which contains the demand for intermediate inputs, might be correlated with factor endowments because industrial production (and hence industrial demand for inputs) would be driven by factor endowments. Suppose, for example, the same factors that give countries a comparative advantage in automobile production also give them a comparative advantage in steel production. If we then regressed steel production on steel absorption we would obtain a spurious acceptance of economic geography because the same factors that caused the automobile sector to expand, and therefore demand more steel, would also generate a comparative advantage in steel production.

Clearly a specification test of the type described by equation (4") is warranted. The third and fourth columns of Table 6 perform this experiment. Adding factor endowments to the model causes the point estimate for the coefficient on IDIODEM to drop below one and the coefficient on SHARE becomes insignificant. *In other words, we can formally reject a model of economic geography in favor of a comparative advantage model with transport costs.* We believe that this is the first time that a model of economic geography has ever been rejected by international data using a theoretically rigorous test.

Several caveats are in order. Even in this more general specification, the coefficient on IDIODEM is still much larger than zero. Within the context of the hypothesis tests that we have constructed, our interpretation is either that transportation costs matter or that economies of scale are only present in a subset of OECD manufacturing. There is reason for concern about whether transport costs, which are usually measured to be relatively small, could cause production to rise by 70% as much as idiosyncratic demand. In defense of this estimate, we need to remember that if factor endowments matter, but there still is some indeterminacy in production patterns at the 4-digit level, then it is not surprising to see this sort of correlation. Indeed, McCallum (1995) has found that even apparently small barriers at the border have tremendous impacts on trade flows between the US and Canada.

In considering these results, it is useful to consider one final twist. Krugman (1980) also develops a model with transport costs and two countries, one large and one small. The twist is that he allows for a mix of industries, one subject to increasing and the other to constant returns to scale. His conclusion was that even if the entire increasing returns to scale industry *could* fit into the smaller country, there would be a tendency for this industry instead to locate in the larger country because of the improved market access. That is, when there are a mix of constant and increasing returns sectors, and in contrast to the results of Weder, absolute -- not only relative -- market size may matter.

In applying this insight to our results, one must pay careful attention to the level of aggregation that is being considered. If some (3-digit) industries are increasing and others constant returns to scale, then the coefficient on IDIODEM pooled across industries does not have the structural interpretation that we have given it. Nevertheless, our use of the Weder framework based on relative demand will continue to hold exactly for those industries featuring increasing returns. The reason is that our assumption of Leontief technologies has made the resource constraints industry-specific. This suggests looking at coefficients on individual industry runs.

In order to see if there was a pattern to the magnitudes of the coefficients, we reran equation (4") with factor endowments separately for each industry. The lack of degrees of freedom meant that it was difficult to obtain precise estimates of the coefficients, but even so, as Table 7 demonstrates we were able to reject a coefficient of zero in most industries. This suggests that in most industries demand does have some role on the location of production. Unfortunately for economic geography, however, we only obtained point estimates of larger than one in one third of the sample and could reject a null of 1 for only 1 of 54 industries (one-sided t-test, 95% confidence level). Of course, it must be emphasized that the small number of degrees of freedom make it very difficult to see statistical patterns in this type of analysis. Even if we expand our criteria to only look at industries with point estimates larger than one, there does not seem to be a pattern to the industries that have (insignificant) coefficients larger than one and our priors about which industries are likely to exhibit economies of scale.

There is a second way that a mix of increasing returns and constant returns sectors might complicate our analysis. If (3-digit) industries are themselves a mix of (4-digit) goods, some of which are constant and others increasing returns to scale, then even the coefficients on IDIODEM in the individual industry runs fail to have the structural interpretation we have placed on them. In such a case, the results of Krugman (1980) suggest that countries with absolutely small markets will tend to concentrate on constant returns goods, while those with absolutely large markets will tend to concentrate on increasing returns goods. A rough test of this can be devised based on our earlier examination of output correlations. Since countries like the US and Japan are likely to have much larger domestic markets than countries like Belgium and Holland, one would expect the increasing returns industries to locate in large countries and constant returns industries in small countries. This implies that we should see a negative correlation in industrial composition between large and small countries. However, Table 3 demonstrates that industrial composition is *positively* correlated between every country pair in our sample. This seems very hard to reconcile with absolute market size driving international specialization.

In light of these results, we conclude that while we can detect a weak relationship that is supportive of economic geography in certain specifications, it is not robust to the inclusion of factor endowments. Economic geography does not appear to drive production in OECD manufacturing in general, but, in the most generous interpretation of the data, geography may play some role in the determination of production in as much as a third of all OECD manufacturing sectors.[11]

So far, most of the analysis has focused on trying to identify statistically whether economic geography has an impact on production patterns. However, there is another equally important question surrounding the economic significance of the coefficients. Harking back to Krugman's initial question regarding the importance of increasing returns, we would like to know how sensitive

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[11] Our results also have implications for those who would use restrictive trade policy as an instrument of industrial or export policy. Krugman (1984) has outlined a theoretical link between protection of the home market and increased export penetration abroad. While Krugman's focus was on oligopolistic trade within a single market, others have been less careful, applying these ideas to broader industrial aggregates and even all of manufacturing. The practical question is whether a larger home market (due either to demand idiosyncracies or protection) will be associated with increased exports. A necessary condition for this would be identification of what we have termed the "magnification effect" of demand on production. Our failure to find this effect strongly suggests that the "import protection as export promotion" idea should not be applied to these broad aggregates. It also raises an important question as to how prevalent such effects are generally, even within OECD manufacturing.

production patterns are to demand factors. Following Leamer (1984), we try to ascertain the relative importance of factor endowments and economic geography by examining β coefficients. Let Z denote our matrix of observations for the independent variables and Z^M the same matrix with the entries for only the variable(s) M set equal to their sample means.[12] We define β^M as

$$\beta^M = \sqrt{\frac{\frac{1}{n-1}(\beta Z - \beta Z^M)'(\beta Z - \beta Z^M)}{\sigma_X^2}}$$

In other words, β^M tells us how many standard deviations of the dependent variable can be explained by a one standard deviation movement in the variable(s) M.

There are two ways we can calculate these β^M's. The first is to nest the economic geography models and the factor endowment models and examine how much of the variance at the 4-digit level can be explained by IDIODEM and SHARE relative to factor endowments. The results from this exercise tell us how much of the explainable variance is driven by an economic geography model nested within a factor endowment model relative to a model that postulates that production patterns are always driven by factor endowments. The results from this exercise are as follows:

$$\beta^{Factors} = 0.66$$

$$\beta^{SHARE,\ IDIODEM} = 0.26$$

The β coefficients indicate that a pure factor endowments model explains 2.5 times more of the variance than a combined model with increasing returns at the 4-digit level and factor endowments

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[12] Means were calculated separately for each 4-digit sector.

driving production at the 3-digit level. In other words, a combined economic geography Heckscher-Ohlin model only accounted for about one quarter of the explainable OECD output variation.

To some degree, this experiment overstates the importance of economic geography because much of the variance attributed to the SHARE term is really due to Heckscher-Ohlin operating at the 3-digit level. If we attribute the explanatory power of SHARE to the Heckscher-Ohlin model, we obtain:

$$\beta^{SHARE,\ Factors}=0.87$$

$$\beta^{IDIODEM}=0.13$$

In other words, demand fluctuations only seem to account for around 10% of OECD production patterns at the 4-digit level, with 90% being accounted for by factor endowments. If we believe that part of the effect that has been attributed to economic geography is really due to transportation costs interacting with CRS industries, then this 10% number overstates the role of economic geography. This also puts the results of Figure 6 and the non-nested results into perspective. Deflating the variables in Figure 6 by 3-digit production and allowing production at the 3-digit level to be driven by Heckscher-Ohlin, resulted in virtually all of the production variance being attributed to Heckscher-Ohlin. In other words, even though we can see a pattern in Figure 6, its importance for overall OECD production is small. We therefore conclude that economic geography is not only statistically insignificant, but economically small as well.

5 Conclusion

This paper reports the first tests that nest the trade models of economic geography and Heckscher-Ohlin-Vanek for estimation on international data. The particular model of economic geography which we employ is based on Krugman (1980), and features the "home market" effect. To test this, we select a setting often cited as featuring pervasive increasing returns -- i.e. one we believed *ex ante* to be most propitious for finding the effects of economic geography. Accordingly, our study focuses on explaining the structure of manufacturing production across the OECD.

Our results provide little support for the economic geography model. We find that the structure of OECD manufacturing production is best explained by a model which allows endowments to determine output at all levels. Some indication of "home market" effects appears in the specification in which HOV determines output structure at the 3-digit level, while economic geography does so at the 4-digit level. However these results are not robust. Allowing endowments to matter for production at the 4-digit level eliminates the home market effect. Similarly, a specification in which endowments determined output structure at the 2-digit level, while economic geography determined output at the 3-digit level likewise fails to support the "home market" effect. Moreover, even in the model most supportive of the presence of home market effects, the results suggest that these are of relatively minor importance. Of the explainable variance, endowments account for 90 per cent, and home market effects just 10 per cent. In sum, the big picture is that endowments are the crucial element in understanding the cross-country structure of OECD manufacturing.

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Table 1

Countries in Data Set

Countries Used	No 4-digit data Available
Australia	
Austria	X
Belgium/Lux	
Canada	
Denmark	X
Finland	
France	
Germany	
Greece	X
Ireland	X
Italy	
Japan	
Netherlands	
New Zealand	X
Norway	
Portugal	X
Spain	X
Sweden	
Turkey	X
UK	
USA	
Yugoslavia	X

Table 2

Industries Used in the Analysis

Dropped (X)	ISIC	Industry
	311	Food products
	3111	Slaughtering, preparing and preserving meat
	3112	Dairy products
	3113	Canning and preserving of fruits and vegetables
	3114	Canning, preserving and processing of fish, crustacea and similar foods
	3115	Vegetable and animal oils and fats
	3116	Grain mill products
	3117	Bakery products
X	3118	Sugar factories and refineries
	3119	Cocoa, chocolate and sugar confectionery
	312	Other food products
X	3121	Food products not elsewhere classified
	3122	Prepared animal feeds
	313	Beverage industries
	3131	Distilling, rectifying and blending spirits
X	3132	Wine industries
	3133	Malt liquors and malt
X	3134	Soft drinks and carbonated waters industries
X	314	Tobacco manufactures
	321	Textiles
	3211	Spinning, weaving and finishing textiles
	3212	Made-up textile goods except wearing apparel
	3213	Knitting mills
	3214	Carpets and rugs
	3215	Cordage, rope and twine industries
	3219	Textiles nec
X	322	Wearing apparel, except footwear
	323	Leather and products of leather, leather substitutes and fur, except footwear and wearing apparel
	3231	Tanneries and leather finishing
X	3232	Fur dressing and dyeing industries
	3233	Products of leather and leather substitutes, except footwear and wearing apparel
X	324	Footwear, except vulcanized or molded rubber or plastic footwear
	331	Wood and wood and cork products, except furniture
	3311	Sawmills, planing and other wood mills
	3312	Wooden and cane containers and small cane ware
	3319	Wood and cork products nec
X	332	Furniture and fixtures, except primarily of metal

Table 2 (Continued)

Table 2 (Continued)

Industries Used in the Analysis

Dropped (X)	ISIC	Industry
	341	Paper and paper products
	3411	Pulp, paper and paperboard
	3412	Containers and boxes of paper and paperboard
	3419	Pulp, paper and paperboard articles nec
X	342	Printing, publishing and allied industries
		Plastic Products
	351	Industrial chemicals
	3511	Basic industrial chemicals except fertilizer
	3512	Fertilizers and pesticides
	3513	Synthetic resins, plastic materials and man-made fibers except glass
	352	Other chemical products
	3521	Paints, varnishes and lacquers
	3522	Drugs and medicines
	3523	Soap and cleaning preparations, perfumes, cosmetics and other toilet preps.
	3529	Chemical products nec
X	353	Petroleum refineries
X	354	Miscellaneous products of petroleum and coal
	355	Rubber products
	3551	Tire and tube industries
	3559	Rubber products nec
X	356	Plastic products nec
X	361	Pottery, china and earthenware
X	362	Glass and glass products
	369	Other non-metallic mineral products
	3691	Structural clay products
	3692	Cement, lime and plaster
	3699	Non-metallic mineral products nec
X	371	Iron and steel basic industries
X	372	Non-ferrous metal basic industries

Table 2 (Continued)

Industries Used in the Analysis

Dropped (X)	ISIC	Industry
	381	Fabricated metal products, except machinery and equipment
	3811	Cutlery, hand tools and general hardware
	3812	Furniture and fixtures primarily of metal
	3813	Structural metal products
	3819	Fabricated metal products except machinery and equipment not elsewhere classified
	382	Machinery except electrical
	3821	Engines and turbines
	3823	Agriculture machinery and equipment
	3823	Metal and wood working machinery
	3824	Special industrial machinery and equipment except metal and wood working machinery
	3825	Office, computing and accounting machinery
	3829	Machinery and equipment, except electrical nec
	383	Electrical machinery apparatus, appliance and supplies
	3831	Electrical industrial machinery and apparatus
	3832	Radio, television and communication equipment and apparatus
	3833	Electrical appliances and housewares
	3839	Electrical apparatus and supplies nec
	384	Transport equipment
	3841	Shipbuilding and repairing
X	3842	Railroad equipment
	3843	Motor vehicles
X	3844	Motorcycles and bicycles
X	3845	Aircraft
X	3849	Transport equipment nec
	385	Professional and scientific and measuring and controlling equipment nec, and of photographic and optical goods
	3851	Professional and scientific, and measuring and controlling equipment nec
X	3852	Photographic and optical goods
X	3853	Watches and clocks
X	3901	Jewelry and related articles
X	3902	Musical instruments
X	3903	Sporting and athletic goods
X	3909	Manufacturing industries nec

Table 3

Sample Statistics

Correlation of 4-digit Output by Country (1985)

	CAN	USA	JPN	AUS
CAN	1.00			
USA	0.82	1.00		
JPN	0.76	0.91	1.00	
AUS	0.80	0.77	0.62	1.00
BLX	0.79	0.79	0.76	0.63
FIN	0.51	0.33	0.14	0.36
FRA	0.77	0.88	0.77	0.79
GER	0.83	0.89	0.88	0.70
ITA	0.75	0.78	0.81	0.60
NTH	0.33	0.50	0.32	0.46
NOR	0.40	0.34	0.17	0.45
SWE	0.91	0.82	0.72	0.72
UK	0.62	0.88	0.81	0.64

	BLX	FIN	FRA	GER
BLX	1.00			
FIN	0.20	1.00		
FRA	0.73	0.32	1.00	
GER	0.90	0.16	0.80	1.00
ITA	0.85	0.19	0.77	0.88
NTH	0.53	0.36	0.52	0.38
NOR	0.23	0.65	0.34	0.20
SWE	0.64	0.69	0.74	0.73
UK	0.75	0.24	0.84	0.81

	ITA	NTH	NOR	SWE
ITA	1.00			
NTH	0.44	1.00		
NOR	0.19	0.49	1.00	
SWE	0.61	0.32	0.50	1.00
UK	0.73	0.60	0.29	0.66

Table 3 (Continued)

Sample Statistics

Variable	Mean	Std Dev	Minimum	Maximum
IDIODEM/X3	0.01	0.11	-0.59	0.61
SHARE/X3	0.27	0.21	0.01	0.87
CAP85	1155980000	1590040000	112748000	5714800000
LABOR85	20763	23547	1796	79190
EDUC85	5287	10145	243	37610
LAND85	26480	51487	771	189799
FUEL85	239358	520333	22	1935810
RGDP85	709383000	1054510000	59084700	3962220000

Table 4

3-Digit Production Regressed on Factor Endowments
(22 Countries, Heteroskedasticity Corrected Estimates)

	t-statistics						$F_{.01,5,16}$ = 4.4	
	Constant	Capital	Labor	Education	Land	Fuel	*F*-Statistic	Adjusted R^2
Food Products	3.7	5.0	-2.0	1.0	.1	1.1	46.9	0.94
Other food	.0	3.3	-1.2	-.1	-.1	-2.3	24.9	0.91
Beverages	-.6	4.2	.2	-.7	-1.4	2.0	50.9	0.92
Tobacco	-1.0	2.8	1.4	-1.8	-1.8	2.7	23.2	0.88
Textiles	-.6	6.7	-.2	-.1	-.2	.7	214.7	0.98
Apparel	-.8	9.0	-2.5	-.3	.4	3.7	560.8	0.99
Leather Goods	.1	4.8	-.3	-2.4	.8	-.4	17.3	0.79
Footwear	.5	3.6	-.3	-1.8	1.0	-.8	8.0	0.71
Wood and Wood Products	1.9	2.8	-1.9	1.8	.3	-.1	31.2	0.88
Furniture and Fixtures	1.7	3.4	1.2	1.9	-1.7	.3	138.5	0.97
Paper and Paper Products	1.0	3.0	-2.3	1.8	-.5	1.4	58.8	0.93
Printing and Publishing	-.1	3.5	-1.0	.7	-1.0	2.7	63.5	0.94
Industrial Chemicals	-.8	5.8	.4	2.2	-4.6	3.3	186.0	0.98
Other Chemical Products	-1.7	5.7	-.8	2.2	-2.7	2.2	160.4	0.97
Petroleum Refining	-.8	4.4	-2.4	.5	-.1	2.7	143.0	0.97

Table 4 (Continued)

3-Digit Production Regressed on Factor Endowments
(22 Countries, Heteroskedasticity Corrected Estimates)

	t-statistics							
	Constant	Capital	Labor	Education	Land	Fuel	*F*-Statistic	Adjusted R^2
Misc. Petroleum and Coal Prods.	-.5	2.0	.5	.4	-1.5	1.0	22.1	0.85
Rubber Prods.	-2.0	9.8	-2.1	.3	-.4	1.0	354.5	0.99
Plastic Prods. NEC	-1.1	4.9	-1.7	.2	-.7	-.2	33.1	0.88
Pottery, china	-.8	4.1	.2	-2.6	-.3	-.1	10.6	0.69
Glass and glass	-1.3	10.8	-1.2	2.0	-1.8	2.0	1707.3	1.00
Other Non-Metallic Min. Prods	.6	5.2	-1.1	-.5	.1	-.7	26.6	0.89
Iron and steel	-2.3	5.2	-.2	-.4	-.8	-.7	24.2	0.85
Non-ferrous Metals	-.5	6.5	-3.0	.7	1.5	2.0	101.0	0.96
Fabricated Metal Prods.	-.5	4.0	-1.1	2.7	-1.4	.1	68.6	0.94
Machinery	-1.5	6.6	-.9	3.1	-3.7	1.5	249.7	0.98
Electrical Machinery	-1.3	5.0	-1.3	.4	-1.7	-.1	40.6	0.90
Transportation Equipment	-2.0	6.8	-1.8	3.7	-1.8	-.8	176.1	0.98
Professional & Scientific Equip.	-1.4	2.9	-.7	2.1	-2.1	.1	39.1	0.90

Table 4a

3-Digit Production Regressed on Factor Endowments
(22 Countries, All Data Deflated by GDP)

	t-statistics						$F_{.01,5,16}$ = 4.4	
	Constant	Capital	Labor	Education	Land	Fuel	*F*-Statistic	Adjusted R^2
Food Products	5.745	3.164	-1.659	0.762	-0.095	-0.538	7.62	0.6117
Other food	0.037	1.391	-0.156	0.242	-1.499	1.006	4.27	0.5764
Beverages	0.805	3.009	-0.692	0.074	-0.235	-0.158	6.82	0.5807
Tobacco	-0.478	1.232	1.668	-0.247	-0.734	0.771	4.75	0.4719
Textiles	1.076	2.415	1.968	-0.427	-0.016	-1.692	10.78	0.6995
Apparel	0.659	4.179	-1.091	0.335	0.640	-1.727	13.87	0.7539
Leather Goods	0.983	2.995	-0.321	-0.681	0.630	-1.855	5.58	0.5216
Footwear	0.234	3.756	-0.594	-1.655	0.865	-2.063	6.35	0.5603
Wood and Wood Products	1.053	1.857	-1.175	0.907	-0.023	0.229	4.18	0.4307
Furniture and Fixtures	2.163	1.784	-0.407	0.954	-0.078	-1.167	3.95	0.4123
Paper and Paper Products	0.436	1.865	-1.297	0.375	-0.134	-0.683	1.93	0.1816
Printing and Publishing	0.457	3.974	-0.792	-0.156	-0.616	0.909	12.77	0.7371
Industrial Chemicals	-0.821	3.282	0.053	0.733	-2.433	1.001	11.79	0.7199
Other Chemical Products	-2.806	4.345	-0.880	1.069	-1.768	-0.370	16.22	0.7838
Petroleum Refining	-1.786	2.749	0.615	0.076	-1.041	1.037	9.90	0.6793

Table 4a (Continued)

3-Digit Production Regressed on Factor Endowments (22 Countries, All Data Deflated by GDP)

	t-statistics							
	Constant	Capital	Labor	Education	Land	Fuel	*F*-Statistic	Adjusted R^2
Misc. Petroleum and Coal Prods	-0.475	0.767	2.268	1.556	-2.145	0.867	6.99	0.6118
Rubber Prods.	-1.905	4.612	-0.390	0.743	-0.284	-1.839	19.82	0.8175
Plastic Prods. NEC	-0.730	3.747	-1.067	0.344	-0.370	-0.578	10.23	0.6873
Pottery, china	-0.177	3.134	0.239	-1.353	-0.479	-1.469	5.10	0.4942
Glass and Glass Prods	0.498	3.558	0.034	0.126	-1.071	-1.163	9.82	0.6774
Other Non-Metallic Min. Prods	1.864	5.131	-1.326	-1.430	0.752	-1.364	12.81	0.7377
Iron and steel	-3.038	4.916	-0.394	-0.406	-0.621	-1.091	16.56	0.7875
Non-ferrous Metals	-1.758	4.733	-1.998	-0.787	1.152	3.545	24.97	0.8509
Fabricated Metal Prods	-0.635	4.213	-1.255	1.850	-0.782	-0.984	19.27	0.8130
Machinery	-1.435	4.160	-0.601	2.028	-2.857	-0.158	19.55	0.8154
Electrical Machinery	-2.053	4.579	-0.631	0.507	-1.990	-1.025	14.75	0.7660
Transportation Equipment	-3.146	3.667	-0.531	2.830	-1.837	-0.584	21.83	0.8322
Professional & Scientific Equip.	-0.908	1.411	-0.091	2.136	-1.890	-0.643	5.14	0.4962
Other Manufacturing Industries	-0.918	3.054	-1.494	2.233	-0.923	-1.023	11.77	0.7194

Table 5

Results of 4-digit Output Regressions on Factor Endowments

(NOBS = 13)

Ind.	F-Stat	R2	Adj. R2	Ind.	F-Stat	R2	Adj. R2
3111	25.7	0.948	0.912				
3112	37.7	0.964	0.939	**3821**	335	0.996	0.993
3113	1580	0.999	0.998	**3822**	38.6	0.965	0.940
3114	2.86	0.671	0.437	**3823**	143	0.990	0.983
3115	142	0.990	0.983	**3824**	628	0.998	0.996
3116	101	0.986	0.976	**3825**	517	0.997	0.995
3117	47.3	0.971	0.951	**3829**	121	0.989	0.980
3118				**3831**	49.0	0.972	0.952
3119	1396	0.999	0.998	**3832**	24.7	0.946	0.908
3121				**3833**	12.6	0.900	0.829
3122	509	0.997	0.995	**3839**	346	0.996	0.993
3131	4.30	0.754	0.579	**3841**	51.9	0.974	0.955
3132				**3842**			
3133	25.0	0.947	0.909	**3843**	45.7	0.970	0.949
3134				**3844**			
3211	60.0	0.977	0.961	**3845**			
3212	858	0.998	0.997	**3849**			
3213	349	0.996	0.993	**3851**	780	0.998	0.997
3214	392	0.996	0.994				
3215	3.73	0.727	0.532				
3219	9.33	0.870	0.776				
3231	2.74	0.662	0.420				
3232							
3233	75.2	0.982	0.969				
3311	28.5	0.953	0.920				
3312	1207	0.999	0.998				
3319	7.97	0.851	0.744				
3411	599	0.998	0.996				
3412	3830	0.999	0.999				
3419	1244	0.999	0.998				
3511	1727	0.999	0.999				
3512	79.2	0.983	0.970				
3513	34.3	0.961	0.933				
3521	899	0.998	0.997				
3522	424	0.997	0.994				
3523	195	0.993	0.988				
3529	62.2	0.978	0.962				
3551	125	0.989	0.981				
3559	437	0.997	0.995				
3691	17.6	0.926	0.874				
3692	19.1	0.932	0.883				
3699	10.2	0.880	0.794				
3811	71.2	0.981	0.967				
3812	134	0.990	0.982				
3813	8.68	0.861	0.762				
3819	124	0.989	0.981				

Table 6

Seemingly Unrelated Regression Results

Dependent Variable is 4-Digit Production

	1	2	3	4
IDIODEM	1.229	1.229	0.712	0.725
	0.005	0.005	0.033	0.033
SHARE	1.103	1.161	0.259	0.478
	0.002	0.004	0.198	0.199
EXPORTD		-0.088		0.211
		0.004		0.025
FACTORS	No	No	Yes	Yes

(Standard errors are below estimates)

Table 7

Equation by Equation Estimation of Nested Model (Std. Errs. below estimates)

Ind	F-Stat	R2	Adj.R2	IDIODEM	SHARE
3111	64.7	0.989	0.974	0.857	0.702
				0.332	2.09
3112	65.8	0.989	0.974	1.59	-7.34
				0.808	8.56
3113	12397	0.999	0.999	0.508	-1.69
				0.092	0.555
3114	265	0.997	0.994	1.17	1.12
				0.166	1.17
3115	481	0.999	0.996	1.29	12.8
				0.293	5.80
3116	290	0.998	0.994	1.42	-0.584
				0.356	6.21
3117	295	0.998	0.994	0.918	2.05
				0.198	1.22
3118					
3119	1037	0.999	0.998	-0.472	-2.40
				0.315	1.77
3121					
3122	768	0.999	0.998	0.063	-3.75
				0.135	1.49
3131	5.0	0.875	0.701	0.005	-4.78
				1.38	5.67
3132					
3133	41.0	0.983	0.959	1.98	13.2
				0.659	9.02
3134					
3211	107	0.993	0.984	3.56	12.8
				1.34	3.85
3212	11681	0.999	0.999	4.09	8.25
				0.367	0.739
3213	213	0.997	0.992	-0.961	-23.9
				2.35	36.8

Ind	F-Stat	R2	Adj.R2	IDIODEM	SHARE
3214	275	0.997	0.994	1.22	1.53
				1.04	3.51
3215	13.6	0.950	0.880	0.257	-3.89
				0.415	2.91
3219	34.6	0.980	0.951	0.676	-1.80
				0.366	2.24
3231	188	0.996	0.991	1.16	-18.0
				0.410	4.72
3232					
3233	69.2	0.990	0.975	0.767	6.30
				0.472	5.31
3311	33.3	0.979	0.950	6.60	47.9
				4.42	19.4
3312	1061	0.999	0.998	-0.124	-2.12
				0.101	1.11
3319	110	0.994	0.985	0.292	-12.1
				0.351	2.32
3411	531	0.999	0.997	0.436	-16.8
				2.73	11.0
3412	2364	0.999	0.999	0.258	-0.827
				0.401	2.16
3419	2064	0.999	0.999	1.54	5.01
				0.580	9.46
3511	895	0.999	0.998	0.255	0.124
				4.45	16.3
3512	166	0.996	0.990	0.676	5.11
				0.211	2.72
3513	22.5	0.969	0.926	1.01	7.15
				0.902	6.37
3521	1606	0.999	0.999	0.896	6.17
				0.260	3.27
3522	219	0.997	0.992	-0.580	-2.01
				3.09	9.13

Table 7

Equation by Equation Estimation of Nested Model (Std. Errs. below estimates)

Ind	F-Stat	R2	Adj.R2	IDIODEM	SHARE
3523	116	0.994	0.985	-4.39	-49.8
				4.89	59.5
3529	99.0	0.993	0.983	1.51	1.60
				0.945	2.88
3551	73.9	0.992	0.979	1.03	4.66
				0.760	4.31
3559	761	0.999	0.998	2.27	9.87
				0.807	4.69
3691	13.2	0.949	0.876	-0.412	-1.29
				0.282	2.52
3692	9.9	0.933	0.838	-0.187	-0.917
				0.793	7.10
3699	11.9	0.943	0.864	1.28	-3.56
				0.810	5.20
3811	48.2	0.985	0.965	-0.647	-8.16
				0.656	6.89
3812	538	0.999	0.997	-0.330	-5.59
				0.174	1.28
3813	7.6	0.914	0.795	0.585	-0.642
				0.615	3.08
3819	95.0	0.993	0.982	0.997	5.14
				0.682	4.22
3821	210	0.997	0.992	0.010	-3.39
				0.264	4.07
3822	35.4	0.980	0.953	1.04	1.76
				0.946	4.75
3823	336	0.998	0.995	-1.59	-27.1
				0.862	8.75
3824	475	0.999	0.996	0.497	-0.314
				0.338	3.00
3825	370	0.998	0.995	-1.20	0.017
				1.83	13.4
3829	574	0.999	0.997	2.11	12.8
				0.644	8.96
3831	26.8	0.974	0.938	-0.344	-.0493
				0.701	4.89
3832	49.5	0.986	0.966	4.53	1.22
				8.42	6.24
3833	16.9	0.959	0.902	-0.633	-3.83
				0.744	1.90
3839	355	0.998	0.995	0.387	3.82
				0.904	3.13
3841	72.2	0.990	0.977	0.937	1.28
				0.481	1.34
3843	120	0.994	0.986	2.64	-20.9
				3.04	43.5
3851	928	0.999	0.998	1.20	9.62
				1.19	4.27