Essays in International Trade

by

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Abstract

This thesis is a collection of essays on the effect of trade costs on international trade. Chapter 1 derives and empirically examines how factor proportions determine the structure of commodity trade when international trade is costly. It combines a many-country version of the Heckscher-Ohlin model with a continuum of goods developed by Dornbusch-Fischer-Samuelson (1980) with the Krugman (1980) model of monopolistic competition and transport costs. The commodity structure of production and bilateral trade is fully determined. Two main predictions emerge. There is a quasi-Heckscher-Ohlin prediction. Countries capture larger shares of industries that more intensively use their abundant factor. There is a quasi-Rybczynski effect. Countries that rapidly accumulate a factor see their production and export structures systematically move towards industries that intensively use that factor. Both predictions receive support from the data. Factor proportions appear to be an important determinant of the structure of international trade.

Chapter 2 focuses on the effect of preferential tariff liberalization on the direction of trade and suggests that NAFTA has had a substantial impact on North American trade. The chapter focuses on where the US sources its imports of different commodities from. It identifies the impact of NAFTA by exploiting the substantial cross-commodity variation in the tariff preference given to goods produced in Canada and Mexico. Canada and Mexico have greatly increased their share of US imports of commodities for which they enjoy a tariff preference. For commodities where no preference is given, Canada's share has declined while Mexico's has increased much more modestly. The empirical results suggest that Canada's share of US imports may have declined without NAFTA, rather than increased, while the growth in Mexico's share of US imports would have been much slower. Useful products of the empirical work are estimates of consumer willingness to substitute between different varieties of the same commodity. The estimated average elasticities of substitution range from 5 to 7.

Chapter 3 examines the effect of international trade costs on the volume of trade. It extends the model in Chapter 1 to allow trade costs to vary by country and commodities. An arbitrary country imports more commodities from countries where bilateral trade costs are lower, and imports more from larger countries. It also sources specific commodities disproportionately from trading partners that possess in relative abundance the productive factors that are used relatively intensively in the production of that commodity. Useful products of the empirical examination are estimates of the willingness to substitute between different varieties of goods within an industry. The implied elasticities of substitution are mostly high, typically ranging between 6 and 16. With such high elasticities of substitution, small costs to international trade will sharply reduce trade volumes.

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Chapter 1

Factor Proportions and the Structure of Commodity Trade

Summary 1 *Chapter 1 derives and empirically examines how factor proportions determine the structure of commodity trade when international trade is costly. It combines a many-country version of the Heckscher-Ohlin model with a continuum of goods developed by Dornbusch-Fischer-Samuelson (1980) with the Krugman (1980) model of monopolistic competition and transport costs. The commodity structure of production and bilateral trade is fully determined. Two main predictions emerge. There is a quasi-Heckscher-Ohlin prediction. Countries capture larger shares of industries that more intensively use their abundant factor. There is a quasi-Rybczynski effect. Countries that rapidly accumulate a factor see their production and export structures systematically move towards industries that intensively use that factor. Both predictions receive support from the data. Factor proportions appear to be an important determinant of the structure of international trade.*

1.1 Introduction

The Heckscher-Ohlin model is one of the pillars of international trade theory. The insight that commodity trade embodies factor services is a profound one, underpinning important theorems relating factor abundance, factor prices, product prices, production and trade. Predictions for the commodity structure of production and trade are, however, limited. This paper seeks to extend our understanding of the effect of factor proportions on the commodity structure of production and trade. It develops a model where the structure of production and bilateral trade is completely determined. The model is a combination of the Dornbusch-Fischer-Samuelson (1980) model with a continuum of goods and the Krugman (1980) model of monopolistic competition and transport costs. Two important predictions emerge. Countries capture larger shares of world production and trade in commodities that more intensively use their abundant factor. This is the quasi-Heckscher-Ohlin prediction of the model. Countries that rapidly accumulate a factor will see their production and export structure move towards commodities that more intensively use that factor. This is the model's quasi-Rybczynski effect.

The quasi-Heckscher-Ohlin prediction is examined using detailed bilateral trade data for the US. The prediction receives strong support from the data. Countries that are abundant in skilled labor and capital do capture larger market shares in industries that intensively use those factors. The effect is particularly pronounced for skilled labor. Figure 1 gives an example using Germany and Bangladesh. Germany, where the average adult has in excess of ten years of formal education, captures large shares of US imports of skill-intensive commodities, and much smaller shares for commodities that sparingly use skilled labor. Bangladesh, where the average adult has just two and a half years of formal education, exhibits the opposite trade pattern, with exports concentrated in commodities that require little skilled labor.

The quasi-Rybczynski effect also receives support from the data. Rapidly growing countries have seen their export structure change towards more skill and capital intensive industries. This effect is illustrated in Figure 2 for the case of the 'miracle' economies of East Asia; Singapore, Hong Kong, Taiwan and Korea. Their rapid accumulation of human and physical capital has not simply led to more skill intensive and capital intensive production of the same goods, with a consequent reduction in marginal products. Instead, ability to trade has allowed them to shift production to more skill and capital intensive industries. As noted by Ventura (1997), this process is a critical feature of their growth experience. The Rybczynski effect helps countries avoid diminishing returns, and sustain high growth rates.

This paper relates to an old literature that found hints that factor proportions were a determinant of the commodity structure of international trade. Keesing (1966) calculated simple correlations of US export performance with skill intensities. The largest positive correlations occurred at the highest skill levels, while export performance was negatively correlated with the unskilled labor share. Regressions by Baldwin (1971) suggested that US net exports were negatively related to capital intensity and positively related to shares of some types of skilled labor. Wright (1990) ran regressions for six time periods from 1879 to 1940 to search for sources of US export success. The US tended to export capital intensive goods in the early periods, but capital intensity became a source of comparative disadvantage by 1940.[1] The problem that rendered cross-commodity comparisons unfashionable was that they had an unclear theoretical foundation. This argument was forcefully made in a number of studies by Leamer, who demonstrated that export performance did not depend on the input characteristics of the industry.[2] In this paper, I demonstrate in a more general Heckscher-Ohlin model that, conditional on factor endowments, export performance is determined by industry input characteristics.

This paper is also related to the factor content of trade studies that examine a similar implication of the Heckscher-Ohlin model; that a country's net trade embodies the services of its abundant factors. The first factor content study was Leontief (1953), who found that US imports were more capital intensive relative to labor than US exports, contrary to expectation. A number of studies surveyed in Leamer (1984) followed Leontief's approach. But Leamer used Vanek's (1968) equations to establish that in a multi-factor world these studies also lack adequate theoretical foundation. Factor content studies since then increasingly tended to be multi-country studies firmly based on the Heckscher-Ohlin-Vanek (HOV) theorem equating factors embodied in net trade to excess factor endowments. These studies use impressive data sets on exports, imports, factor endowments and technology for a large number of countries. Early studies based on HOV performed poorly. Bowen, Leamer and Sveikauskas (1987) used 1967 data on 12 factors and 27 countries. They tested sign and rank propositions derived from the HOV theorem, but found, at best, only modest support for the factor proportions model. Trefler's (1993, 1995) examination of 1983 data on 10 factors and 33 countries accounting for 76% of world exports found zero factor content in net trade.

[1] These results are from brief surveys by Leamer (1984) and Leamer and Levinsohn (1995).
[2] See, for example, Leamer and Levinsohn (1995).

Subsequent work by Davis, Weinstein, Bradford and Shimpo (1997), Davis and Weinstein (1998a, 2000), and Wolfson (1999) have shed light on why the early work failed to find factor content. A key explanation is that countries appear to use different production techniques. Early studies assumed that all countries used the same techniques, and estimated these using US input-output matrices. Examination of input-output matrices for other countries show that countries do use different techniques, and that these differences reflect factor endowment differences. Under these conditions, factor content studies that use a common technology matrix will systematically understate actual factor content. Davis and Weinstein (2000) show that for a sample of 10 wealthy countries, use of actual technology matrices lifts estimates of net factor content of trade to typically 10 to 12 percent of national endowments, and to a substantial 38 to 49 percent of endowments devoted to tradeables. The other important explanation for the early failure to find factor content is an apparent 'bias' in consumption towards locally produced goods.

The use of different production techniques is very interesting because it suggests that there may be a failure of FPE. Repetto and Ventura (1998) confirm that there is a failure of FPE. Factor prices differ systematically across countries even after controlling for productivity differences. Locally abundant factors have lower prices. The failure of FPE can be accommodated by factor content studies by use of a multi-cone Heckscher-Ohlin model. Without a more precise model, empirical implementation is limited by access to input-output tables. Although these tables are becoming available for more countries, they are arguably not the highest quality economic data available. But the failure of FPE provides us with another opportunity, because without FPE, the commodity structure of production and trade is determined, and commodity trade data is some of the best and most abundant data we have. There is an opportunity to explore just how pervasive the effect of factor proportions is on the structure of international trade.

There are many ways to generate a failure of FPE in a Heckscher-Ohlin world. One way is to assume that factor proportions are sufficiently different that they are outside the FPE set. Another way is to introduce costs to international trade, which could have a strong effect on trade volume.[3] This paper takes the second route. It commences by generalizing the Heckscher-Ohlin model, and by exploring the effects of these generalizations on trade structure. The starting point is a many-country version of the Heckscher-Ohlin model with a continuum of goods developed by Dornbusch-Fischer-Samuelson (1980). I combine this with the Krugman (1980) model of intraindustry trade generated by economies of scale and product differentiation. Finally, I add transport costs. The traditional Heckscher-Ohlin model can be seen as a limiting case of this model with zero transport costs and perfect competition. The generalizations are made to obtain predictions of the factor proportions model in all commodity markets, so that its performance can be assessed using the very detailed trade data that Leamer and Levinsohn (1995) claim has been "measured with greater accuracy over longer periods of time than most other economic phenomena".

Predictions of the factor proportions model in commodity markets are primarily driven by the deviation from FPE caused by the transport cost. Monopolistic competition smooths some of the hard edges of the perfectly competitive model and determines bilateral trade.[4] In this model, the transport cost causes locally abundant factors to be relatively cheap. The location decisions of industries are affected by factor costs, so that countries tend to attract industries that intensively use their abundant factor. The model also predicts some of the technology and demand modifications needed by the empirical factor content studies to make the Heckscher-Ohlin model fit the data. Every industry substitutes towards the relatively cheap, locally abundant factor. Consumers also substitute towards cheaper local varieties.

The closest theoretical papers to this are due to Deardorff (1998) and Helpman and Krugman.[5] The closest empirical papers are Davis and Weinstein (1998b) and Petri (1991). Deardorff introduces trade impediments to a Heckscher-Ohlin model to determine bilateral trade volumes. Davis and Weinstein use Helpman's and Krugman's theory to find evidence that increasing returns help determine the structure of production and trade. Petri's study of Japanese

[3]See McCallum (1995), Helliwell (1999) and Parsley and Wei (2000) for the effects of borders on trade volumes.

[4]Bilateral trade in general is not determined in the perfectly competitive model, unless no two countries have the same factor prices. The simple form of imperfect competition considered in this paper determines bilateral trade even when some countries have the same factor prices.

[5]See, for example, Helpman and Krugman (1985) for models with imperfect competition and more than one factor.

trading patterns identifies cross-commodity regressions by relaxing the FPE assumption and by assuming that home goods are imperfect substitutes for imports. This paper goes further, it explicitly connects departures from FPE to factor abundance in a general equilibrium model with a continuum of goods, and uses the implications of that departure to examine the relationship between factor abundance and trade structure using detailed commodity trade data.

The paper is organized as follows. Section 2 develops the model. Section 3 examines the quasi-Heckscher-Ohlin effect. Section 4 examines the quasi-Rybczynski effect. Section 5 concludes.

1.2 The Model

A. Model Description

The model commences with a many-country version of the Heckscher-Ohlin model with a continuum of goods. Countries differ in their relative factor abundance. Factor proportions will be one force generating international trade. I combine this with the Krugman (1980) model of intraindustry trade driven by scale economies and product differentiation. Scale economies are the second force generating international trade. Finally I add 'iceberg' transport costs. The transport costs will determine the commodity structure of production and trade by generating a departure from FPE. The model assumptions are set out in detail below.

1. There are $2M$ countries, M each in the North and South. Southern variables, where needed, are marked with an asterisk.

2. There are two factors of production supplied inelastically; skilled labor and unskilled labor earning factor rewards s and w respectively. The total labor supply is 1. The proportion of skilled labor is denoted by β. Northern countries are relatively abundant in skilled labor; $\beta > \beta^*$. A third factor capital is considered at the end of this Section.

3. There is a continuum of industries z on the interval [0,1]. The index z ends up playing a dual role in the paper, because below z will also be used to rank industries by factor intensity. Industries with higher z are more skill intensive.

4. All consumers in all countries are assumed to have identical Cobb-Douglas preferences with the function of income spent on industry z being $b(z)$ (Equation 1). Expenditure shares for each industry are therefore constant for all prices and incomes. All income is spent so the integral of $b(z)$ over the interval [0,1] is 1 (Equation 2).

$$U = \int_0^1 b(z) \ln Q(z) dz. \tag{1.1}$$

$$\int_0^1 b(z) dz = 1. \tag{1.2}$$

5. Monopolistic competition. In the traditional model each industry z produces a homogeneous good. In this model, there are economies of scale in production and firms can costlessly differentiate their products. The output of each industry consists of a number of varieties that are imperfect substitutes for one another. The quantity of variety i in industry z is denoted by $q(z,i)$. $N(z)$ is the endogenously determined number of varieties in industry z:

$$N(z) = n(z) + n^*(z). \tag{1.3}$$

As z is no longer a homogeneous good, $Q(z)$ can be interpreted as a sub-utility function that depends on the quantity of each variety of z consumed. I choose the symmetric CES function with elasticity of substitution greater than 1:

$$Q(z) = \left(\int_0^{N(z)} q(z,i)^\theta di \right)^{\frac{1}{\theta}}, \qquad \theta \in (0,1]. \tag{1.4}$$

Production technology, represented by a total cost function TC, is assumed to be identical Cobb-Douglas in all countries, but there is a fixed cost equal to α units of production:

$$TC(q(z,i)) = s^z w^{1-z}(\alpha + q(z,i)) \tag{1.5}$$

Average costs of production decline at all levels of output, although at a decreasing rate. This cost function has the convenience of generating factor shares that do not depend on factor rewards. The total cost function also gives the dual role for the index z, because z denotes both the industry *and* skilled labor's share of income in that industry. Finally, there is free entry into each industry, so in equilibrium profits are zero.

6. Costly international trade. There may be a transport cost for international trade. To avoid the need to model a separate transport sector, transport costs are introduced in the convenient but special iceberg form: τ units of a good must be shipped for 1 unit to arrive in any other country ($\tau \geq 1$).

B. Equilibrium in an Industry

In general equilibrium consumers maximize utility, firms maximize profits, all factors are fully employed and trade is balanced. The model solution proceeds in two steps. The first step is to solve for the partial equilibrium in an arbitrary industry. In particular, I solve for the share of world production that each country commands, conditional on relative production costs. I show that countries with lower costs capture larger market shares. The next step is to show that in general equilibrium, locally abundant factors are relatively cheap. Skilled labor is relatively cheap in the North, and unskilled labor is relatively cheap in the South. The North becomes the low-cost producer of skill-intensive goods, and commands larger shares of these industries. The South is the low-cost producer of low-skill goods, and produces relatively more of these.

The properties of the model's demand structure have been analyzed in Helpman and Krugman (1985).[6] Firstly, we need four additional pieces of notation. Denote the (constant) elasticity of substitution between varieties within an industry by $\sigma = \frac{1}{1-\theta}$; let $\widehat{p}(z,i)$ be the price paid by consumers, inclusive of transport costs, for variety i in industry z, let $I(z)$ be the set of all varieties in industry z, and let national income be $Y = s\beta + w(1-\beta)$. Maximization of $Q(z)$ conditional on expenditure $E(z)$ yields the following demand functions:

$$q(z,i)^D = \frac{\widehat{p}(z,i)^{-\sigma}}{\int_{i' \in I(z)} \widehat{p}(z,i)^{1-\sigma}\, di'} E(z); \qquad i \in I(z). \tag{1.6}$$

A firm's share of industry revenues depends on its own price and on the prices set by all other firms in that industry. It is convenient to define the ideal price index $G(z)$:

$$G(z) = \left[\int_{i \in I(z)} \widehat{p}(z,i)^{1-\sigma}\, di\right]^{\frac{1}{1-\sigma}} \tag{1.7}$$

Due to the unit elasticity of substitution between industries, a constant function of income $b(z)$ is spent on industry z in every country. An individual Northern firm sets a single factory gate price of p. Its products sell in its own domestic market at p, but in the $M-1$ other Northern markets and the M Southern markets the transport cost raises the price to $p\tau$. The ideal industry price index G is given in Equation 8. G^* is symmetric. Implicit in these indices is the assumption that in equilibrium all Northern countries are alike and all Southern countries are alike. Except where needed, the 'z' notation is suppressed.

$$G = \left[np^{1-\sigma} + (M-1)\, n\, (p\tau)^{1-\sigma} + Mn^* \,(p^*\tau)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{1.8}$$

The revenues of a typical Northern firm are given by Equation 9. The three terms reflect revenues in its domestic market, the $M-1$ other Northern markets and the M Southern

[6]See Sections 6.1, 6.2 and 10.4 in particular.

markets. The equivalent Southern expression is symmetric.

$$pq = bY\left(\frac{p}{G}\right)^{1-\sigma} + (M-1)\,bY\left(\frac{p\tau}{G}\right)^{1-\sigma} + MbY^*\left(\frac{p\tau}{G^*}\right)^{1-\sigma}. \tag{1.9}$$

The production and trade structure has also been studied in Helpman and Krugman (1985).[7] Each firm produces a different variety of the product. Each country, if it produces in the industry at all, produces different varieties. Every variety is demanded in every country. Profit maximizing firms perceive a demand curve that has a constant elasticity, and therefore set price at a constant markup over marginal cost:[8]

$$p(z) = \frac{\sigma}{\sigma-1} s^z w^{1-z} \tag{1.10}$$

With free entry, profits are zero in equilibrium. The pricing rule, the zero profit condition and the special form of the fixed cost produce an equilibrium where all firms produce the same quantity of output:

$$q = q^* = \alpha(\sigma - 1). \tag{1.11}$$

We now have everything we need to solve for the partial equilibrium in this industry. Notation is simplified by defining world income $W = M\,(Y + Y^*)$, the relative price of Northern goods $\widetilde{p} = \frac{p}{p^*}$ and the expression $F = 1 + (M-1)\,\tau^{1-\sigma}$.[9] Conditional on relative prices, Equations 8 and 9 contain four equations in four unknowns n, n^*, G and G^*. These equations may not have positive solutions for both n and n^*. If they do not, the solution for n and n^* will

[7] See Chapter 7.

[8] The demand curve faced by a firm has a constant elasticity if the set of varieties is of non-zero measure.

[9] F is the quantity of goods a Northern firm sells in all Northern markets divided by its domestic sales; $F > M\tau^{1-\sigma}$.

either be Equation 12 or Equation 13. If $\widetilde{p}$ is low then Equation 12 is the solution; if $\widetilde{p}$ is high then Equation 13 is the solution.[10]

$$n = \frac{b\,(Y+Y^*)}{p\alpha\,(\sigma-1)}, \qquad n^* = 0 \qquad \text{if} \qquad \widetilde{p} \leq \underline{p} = \left[\frac{\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}{\tau^{2-2\sigma}M^2 + F^2\frac{Y^*}{Y}}\right]^{\frac{1}{\sigma}}. \tag{1.12}$$

$$n = 0, \qquad n^* = \frac{b\,(Y+Y^*)}{p^*\alpha\,(\sigma-1)} \qquad \text{if} \qquad \widetilde{p} \geq \overline{p} = \left[\frac{\tau^{2-2\sigma}M^2\frac{Y^*}{Y} + F^2}{\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}\right]^{\frac{1}{\sigma}}. \tag{1.13}$$

If both n and n^* are positive, Equations 8, 9 and 11 solve for $\frac{n}{n^*}$, which is given in Equation 14. This expression is derived by dividing the demand Equation 9 by its Southern equivalent; substituting for q and q^* using Equation 11; substituting for G and G^* using Equation 8; and rearranging. The relative number of Northern firms declines in both the relative price of Northern goods and in the relative size of Southern economies.

$$\frac{n}{n^*} = \frac{\tau^{2-2\sigma}M^2\frac{Y^*}{Y} + F^2 - \widetilde{p}^{\sigma}\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}{\widetilde{p}\left(\tau^{2-2\sigma}M^2 + F^2\frac{Y^*}{Y}\right) - \widetilde{p}^{1-\sigma}\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)}, \text{ if } \widetilde{p} \in \left(\underline{p}, \overline{p}\right). \tag{1.14}$$

Equation 14 can be used to solve for a more useful expression, the share v of world revenues in that industry that accrue to firms in each Northern country. When solving for v, we have to account for the indirect demand for goods used up in transit. Each Northern firm's revenue is given by pq, where q is the quantity produced, not the quantity consumed. Equation 15 is the definition of v. Equation 16 is the solution for v.

$$v = \frac{npq}{M\,(npq + n^*p^*q^*)} \tag{1.15}$$

[10] The conditions for $\widetilde{p}$ are derived from Equation 14.

$$v = \begin{cases} \frac{1}{M} & \text{if} \quad \widetilde{p} \in (0, \underline{p}] \\ \frac{Y}{W}\left[\frac{-\widetilde{p}^{\sigma}\tau^{1-\sigma}MF\left(\frac{Y^*}{Y}+1\right)+\tau^{2-2\sigma}M^2\frac{Y^*}{Y}+F^2}{-(\widetilde{p}^{\sigma}+\widetilde{p}^{-\sigma})\tau^{1-\sigma}MF+\tau^{2-2\sigma}M^2+F^2}\right] & \text{if} \quad \widetilde{p} \in (\underline{p}, \overline{p}) \\ 0 & \text{if} \quad \widetilde{p} \in [\overline{p}, \infty) \end{cases} \tag{1.16}$$

The revenue share v declines in both the relative price of Northern goods $\widetilde{p}$ and the relative size of Southern economies $\frac{Y^*}{Y}$. The sensitivity of market share v to relative price increases with the elasticity of substitution σ and with the number of countries. To better illustrate this, Equation 17 gives $\frac{\partial v}{\partial \widetilde{p}}$ evaluated at $\widetilde{p} = 1$:

$$\frac{\partial v}{\partial \widetilde{p}}|_{\widetilde{p}=1} = \frac{-\sigma\tau^{1-\sigma}F}{(\tau^{1-\sigma}-1)^2} < 0. \tag{1.17}$$

Market share responds negatively to relative price. But by Equation 10, relative price is equal to relative production costs, which depend on factor prices. This generates the role for factor abundance; I next demonstrate that in general equilibrium, locally abundant factors are relatively cheap. Therefore the relative price of Northern goods declines with the skill intensity of the industry, and every Northern country captures larger shares of more skill intensive industries.

C. General Equilibrium

All factors must be fully employed in all countries in equilibrium. With assumed preferences, the function of world income spent on each industry is invariant to prices and income. With the assumed production technology, factor shares in each industry are invariant to factor prices. Skilled labor's share of revenues in industry z is constant and equal to z. The balance goes to unskilled labor. Equations 18 to 21 are, respectively, the full employment conditions for: skilled labor in the North; unskilled labor in the North; skilled labor in the South; and unskilled labor in the South. The left side of each equation is factor demand, the right is factor supply. The wages of unskilled labor in the South have been normalized to 1. National income equals national expenditure in every country, so trade is balanced.

$$\int_0^1 \frac{1}{s} zb(z)\, Wv(z)\, dz = \beta. \tag{1.18}$$

$$\int_0^1 \frac{1}{w}(1-z)b(z)\, Wv(z)\, dz = 1-\beta \tag{1.19}$$

$$\int_0^1 \frac{1}{s^*} zb(z)\, W(\frac{1}{M} - v(z))dz = \beta^*. \tag{1.20}$$

$$\int_0^1 (1-z)\, b(z)\, W(\frac{1}{M} - v(z))dz = 1-\beta^*. \tag{1.21}$$

So long as M is finite, the failure of FPE can be demonstrated by contradiction.[11] With FPE, $\widetilde{p}(z) = 1$ by Equation 10, and $v(z)$ is constant over z by Equation 16. By Equations 18 to 21, relative factor demands in the North equal relative factor demands in the South. But the relative supply of these factors is not equal by assumption. Therefore we cannot have full employment equilibrium with FPE.

The North has more skilled labor; the South more unskilled labor. Full employment requires the North to either (i) have a larger share of skill-intensive industries, or (ii) use skilled labor

[11] In the limit as $M \to \infty$, factor price equalization is again achieved. This is shown by proving that equilibrium in an arbitrary industry requires production costs to be the same in both the North and the South. The reason for FPE returning is simple. The domestic market becomes increasingly less important as M gets larger. In the limit everything is exported, so that transport costs affect locally scarce and abundant factors equally.

more intensively in each industry than in the South. For the North to obtain a larger share of skill-intensive industries, Equation 16 requires that $\widetilde{p}(z)$ declines in z. By Equation 10, $\widetilde{p}(z)$ declines in z if and only if $\frac{s}{w} < \frac{s^*}{w^*}$.[12] Factor demands obtained by differentiating Equation 5 with respect to factor prices show that for any industry, the North will use skilled labor more intensively than the South if and only if $\frac{s}{w} < \frac{s^*}{w^*}$. Therefore skilled labor must become relatively cheap in the North, and unskilled labor relatively cheap in the South. The relative price $\widetilde{p}(z)$ declines in z, and every Northern country's share of world production in an industry rises with the skill intensity z of the industry. The equilibrium is depicted in Figure 3.

D. *The Separate Contributions of Transport Costs and Monopolistic Competition*

The traditional Heckscher-Ohlin model is a special case of this model with no transport costs ($\tau = 1$) and perfect competition ($\alpha = 0$ and $\sigma = \infty$). It is therefore possible to consider the separate effects of transport costs ($\tau > 1$) and monopolistic competition ($\alpha > 0$, $\sigma < \infty$). In the traditional model with a continuum of goods, Dornbusch, Fischer and Samuelson (1980) show that FPE holds if factor endowments are not too dissimilar. Production costs are therefore the same everywhere because all goods can be produced just as well in any country. With zero transport costs, there is commodity price equalization. The geographic pattern of production and trade of a given commodity is therefore indeterminate. Overall patterns of production and trade are not totally indeterminate, because full employment of both factors requires the North to produce, on balance, more skill-intensive goods. This prediction is formalized in the standard HOV factor content of trade equations.

The addition of the transport cost makes the commodity structure of production determinate. The transport cost causes a departure from FPE, and therefore production costs differ between countries. Locally abundant factors become relatively cheap. Countries have a cost advantage in goods that intensively use their abundant factor. Consumers only purchase goods from the cheapest source, inclusive of transport costs. If factor proportions are sufficiently different, low skill goods in the interval $[0, \underline{z}]$ will only be produced in the South.[13] The cost advantage that the South enjoys in these goods outweighs the transport cost. High skill goods

[12] This can be proved by differentiating the log of $\widetilde{p}(z)$.

[13] If $\frac{1-\beta^*}{\beta^*} > \frac{1-\beta}{\beta}\tau^2$, then this type of equilibrium emerges.

$[\overline{z}, 1]$ will only be produced in the North. Intermediate goods $[\underline{z}, \overline{z}]$ will be produced by all countries and will not be traded internationally because the transport cost outweighs any production cost advantage. The range of these non-traded goods increases as the countries' relative factor endowments become more similar or as costs of international trade become greater.

The addition of the transport cost to the traditional model therefore leads to the very stark structure of production and trade illustrated in Figure 4: there is a sharp pattern of specialization; there is no North-North or South-South trade; there is no intra-industry trade; and there is no trade at all in commodities with intermediate factor intensities. All trade is North-South in commodities that embody extreme factor proportions. There are no additional predictions beyond this. In particular, the bilateral pattern of trade is not determined. These crisp predictions sit uncomfortably with the hard facts of trade. Much trade flows between countries with similar factor endowments and much of it appears to be intra-industry trade (Helpman 1999).

Now consider the case of monopolistic competition but no transport costs. The fixed cost of production limits the range of products that the market will profitably support. Countries will specialize in different varieties. When consumers demand a wide spectrum of varieties, economies of scale generated by the fixed cost will lead to trade. Provided factor endowments are not too dissimilar, Helpman and Krugman (1985) show that FPE prevails. Production costs are identical in all countries. There is also commodity price equalization. The geographic pattern of production and trade of a given commodity is therefore indeterminate. Overall patterns of production and trade are again not totally indeterminate, because full employment of both factors requires the North to produce, on balance, more skill-intensive goods. The standard HOV factor content of trade equations hold but there is now an additional feature; these equations hold bilaterally. This can be seen in the HOV framework. All of the traditional assumptions are present. The bilateral prediction is a result of two features of this model: countries specialize in different varieties; and as long as there is commodity price equalization consumers will demand the same proportion of world output of *each variety* of every good produced. There is North-North and South-South trade, but the net factor content of any of these trading relationships is zero. Differences between factor endowments and consumption of factors is resolved entirely by North-South trade.

Transport costs generate sharp predictions for the location of production, but apart from ruling out trade between like countries, they generate no predictions for trade between country pairs.[14] Monopolistic competition generates predictions for the total volume and factor content of bilateral trade, but does not give sharp predictions for where individual industries locate. Simultaneous consideration of transport costs and monopolistic competition results in both sharp predictions for the location of production and for bilateral trade in each industry.

Figures 5 to 7 illustrate the influence of transport costs τ, the elasticity of substitution σ, and factor proportions β, β^* in the model. I use as a benchmark a model where transport costs are moderate ($\tau = 1.05$), the substitutability of varieties within an industry is substantial but far from perfect ($\sigma = 5$), and the North has twice the skilled labor of the South and half of the unskilled labor ($\beta = \frac{2}{3}, \beta^* = \frac{1}{3}$).[15] An increase in transport costs causes countries to become more diversified and reduces trade (Figure 5). An increase in the elasticity of substitution between varieties within an industry pushes the model towards the sharp pattern of specialization that characterizes the perfectly competitive model (Figure 6). Figure 7 illustrates the sensitivity of the model to relative factor abundance. Larger differences in factor abundance between the North and the South result in greater specialization in equilibrium.

E. The Three Factor Model

The role of physical capital in trade has traditionally been of great interest. It is possible to add additional factors to the model. The three-factor model with capital is the same as the two-factor model but with the following modifications:

1. There are three factors of production supplied inelastically; skilled labor, unskilled labor and capital earning factor rewards s, w and r respectively. The total factor supply is 1. The proportions of skilled labor and capital are respectively denoted by β and γ. Northern countries are relatively abundant in skilled labor and capital; $\beta > \beta^*$ and $\gamma > \gamma^*$.

[14] In this model there is FPE within the two subsets of countries.

[15] I also set $b(z) \equiv 1$ so that expenditure shares for all industries are identical, and $M = 2$.

2. There is a continuum of industries kz on the 2-dimensional simplex. The indices k and z end up playing dual roles, because k and z will rank industries by capital and skill intensity respectively.

3. The utility function becomes:

$$U = \int_0^1 \int_0^{1-z} b(kz) \ln Q(kz) dkdz. \tag{1.22}$$

4. $b(kz)$ is the function of income spent on industry kz. All income is spent:

$$\int_0^1 \int_0^{1-z} b(kz) dkdz = 1. \tag{1.23}$$

5. The total cost function becomes:

$$TC(q(kz,i)) = r^k s^z w^{1-k-z}(\alpha + q(kz,i)) \tag{1.24}$$

A similar equilibrium emerges. In particular, Equation 16 relating the location of production to relative costs of production is unchanged. There are now six full employment conditions analogous to Equations 18 to 21. These are listed in Appendix B. By the same reasoning as in the 2-factor case, full employment equilibrium with FPE can not occur if factor proportions differ between countries. With FPE, relative factor demands are the same in every country. But relative factor supplies are not the same by assumption. However, unless more assumptions are made about the form of $b\,(kz)$ it is difficult to comment further on factor rewards. If $b\,(kz) \equiv 2$ then the function of income spent on each industry is identical, and this task is simplified. Full employment requires the North to either have larger shares of skill and capital intensive industries, or to use skilled labor and capital more intensively in each industry than in the South. Either of these things requires $\frac{s}{w} < \frac{s^*}{w^*}$ and $\frac{r}{w} < \frac{r^*}{w^*}$. In the North, skilled labor and capital must become cheap relative to unskilled labor. For a given skill intensity z, the relative price of Northern goods $\widetilde{p}(kz)$ declines with capital intensity k. Given z, every Northern country's share of world production in an industry is increasing in k. For a given capital intensity k, the relative price of Northern goods $\widetilde{p}(kz)$ declines with skill intensity z. Given k, every Northern country's share of world production in an industry is increasing in z.

1.3 The Quasi-Heckscher-Ohlin Prediction

A. Overview and Brief Data Description

Figure 3 illustrates the basis of production and trade based examinations of the model. Production of skill-intensive goods is concentrated in the North. The more skill-intensive the good, the greater is this concentration. Given our assumption on preferences, this leads to a very sharp and convenient prediction for trade. Consider the consumers in any individual country C, which can be from the North or the South. Consumers in C will purchase some of every variety of every good, and given the elasticity assumptions, they spend relatively more on varieties that are relatively cheap. Northern countries produce more varieties of skilled goods, and due to the behavior of factor prices, do so more cheaply than in the South. Northern countries' share of C's imports therefore increase with the skill intensity of the industry. The prediction holds for all of C's bilateral trading relationships. Each Northern country will command a higher share of C's imports of skilled goods than it will of unskilled goods; their market share will systematically increase with the skill intensity of the good. The reverse is true for Southern countries. This is the quasi-Heckscher-Ohlin prediction of the model.

The Heckscher-Ohlin prediction can be examined using detailed commodity trade data and estimates of factor intensity and factor abundance. I use 1998 data from the USA Trade CD-ROM on US imports classified by detailed commodity and country or origin. There are over 16,000 commodities and 200 trading partners. This data is then mapped into 4-digit US SIC codes using a concordance maintained by Jon Haveman.[16] The shares of US imports by SIC industry are then calculated for each country.

The model assumes that there are no factor intensity reversals. Indeed, a property of the model is that factor shares are fixed for each industry. With this assumption, factor intensity can be consistently ranked using factor share data for just one country. I choose US data both for reasons of availability and because the estimates are likely to be the most satisfactory due to the US being the largest and most diverse industrial economy. In this paper I mostly consider a two factor model with skilled and unskilled labor and a three factor model with capital. I also consider the robustness of the results to the inclusion of raw materials in a four factor model. All factor intensity data is derived from the US Census of Manufactures for 1992.

In the two factor model I follow Berman, Bound and Griliches (1994) and measure the skill intensity of industry z_2 as the ratio of non-production workers to total employment in each industry. The unskilled labor intensity is $u_2 = 1 - z_2$. In the three factor model I have to account for the share of capital. Capital intensity k_3 is measured by $1-$ the share of total compensation in value added. Skill intensity z_3 is now equal to $z_2(1 - k_3)$, and the intensity of unskilled labor is $u_3 = u_2(1 - k_3)$. Table 1 lists the 10 industries that most intensively use each factor and the 10 industries that least intensively use each factor. Many of the most capital intensive industries are also industries that most intensively use raw materials, generating the potential for bias if raw materials are omitted from the analysis. In particular, the concern is that many poor countries may be relatively abundant in raw materials and export simply transformed raw materials. These exports often end up being classified as capital intensive manufacturing.

Raw material inputs are derived from detailed data on intermediate inputs by industry. This data is screened to keep only food, forestry and mining industry output. Raw material intensity m_4 is measured as the value of raw material inputs divided by the sum of raw materials and value added. The industries that most intensively use raw materials come from the Food, Tobacco, Wood, Paper, Chemicals, Metals and Non-metallic Mineral Product groupings. Other factor

[16] Various concordances are available from the site www.haveman.org.

intensities need to be adjusted to reflect the share of raw materials. Capital intensity becomes $k_4 = k_3(1 - m_4)$; skill intensity becomes $z_4 = z_3(1 - m_4)$; and unskilled labor intensity is $u_4 = u_3(1 - m_4)$. Tables 2 and 3 report summary statistics for the factor intensity estimates.

The model relates market shares to factor intensity and factor abundance. The abundance of skilled labor is measured by the human capital to labor ratio from Hall and Jones (1999), which is based on education levels reported in Barro and Lee (2000). The abundance of capital is measured by the investment based measure of the capital to labor ratio sourced from Hall and Jones. The Hall and Jones measures are available for a large number of countries, 123 in total. Relative GDP per capita is used as an alternative proxy for the abundance of physical and human capital.[17] Raw material abundance is measured by total land area divided by the total labor force sourced from the World Bank World Development Indicators 2000 CD-ROM, a simple but imperfect estimate of the abundance of agricultural and mineral resources. All measures of abundance are relative to the US. Summary statistics for the factor abundance measures are reported in Tables 4 and 5.

The final sample includes 123 countries and 370 industries.[18] In all tests I estimate variations of Equation 25 for two-factor models, Equation 26 for three-factor models and Equation 27 for four-factor models. The model does not have a closed-form solution for market share as a function of factor intensity and factor abundance. I use linear specifications that impose a very rigid functional form and non-parametric techniques that do not impose a functional form. The regression estimates are interpreted as conditional expectations of US import market share given the factor intensities of the industry. $\widetilde{v}_{cz}$ is the share that country c commands of US imports in industry z. z, k and m are, respectively, the skill and capital intensity of industry z. The subscripts 2, 3 and 4 on the factor intensities denote the number of factors considered when estimating those intensities. I assume that $\widetilde{v}_{cz}$ does not affect the factor intensity of individual industries; that the production structure of an economy does not affect factor accumulation; and that any technology differences between countries are orthogonal to the input characteristics of

[17] GDP per capita in the Heckscher-Ohlin framework is a measure of the abundance of all factors relative to population.

[18] 120 countries when raw materials are included.

industry.[19]

$$\widetilde{v}_{cz} = \alpha_c + \alpha_{1c} z_2 + \varepsilon_{cz} \tag{1.25}$$

$$\widetilde{v}_{cz} = \alpha_c + \alpha_{1c} z_3 + \alpha_{2c} k_3 + \varepsilon_{cz} \tag{1.26}$$

$$\widetilde{v}_{cz} = \alpha_c + \alpha_{1c} z_4 + \alpha_{2c} k_4 + \alpha_{3c} m_4 + \varepsilon_{cz} \tag{1.27}$$

B. The Aggregate North

The first regression is performed at a very aggregate level. I define the North to be any industrial country with per capita GDP at PPP of at least 50 percent of the US level. The countries are listed in Table 6. Characteristics of these countries summarized in Table 7 include high levels of physical and human capital. I calculate the share $\widetilde{v}_{nz} = \sum_{c \in North} \widetilde{v}_{cz}$ for each industry z, and regress this on measures of factor intensity. The results for the two-factor case are reported in Figure 8 and Table 8. The North's market share rises strongly with the skill intensity of the industry. Each 1 percent increase in skill intensity is estimated to add almost 1 percent to the North's market share. The predicted shares vary from 46 percent to all of the market. This coefficient is precisely estimated, with a t-statistic of over 9. I check the robustness of this result using a non-parametric procedure that estimates the North's market share for a given skill intensity z_o as a weighted average of all market shares. The weights are much greater for observations that have a skill intensity close to z_o.[20] The results are similar except for a few industries that use extreme factor proportions. Predicted market shares range from a low of 55

[19]These last two assumptions are, of course, very strong.
[20]I estimate the North's share for an industry with skill intensity z_o by
$\widehat{v}_{z_o} = \frac{\sum_Z w_{z_o} \widetilde{v}_{nz}}{\sum_Z w_{z_o}}$, where $w_{z_o} = \exp(-15 \, |z - z_o|)$.

percent to a high of 88 percent. For most observations, the linear regression line is close to the non-parametric estimate.

In Table 8 I report the regression results for the 3 and 4-factor models. The results are again strong. The estimated coefficient on skill increases in magnitude and maintains its statistical significance, the North's market share increases by almost 2 percent for every 1 percent increase in skill intensity. The effect of capital is smaller, but is reasonably precisely estimated with t-statistics of about 5. Each 1 percent increase in capital intensity adds 0.5 per cent to the North's market share. The North's predicted shares range from 45 percent to all of the market.

C. Individual Country Results

The model performs well for the aggregate North and therefore for the aggregate South. To ensure that the result is not just driven by a few large trading partners I examine whether the effect is systematic across individual countries. I firstly rescale the equations to account for countries being of different sizes. The purpose of this rescaling is so that the coefficients α_c, α_{1c}, α_{2c} and α_{3c} should be comparable across countries regardless of country size. I define V_{cz} as $\widetilde{v}_{cz}$ divided by the average value of $\widetilde{v}_{cz}$ for country c.[21] Equations 28 and 29 are estimated for each country:

$$V_{cz} = \alpha_c + \alpha_{1c} z_3 + \alpha_{2c} k_3 + \varepsilon_{cz} \tag{1.28}$$

$$V_{cz} = \alpha_c + \alpha_{1c} z_4 + \alpha_{2c} k_4 + \alpha_{3c} m_4 + \varepsilon_{cz} \tag{1.29}$$

[21] A log-transformation can not be used because many of the import shares are 0. If a large country is simply the sum of smaller countries then the coefficients will be invariant to country size after the rescaling. If there really are border effects then large countries will be more diversified, reducing the absolute value of α_{1c}, α_{2c} and α_{3c}.

The results for the 123 countries in the sample are summarized in Figures 9 to 12. In Figure 9 I plot the estimated coefficients on skill intensity z_3 against the human-capital to labor ratio, a proxy for the abundance of skilled labor. The size of each country's label is inversely proportional to the standard errors of the coefficient estimate. The estimates are strongly related to skill abundance. Countries with high levels of human capital tend to export skill intensive goods, while countries with low levels export goods that more sparingly use skilled labor. Many of these coefficients are also very large. The equivalent standardized coefficient for the aggregate North is 3. The results are similar in Figure 10 when raw materials have been included in the analysis.

The equivalent results for capital reported in Figures 11 and 12 are not as strong. Coefficients tend to be smaller and less precisely estimated. The 123 coefficients are barely correlated with per capita GDP, although the more precisely estimated coefficients are positively correlated. When raw materials are included the results improve. This improvement is likely due to a reduction in the bias generated by simply transformed raw materials being classified as capital intensive manufacturing in the 3-factor model. Coefficients tend to be more precisely estimated, and are positively correlated with capital abundance. This provides stronger evidence that capital abundant countries do export capital intensive products, and capital scarce countries export commodities that require little capital in their production. These results are more thoroughly explored next by pooling the data.

D. The Pooled Regression

The relationship between market shares and factor abundance can be explored more systematically by pooling the data. The model predicts that α_{1c}, α_{2c} and α_{3c} are positive for countries that are abundant in skilled labor, capital and raw materials respectively, and negative for countries where these factors are scarce. The theory provides no closed form solution relating α_{1c}, α_{2c} and α_{3c} to factor abundance. I model these coefficients according to Equations 30 to 32. This results in the pooled regressions in Equations 33 and 34. The variables $skill_c$, $capital_c$ and raw_c are abundance measures for skilled labor, capital and raw materials in country c. Countries that are scarce in a factor will capture a large share of industries that use that factor sparingly: this implies $\beta_1, \beta_3, \beta_5 < 0$. Countries that are abundant in a factor should capture a large share of industries that use that factor intensively, implying $\beta_2, \beta_4, \beta_6 > 0$.

$$\alpha_{1c} = \beta_1 + \beta_2 skill_c \tag{1.30}$$

$$\alpha_{2c} = \beta_3 + \beta_4 capital_c \tag{1.31}$$

$$\alpha_{3c} = \beta_5 + \beta_6 raw_c \tag{1.32}$$

$$V_{cz} = \alpha_c + (\beta_1 + \beta_2 skill_c)\, z_3 + (\beta_3 + \beta_4 capital_c)\, k_3 + \varepsilon_{cz} \tag{1.33}$$

$$V_{cz} = \alpha_c + (\beta_1 + \beta_2 skill_c)\, z_4 + (\beta_3 + \beta_4 capital_c)\, k_4 + (\beta_5 + \beta_6 raw_c)\, m_4 + \varepsilon_{cz} \tag{1.34}$$

Equations 33 and 34 are estimated by weighted least squares, where the variance weights are estimated conditional on country dummies only.[22] I measure skill abundance $skill_c$ with the education based measure of human capital taken from Hall and Jones (1999). I measure capital abundance $capital_c$ with the capital-labor ratio from Hall and Jones. For comparison I also proxy skill and capital abundance with relative per capita GDP. The results are reported in Table 9. The results for skilled labor are strong. The exports of countries with low levels of human capital are extremely tilted towards goods that embody little skilled labor, with

[22]The variance of V_{cz} is larger for countries that have less diversified exports. These countries typically have smaller trade volumes. Because the data underlying V_{cz} are market shares, there is some dependence between the observations that WLS does not acount for.

the reverse being true for countries with abundant skilled labor. The same effect is present for capital, but is weaker. The estimated effect of capital increases after accounting for raw materials, as expected, but capital abundance appears to be less important than skill abundance in determining the pattern of specialization.

1.4 The Quasi-Rybczynski Prediction

A. The Miracle Economies

The model predicts that if a country quickly accumulates a factor, then its production and exports will systematically shift towards industries that more intensively use that factor. Consider the model when M is large and one of the countries makes the leap from the South to the North. The world equilibrium is scarcely upset because each country is small relative to the world. Essentially this country moves from a Southern pattern of production and trade to a Northern one, while the rest of the world carries on as before. The existence of a number of growth "miracles" that have joined the ranks of wealthy industrial economies with high levels of physical and human capital provides an opportunity to examine this quasi-Rybczynski effect. Ventura (1997) noted that the Rybczynski effect is a critical feature of the growth experience of the miracle economies. In a closed economy, rapid accumulation of physical and human capital could lead to falling factor prices. Small open economies can avoid this by shifting production to more skill and capital intensive industries and exporting the output. If M is large in this model, factor accumulation in one country has little effect on factor prices either locally or globally. The Rybczynski effect lets small countries beat diminishing returns.

There are 7 economies that made the cut-off for the North in 1998 that were not present in 1960: Japan, Singapore, Hong Kong, Taiwan, Israel, Spain and Ireland. Their substantial growth in real income relative to the US is shown in Table 10. I add Korea to Table 10 because of its extremely rapid growth since 1970. I perform the regression defined in Equation 26 for each country using data for 1960, 1972, 1980, 1990 and 1998. The results summarized in Table 11 are suggestive of the quasi-Rybczynski effect. In 1960 and 1972, market shares for these countries tend to be negatively related to skill and capital intensity. As these countries have grown the coefficients on skill and capital intensity have increased, so that by 1998 the picture has changed a lot. Positive relationships are more common. The only significant negative coefficients are for two of the poorer countries in the sample, Korea and Taiwan, and even there the change in the size of the coefficients makes it clear that production is moving towards more skill and capital intensive goods. These countries, once firmly rooted in the South, are developing Northern patterns of production and trade.

The Rybczynski effect can be represented graphically using the same nonparametric technique used in Figure 8. Some of the most pronounced changes in export structure occurred in two groups of countries that experienced unprecedented growth rates substantially attributable to rapid accumulation of human and physical capital: Japan and the four 'miracle' economies of Singapore, Hong Kong, Taiwan and Korea.[23] Between 1960 and 1998 Japan's income levels went from 54 per cent of Western-European levels to 114 per cent, with equality occurring in 1981. The four miracle economies moved from 21 per cent of European income levels in 1960 to 72 percent in 1998. The Rybczynski prediction would be a convergence in the production and trade structures of these economies towards European patterns. The prediction is supported by the data. Figures 13 to 15 show the trade structure of the four miracle economies, Japan and Western Europe in 1960, 1980 and 1998. Convergence is apparent. In 1960 the trade of the then poor miracle economies was concentrated in goods that used little skilled labor, while Europe captured larger market shares for skilled goods. Japan, with an intermediate income level, had a production structure neatly between the two. As the relative income levels of the economies converged, so too did their production structures. Japan's looks almost the same as Europe by 1980, the same time as income levels converged. The miracle economies appear to be systematically approaching Europe in terms of both income and trade structure, although as a group they still have some way to go. The results for physical capital are less pronounced, consistent with Table 11. Japan's exports actually appear to be less capital intensive now than in 1960.

[23] For analysis of the growth experience of the Asian miracles, see Young (1992, 1993), Lucas (1993), and Krugman (1994).

B. The Pooled Rybczynski Regression

To more formally test for the Rybczynski effect I estimate Equation 33 in differences:

$$\Delta V_{cz} = \Delta\alpha_c + (\Delta\beta_1 + \beta_2 \Delta skill_c)\, z_3 + (\Delta\beta_3 + \beta_4 \Delta capital_c)\, k_3 + \Delta\varepsilon_{cz} \tag{1.35}$$

The Rybczynski prediction implies that $\beta_2, \beta_4 > 0$; countries that have accumulated skilled labor and physical capital faster than the rest of the world will see their production and trade move towards skill and capital intensive industries. The parameters $\Delta\beta_1$ and $\Delta\beta_3$ may not be zero because US factor proportions may have moved relative to the rest of the world and because $\Delta skill_c$ and $\Delta capital_c$ are measured relative to the US. To maximize the number of comparable industries, I calculate ΔV_{cz}, $\Delta skill_c$ and $\Delta capital_c$ using a start date of 1972 rather than 1960. The end date is 1998. For $\Delta skill_c$ I use two education based measures from Barro and Lee (2000). One is the change in average years of college education between 1970 and 1995, and the other is the change in average total years of education for the same period. For $\Delta capital_c$ I use investment based measures of the capital-labor ratio from the Penn World Tables in 1972 and 1992. For comparison, I also use the more widely available change in relative GDP per capita as a proxy for both $\Delta skill_c$ and $\Delta capital_c$.[24]

The sample consists of 317 industries, with 45 countries when factor data is used to estimate factor accumulation, and 103 countries when income data is used as a proxy for factor accumulation. The results are reported in Table 12. The results for capital weakly suggest that countries that rapidly accumulate capital move towards more capital intensive industries. All of the education based variables are insignificant. The human capital measures may not work well because years of formal education take no account of education quality, and because formal education accounts for only a fraction of human capital development.[25] Krueger and Lindahl (2000) suggest that measurement error in first-differenced cross-country education data is extreme. This would bias downwards the estimated coefficients. Table 13 is suggestive of this

[24] This of course ignores any role for technological explanations of cross-country growth differences, and makes strong assumptions about how factors are accumulated.
[25] See, for example, Lucas (1993) and Barro and Lee (2000).

explanation. Changes in education levels are barely correlated with per capita income growth. It is hard to believe that human capital accumulation is truly uncorrelated with growth. The quality of education can to some extent be controlled for by the inclusion of scores from standardized tests administered internationally.[26] The problem is that the number of countries in the sample contracts greatly. When test scores are added to the regression, the coefficients on human capital accumulation increase but remain insignificant. Interestingly, the education quality measure itself is a significant explanator of the change in production structure. Countries that perform highly on international test scores have moved towards more skill intensive industries. Students in Japan and the Asian miracle economies perform best in these tests.

The income based measures are large and highly significant for both skill and capital intensity. Fast growing countries see their trade move towards skill and capital intensive industries. The coefficients β_2 and β_4 should be the same size as in the levels regression on Equation 33. The skill coefficient is the same size, but the capital coefficient is now noticeably larger. One possible explanation for the increase in the capital coefficient is that there is an omitted factor that is partly controlled for by the differencing employed in the Rybczynski regression.

1.5 Conclusion

The aim of this chapter is to derive and examine predictions of the factor proportions model in commodity markets. All that is required to make these predictions are two reasonable generalizations of the traditional Heckscher-Ohlin model. I introduce transport costs and monopolistic competition. This produces two main predictions. There is a quasi-Heckscher-Ohlin effect and a quasi-Rybczynski effect. Both of these predictions can be examined using detailed import data for just one country. The Heckscher-Ohlin prediction finds strong support in the data. The role of skill abundance appears to be especially pronounced. There is also support for the Rybczynski effect for fast-growing countries. Factor proportions appear to be an important determinant of the structure of production and international trade.

[26]The data on international tests of students in mathematics and science are contained in Barro and Lee (2000). I sum the two scores and divide the sum by its mean of 1000.

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Table 1: Industries with Extreme Factor Intensities

10 Most Skill Intensive Industries		10 Most Capital Intensive Industries		10 Most Unskilled Labor Intensive Industries	
3764	Space propulsion units and parts	2111	Cigarettes	3321	Gray iron founderies
3826	Analytical instruments	2087	Flavoring extracts and syrups	3543	Industrial patterns
3769	Space vehicle equipment nec	2043	Cereal breakfast foods	2299	Textile goods nec
3812	Search and navigation equipment	2046	Wet corn milling	2397	Schiffli machine embroideries
3547	Rolling mill machinery	2047	Dog and cat food	3149	Footwear, except rubber, nec
2711	Newspapers	2879	Agricultural chemicals nec	3151	Leather gloves and mittens
3721	Aircraft	2095	Roasted coffee	2517	Wood TV and radio cabinets
3699	Electrical equipment and supplies nec	2085	Distilled liquor, except brandy	2393	Textile bags
3827	Optical instruments and lenses	2834	Pharmaceutical preparations	3544	Special dyes, tools, jigs and fixtures
3541	Machine tools, metal cutting types	2813	Industrial gases	3731	Ship building and repairing
10 Least Skill Intensive Industries		**10 Least Capital Intensive Industries**		**10 Least Unskilled Labor Intensive Industries**	
2111	Cigarettes	2299	Textile goods nec	2087	Flavoring extracts and syrups
2043	Cereal breakfast foods	3534	Elevators and moving stairways	2111	Cigarettes
2087	Flavoring extracts and syrups	3321	Gray iron foundries	2721	Periodicals
2032	Canned specialties	3543	Industrial patterns	2731	Book publishing
2047	Dog and cat food	3547	Rolling mill machinery	2834	Pharmaceutical preparations
2322	Men's and Boy's underwear	3731	Ship building and repairing	2879	Agricultural chemicals nec
2284	Thread mills	3542	Machine tools, metal forming types	2813	Industrial gases
2035	Pickles, sauces and salad dressings	3544	Special dyes, tools, jigs and fixtures	2046	Wet corn milling
2676	Sanitary paper products	2397	Schiffli machine embroideries	2095	Roasted coffee
2085	Distilled liquor, except brandy	3671	Electronic computers	3571	Electronic computers

Table 2: Factor Intensity Summary Statistics

	Mean	Std. Dev.	Min	Max
z_2	0.29	0.12	0.08	0.83
z_3	0.14	0.07	0.02	0.39
z_4	0.13	0.07	0.01	0.39
u_2	0.71	0.12	0.17	0.92
u_3	0.34	0.12	0.05	0.63
u_4	0.32	0.13	0.02	0.62
k_3	0.52	0.14	0.19	0.93
k_4	0.47	0.14	0.09	0.87
m_4	0.08	0.17	0.00	0.86

Table 3: Correlation and Variance of Factor Intensities

	z_2	z_3	k_3	u_3	z_4	k_4	u_4	m_4
z_2	0.015							
z_3	0.723	0.005						
k_3	0.115	-0.555	0.019					
u_3	-0.579	0.057	-0.862	0.014				
z_4	0.685	0.976	-0.567	0.086	0.006			
k_4	0.187	-0.301	0.669	-0.620	-0.175	0.020		
u_4	-0.434	0.163	-0.840	0.909	0.259	-0.351	0.016	
m_4	-0.134	-0.303	0.321	-0.200	-0.484	-0.474	-0.559	0.030

Table 4: Summary Statistics for Factor Abundance

Variable	Mean	Std. Dev.	Min	Max
H/L	0.567	0.168	0.325	1.017
K/L	0.286	0.323	0.004	1.236
GDPPC	0.272	0.280	0.015	1.132
LAND/L	1.841	3.195	0.004	18.20

Table 5: Correlation and Variance of Factor Abundance

	H/L	K/L	GDPPC	LAND/L
H/L	0.028			
K/L	0.799	0.105		
GDPPC	0.807	0.917	0.078	
LAND/L	-0.054	0.058	-0.025	10.21

Table 6: North and South

North	South		
Australia[1]	Algeria[3]	Guatemala[2]	Papua New Guinea[4]
Austria[1]	Angola[3]	Guinea[3]	Paraguay[2]
Belgium[1]	Argentina[3]	Guinea Bissau[3]	Peru[2]
Canada[1]	Bangladesh[3]	Guyana[3]	Philippines[2]
Denmark[1]	Barbados[3]	Haiti[3]	Poland[4]
Finland[2]	Benin[3]	Honduras[2]	Portugal[3]
France[1]	Bolivia[2]	Hungary[4]	Romania[3]
Germany[1]	Botswana[4]	India[2]	Russia[4]
Hong Kong[1]	Brazil[3]	Indonesia[3]	Rwanda[3]
Iceland[1]	Burkina Faso[3]	Ivory Coast[3]	Saudi Arabia[3]
Ireland[1]	Burundi[3]	Jamaica[3]	Senegal[3]
Israel[2]	Cameroon[3]	Jordan[3]	Seychelles[3]
Italy[2]	Cape Verde[4]	Kenya[2]	Sierra Leone[4]
Japan[1]	Central African Republic[3]	Korea[3]	Slovakia[4]
Luxembourg[4]	Chad[3]	Lesotho[4]	Somalia[4]
Netherland[1]	Chile[3]	Madagascar[3]	South Africa[3]
New Zealand[1]	China[2]	Malawi[2]	Sri Lanka[3]
Norway[1]	Colombia[1]	Malaysia[3]	Sudan[4]
Singapore[3]	Comoros[4]	Mali[3]	Surinam[3]
Spain[1]	Congo, Democratic Republic[3]	Malta[3]	Swaziland[4]
Sweden[1]	Congo, Republic[3]	Mauritania[3]	Syria[2]
Switzerland[1]	Costa Rica[3]	Mauritius[2]	Tanzania[3]
Taiwan[2]	Cyprus[3]	Mexico[2]	Thailand[1]
United Kingdom[1]	Czech Republic[4]	Morocco[3]	Togo[3]
	Dominican Republic[2]	Mozambique[3]	Trinidad and Tobago[3]
	Ecuador[2]	Myanmar[3]	Tunisia[3]
	Egypt[3]	Namibia[4]	Turkey[2]
	El Salvador[3]	Nicaragua[3]	Uganda[3]
	Fiji[3]	Niger[3]	Uruguay[3]
	Gabon[3]	Nigeria[3]	Venezuela[2]
	Gambia[4]	Oman[4]	Yemen[4]
	Ghana[3]	Pakistan[3]	Zambia[2]
	Greece[1]	Panama[2]	Zimbabwe[2]

Notes: [1] denotes countries that are included in all Rybczynski regressions.
[2] denotes countries with factor data for Rybczynski regressions but no test scores.
[3] denotes countries with per capita GDP data only for Rybczynski regressions.
[4] denotes countries that are not included in any Rybczynski regression.

Table 7: Characteristics of North and South

	H/L	K/L	GDPPC	LAND/L
North	0.79	0.83	0.75	1.74
South	0.51	0.15	0.15	1.75

Table 8: Regression for the Aggregate North

(Dependent Variable: v_{nz})

	2 Factors	3 Factors	4 Factors
Constant	0.39***	0.12	0.05
	(0.04)	(0.08)	(0.08)
z_2	0.93***		
	(0.10)		
z_3		1.90***	
		(0.22)	
k_3		0.54***	
		(0.11)	
z_4			2.00***
			(0.22)
k_4			0.64***
			(0.11)
m_4			0.60***
			(0.12)
Observations	370	370	370
R^2	0.19	0.18	0.24

Note: robust standard errors in parentheses. ***,**,* denote significance at the 1,5,10 and percent level.

Table 9: Pooled Regression of Import Share on Factor Intensities

(Dependent Variable: V_{cz})

Variable	(1)	(2)	(3)	(4)
z	-16.66***	-9.52***	-16.72***	-7.74***
	(1.32)	(0.62)	(1.14)	(0.49)
Skill*z	23.26***		24.13***	
	(1.83)		(1.60)	
GDPPC*z		17.87***		15.46***
		(1.05)		(0.84)
k	-0.77***	-1.91***	-1.17***	-1.85***
	(0.26)	(0.31)	(0.24)	(0.27)
Capital*k	1.30***		2.22***	
	(0.37)		(0.35)	
GDPPC*k		3.66***		3.80***
		(0.53)		(0.45)
m			-17.26	-16.98
			(45.32)	(45.32)
Raw*m			0.38***	0.37***
			(0.04)	(0.03)
Country Dummies	Yes.	Yes.	Yes.	Yes.
Countries	124	123	120	120
Obs.	45,880	45.510	44.400	44.400

Note: standard errors in parentheses. ***,**,* denote significance at 1,5,10 percent level.

Table 10: Per Capita Real Income Relative to the US

	1960	1970	1980	1990	1998
Japan	0.30	0.56	0.66	0.79	0.79
Singapore	0.17	0.23	0.46	0.65	0.82
Hong Kong	0.23	0.35	0.57	0.82	0.70
Taiwan	0.13	0.17	0.29	0.45	0.54
Korea	0.09	0.11	0.20	0.37	0.46
Ireland	0.33	0.39	0.45	0.51	0.73
Spain	0.32	0.45	0.48	0.53	0.55
Israel	0.35	0.46	0.52	0.51	0.58

Table 11: Regression Coefficients of Market Share on Factor Intensities
(Dependent Variable: V_{cz})

Country	Factor	1960	1972	1980	1990	1998
Japan	Skill	-3.16	-1.62***	1.22*	3.10***	5.66***
		(3.78)	(0.57)	(0.71)	(0.78)	(0.95)
Japan	Capital	5.76*	-1.59***	-0.95***	-0.40	0.47
		(3.23)	(0.31)	(0.36)	(0.42)	(0.49)
Singapore	Skill	n.a.	3.04	-0.01	1.75	8.30***
			(4.94)	(2.11)	(2.48)	(2.42)
Singapore	Capital	n.a.	-1.48	-0.91	0.54	0.36
			(1.08)	(0.74)	(0.81)	(2.10)
Hong Kong	Skill	-6.88**	-6.64***	-5.77***	-5.68***	-2.54
		(2.76)	(1.63)	(1.24)	(1.52)	(1.92)
Hong Kong	Capital	-1.95*	-3.05***	-2.00***	-2.56***	-1.44
		(2.35)	(0.71)	(0.63)	(0.82)	(1.18)
Taiwan	Skill	-11.15***	-7.12***	-5.48***	-4.07***	-1.97**
		(2.91)	(1.70)	(0.82)	(0.70)	(0.85)
Taiwan	Capital	-6.18**	-3.71**	-3.07***	-3.12***	-2.54***
		(2.49)	(0.74)	(0.47)	(0.45)	(0.54)
Israel	Skill	-11.76***	-2.06	0.61	4.25***	7.46***
		(2.67)	(1.75)	(4.25)	(1.61)	(2.66)
Israel	Capital	-5.35**	-0.31	-1.50	0.03	1.41
		(2.28)	(0.76)	(1.82)	(0.65)	(0.96)
Ireland	Skill	n.a.	1.35	-0.39	3.04***	4.80***
			(2.87)	(1.97)	(1.15)	(1.39)
Ireland	Capital	n.a.	3.06	5.70*	6.25*	6.58**
			(2.15)	(2.95)	(3.41)	(3.07)
Spain	Skill	n.a.	-3.35**	-1.23	-0.78	-1.2
			(1.48)	(1.56)	(1.69)	(1.60)
Spain	Capital	n.a.	1.13	2.60*	1.24	0.62
			(0.92)	(1.33)	(0.81)	(0.92)
Korea	Skill	-14.91*	-10.53***	-6.70***	-5.39***	-3.52**
		(8.90)	(2.67)	(1.23)	(1.19)	(1.66)
Korea	Capital	-12.62*	-4.65***	-2.20***	-3.06***	-3.26**
		(7.61)	(1.10)	(0.63)	(0.56)	(1.49)
Average Skill Coefficient		-9.57	-3.37	-2.22	-0.47	2.12
Average Capital Coefficient		-4.07	-1.33	-0.29	-0.14	0.28
Number of Industries		151	376	376	366	370

Note: robust standard errors in parentheses. ***,**,* denote significance at 1,5,10 percent level.

Table 12: Pooled Rybczynski Regressions
(Dependent Variable: ΔV_{cz})

Variable	(1)	(2)	(3)	(4)	(5)
z	2.57***	-18.85**	2.47***	-19.48**	0.99**
	(0.52)	(7.93)	(0.46)	(7.91)	(0.46)
ΔCollege*z	-0.63	2.14			
	(3.49)	(3.73)			
ΔEducation*z			1.89	7.93	
			(4.42)	(6.44)	
Test Scores*z		21.54***		22.30***	
		(7.98)		(7.93)	
ΔGDPPC*z					16.31***
					(3.32)
k	0.61**	0.77***	0.62**	0.76***	-0.05
	(0.24)	(0.28)	(0.24)	(0.28)	(0.23)
ΔCapital*k	1.26*	1.47*	1.23*	1.51*	
	(0.71)	(0.83)	(0.70)	(0.81)	
ΔGDPPC*k					6.70***
					(1.62)
Country Dummies	Yes.	Yes.	Yes.	Yes.	Yes.
Countries	45	21	45	21	103
Obs.	14,265	6657	14,265	6657	32.651

Note: standard errors in parentheses. ***,**,* denote significance at 1,5,10 percent level.

Table 13: Correlation of Education and Capital Growth with GDP

	Δrelgdppc7298	Δedn7095	Δcol7095	ΔK/L7292
Δrelgdppc7298	1			
Δedn7095	-0.01	1		
Δcol7095	0.13	0.24	1	
ΔK/L7292	0.33	-0.08	0.12	1

Figure 1: Heckscher-Ohlin Effect for Germany and Bangladesh
Skill Intensity and US Import Shares in 1998

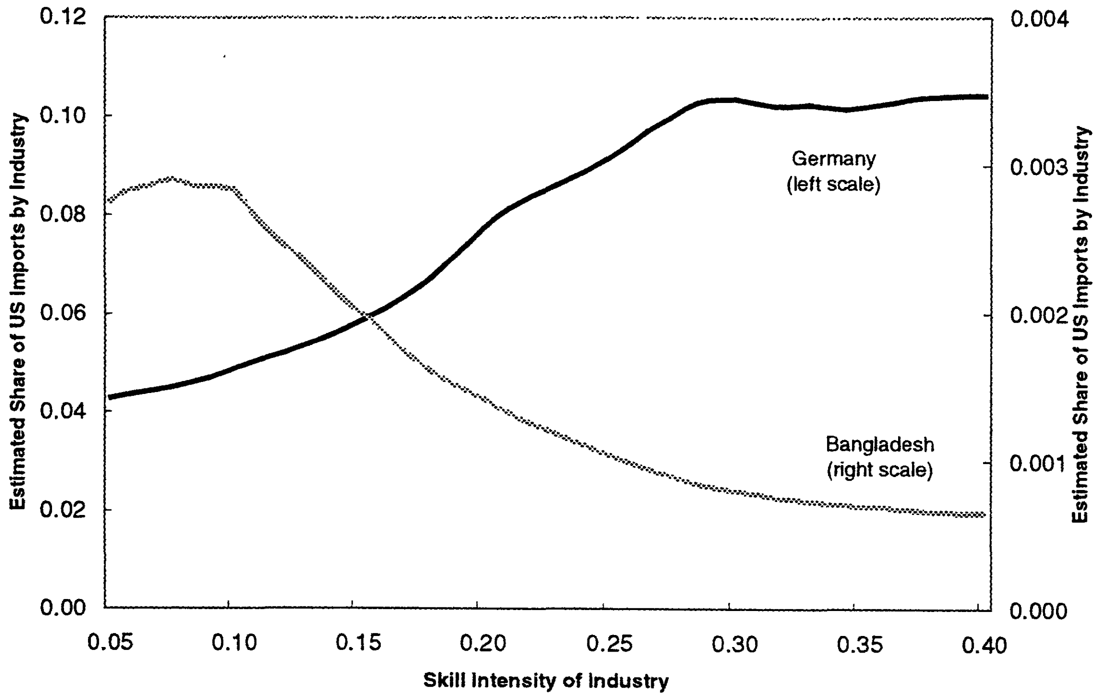


Figure 2: Rybczynski Effect for the Asian Miracle Economies*
Combined US Import Shares 1960-1998
(*Singapore, Hong Kong, Taiwan, Korea)

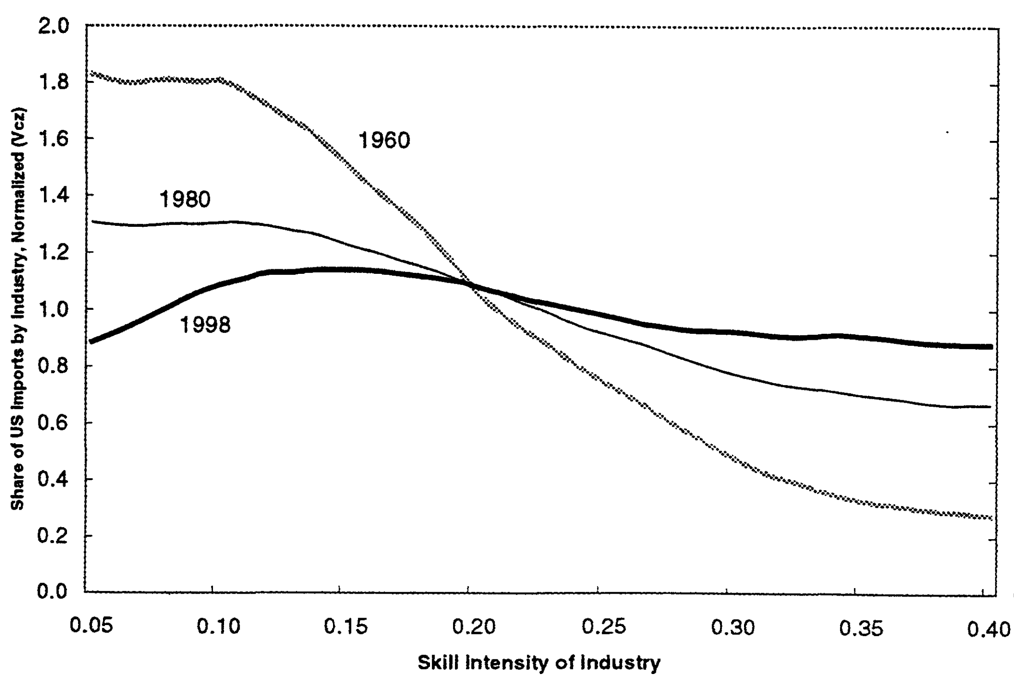


Figure 3: The Location of Production

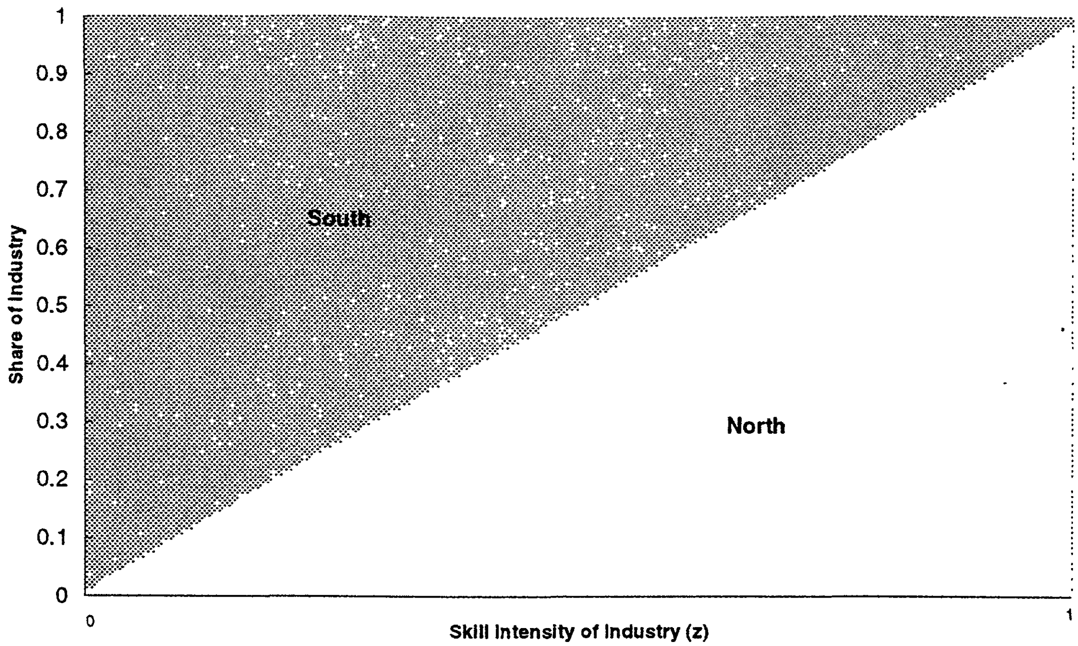


Figure 4: Location of Production in DFS Model With Transport Costs

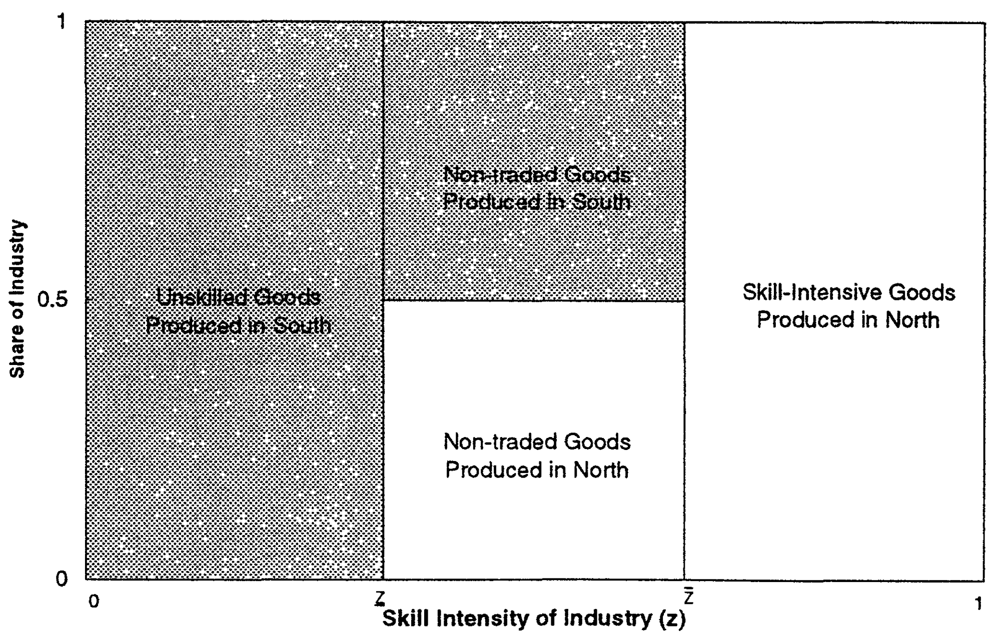


Figure 5: Effect of Transport Costs on the Location of Production

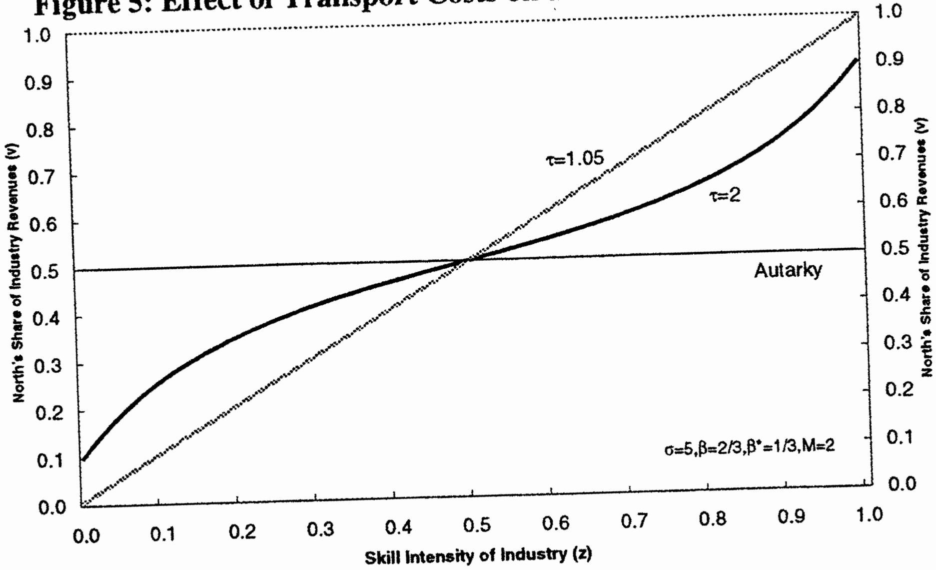


Figure 6: The Effect of σ on the Location of Production

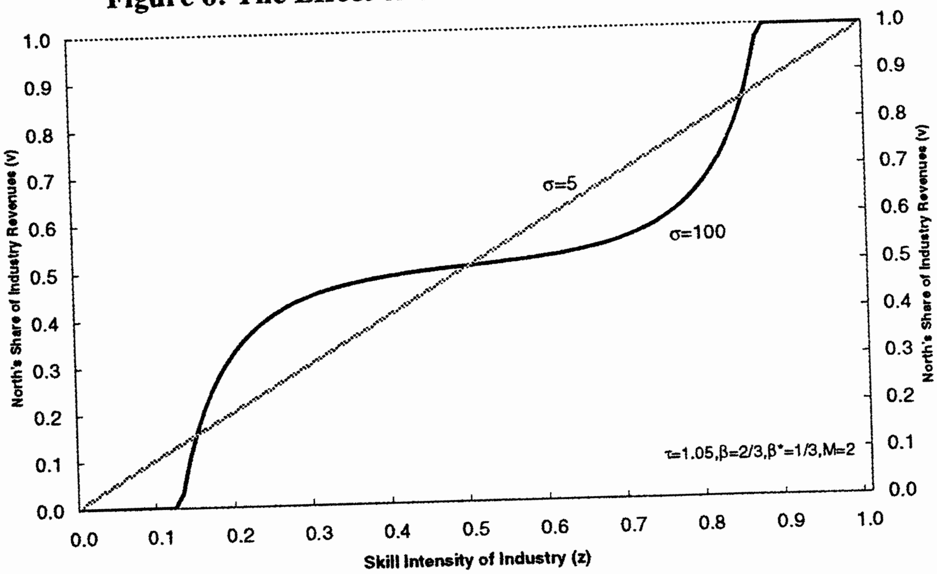


Figure 7: The Effect of Factor Abundance on the Location of Production

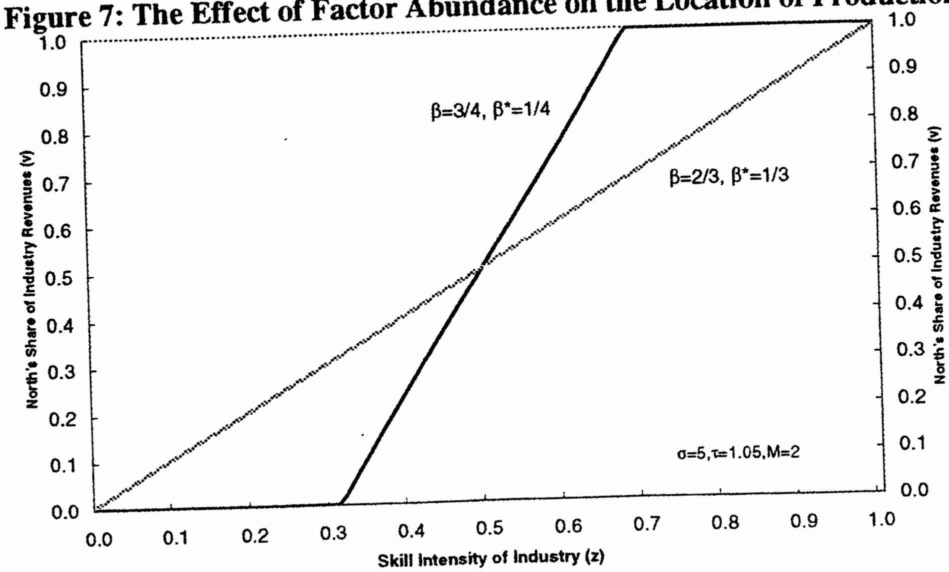
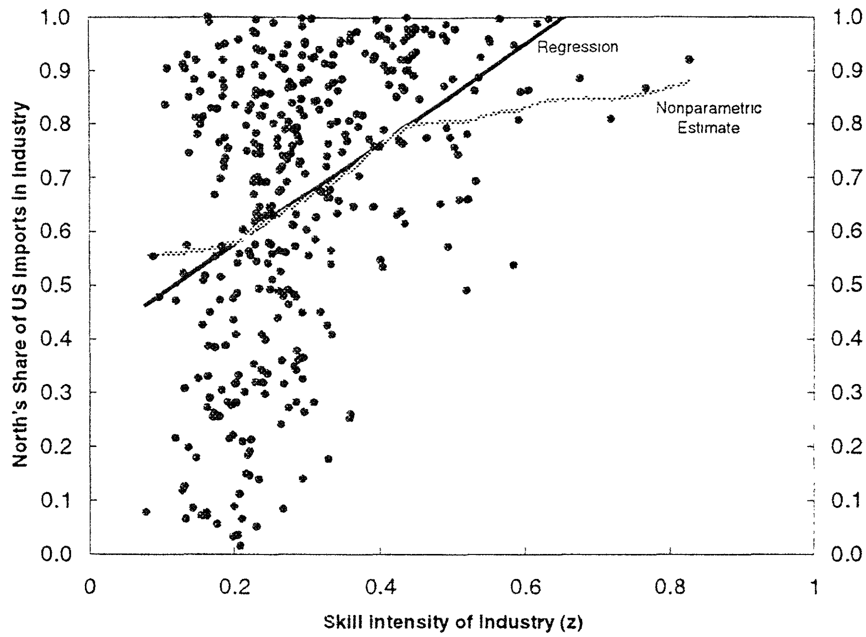


Figure 8: Factor Intensity and the North's Market Share



Figures 9 to 12: Coefficients from Regressions of Country's Share of US Imports by Industry (V_{cz}) on Factor Intensity of Industry

Figure 9: Skill Intensity; 3 Factor Model

WLS regression line: Coeff.= -19.75 + 27.89H/L
standard errors: (1.42) (1.97)

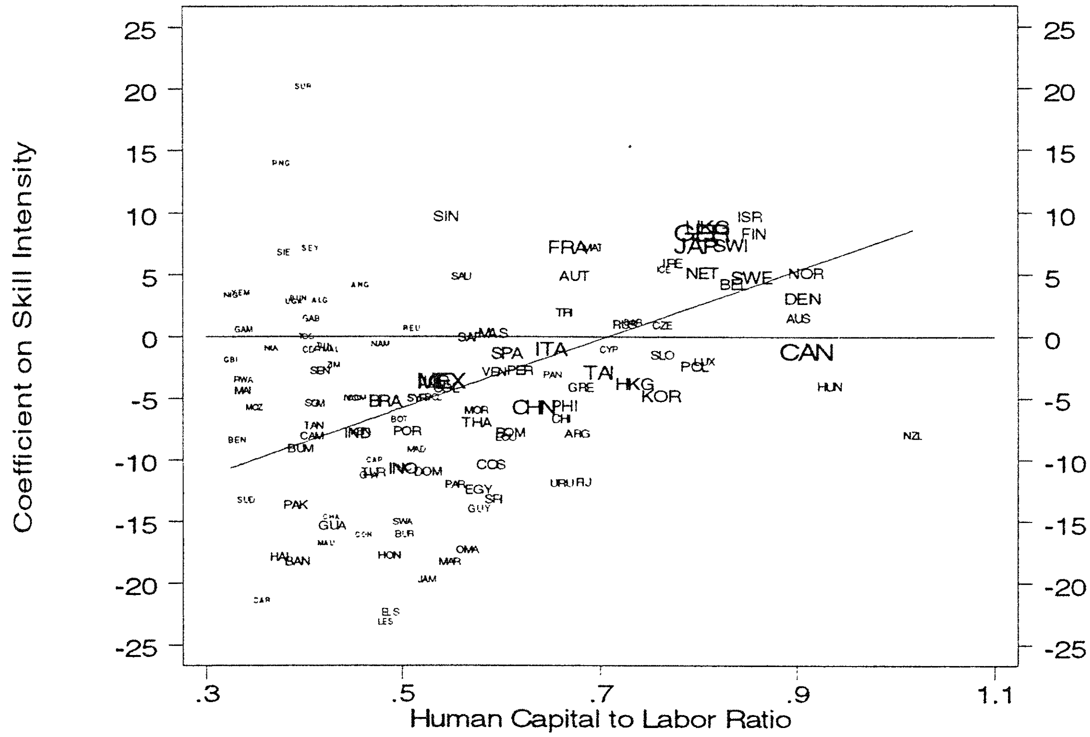


Figure 10: Skill Intensity; 4 Factor Model

WLS regression line: Coeff.= -19.55 + 27.66H/L
standard errors: (1.47) (2.04)

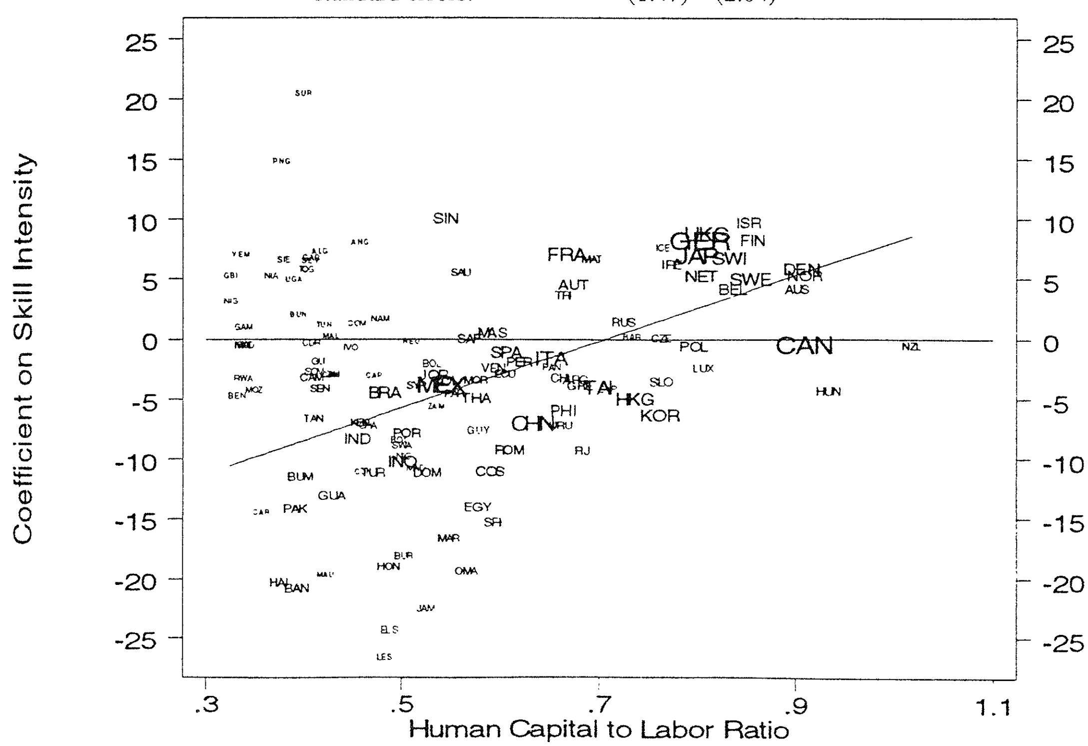


Figure 11: Capital Intensity, 3 Factor Model

WLS regression line: Coeff.= -1.77 + 3.07K/L
standard errors: (0.27) (0.40)

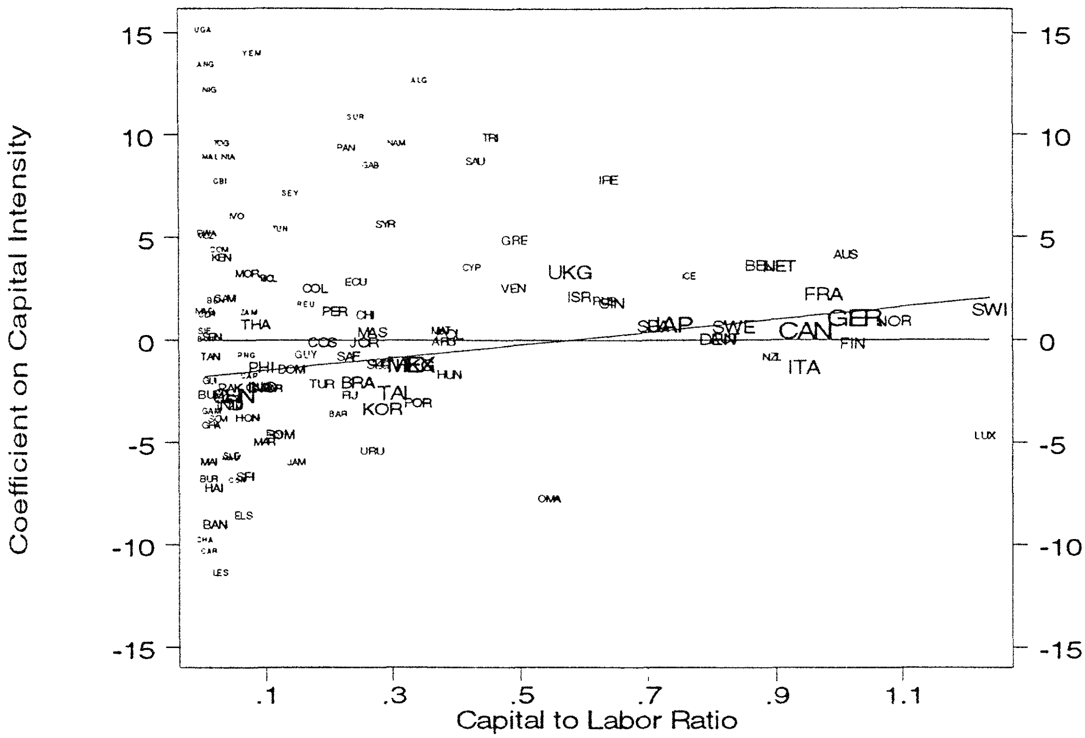


Figure 12: Capital Intensity, 4 Factor Model

WLS regression line: Coeff.= -2.30 + 3.80K/L
standard errors: (0.27) (0.40)

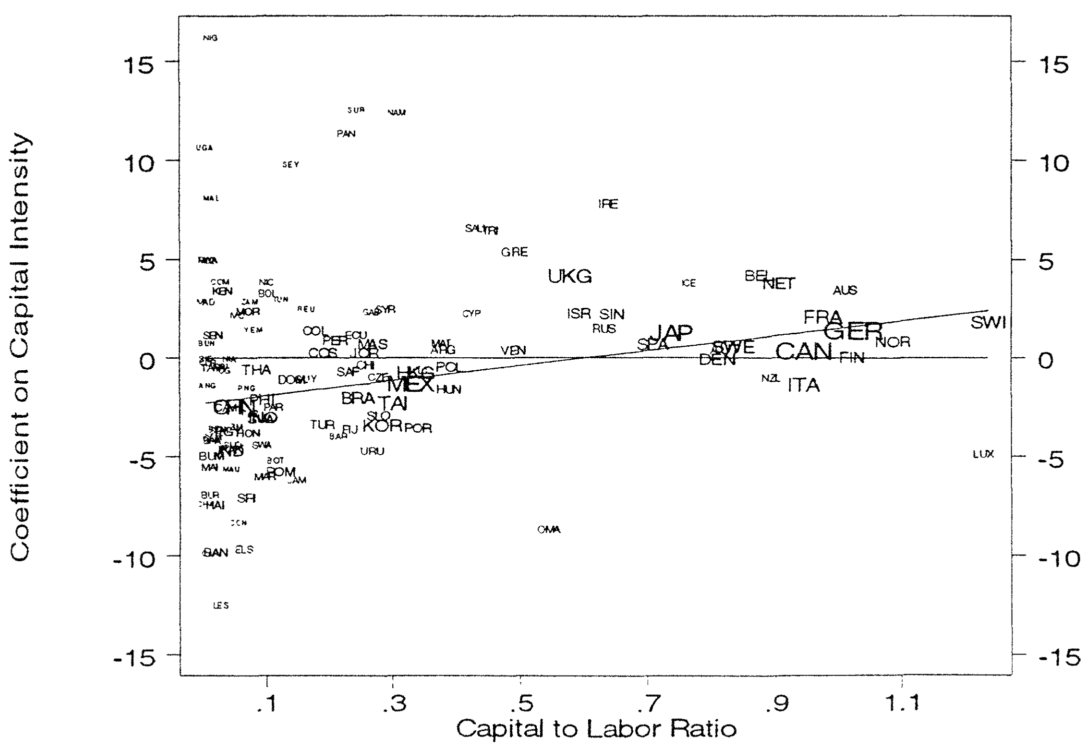


Figure 13: Skill Intensity and US Import Shares in 1960

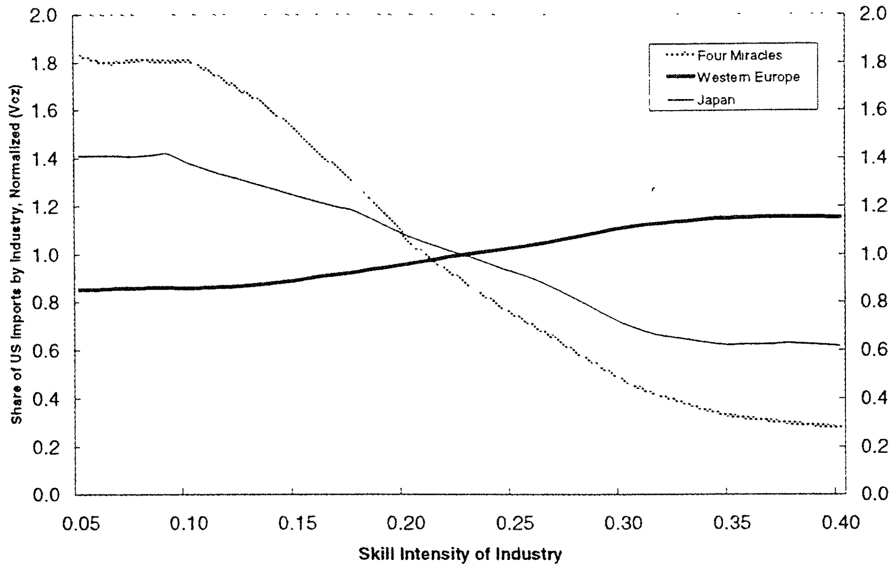


Figure 14: Skill Intensity and US Import Shares in 1980

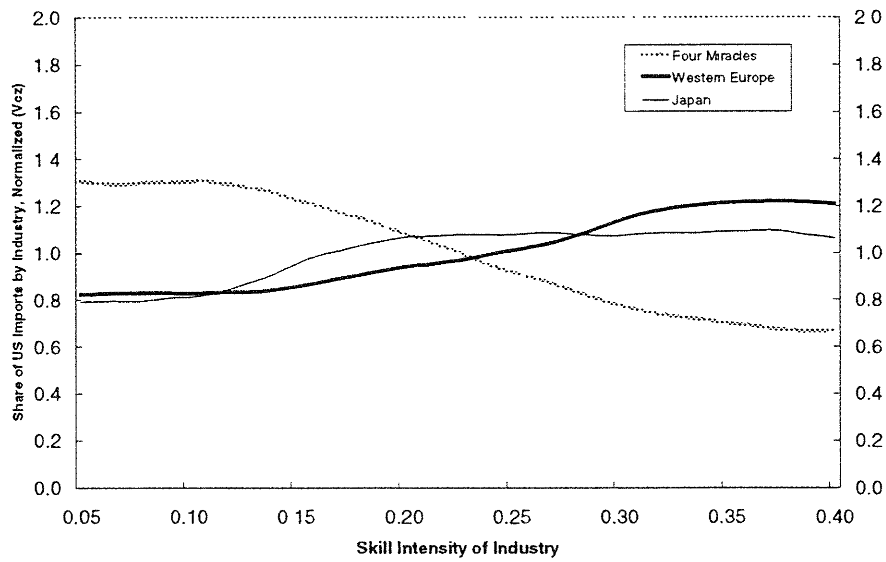
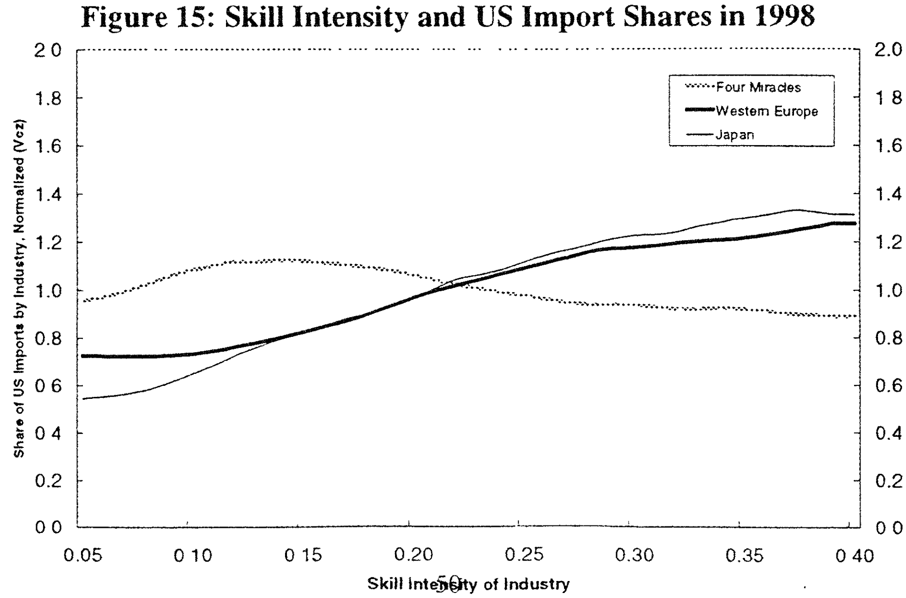


Figure 15: Skill Intensity and US Import Shares in 1998



Chapter 2

NAFTA's Impact on North American Trade

Summary 2 *Chapter 2 focuses on the effect of preferential tariff liberalization on the direction of trade and suggests that NAFTA has had a substantial impact on North American trade. The chapter focuses on where the US sources its imports of different commodities from. It identifies the impact of NAFTA by exploiting the substantial cross-commodity variation in the tariff preference given to goods produced in Canada and Mexico. Canada and Mexico have greatly increased their share of US imports of commodities for which they enjoy a tariff preference. For commodities where no preference is given, Canada's share has declined while Mexico's has increased much more modestly. The empirical results suggest that Canada's share of US imports may have declined without NAFTA, rather than increased, while the growth in Mexico's share of US imports would have been much slower. Useful products of the empirical work are estimates of consumer willingness to substitute between different varieties of the same commodity. The estimated average elasticities of substitution range from 5 to 7.*

2.1 Introduction

On January 1, 1994 the North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico entered into force. It has been described as the most comprehensive free trade pact, short of a common market, that has ever been negotiated between regional trading partners (Hufbauer and Schott, 1993). It is by far the largest free trade pact outside of the European Union and is the first reciprocal free trade pact between a substantial developing country and developed economies. Further expansion is in prospect following the April 2001 Summit of the Americas. Ministers from almost all North and South American nations have been directed to negotiate the Free Trade Area of the Americas (FTAA) by January 2005.

Since the advent of NAFTA, one of the more striking occurrences has been the rapid increase in Mexican trade. Mexico has become one of the US's largest trading partners, accounting for 11.2 percent of total US imports in 2000, up from 6.9 percent 1993. Only Canada (18.8 percent) and Japan (12.0 percent) account for larger shares (Figures 1 and 2). Mexico exports more to the US than Korea, Thailand, Singapore, Malaysia, Hong Kong and the Philippines combined. Krueger (1999, 2000) attributes this increase not to NAFTA, but to the real depreciation of the Mexican exchange rate in 1994 and to Mexico's reduction of tariffs and quantitative trade restrictions against all of its trading partners.

By contrast, this paper finds that NAFTA has had a substantial impact on North American trade. It focuses on where one of the NAFTA partners, the United States, sources its imports at a very detailed commodity level. Figure 3 shows that Mexico's share of US imports has increased most rapidly in commodities for which it has been given the greatest tariff preference, defined as the difference between the tariff on a commodity sourced from Mexico and the US's Most Favored Nation (MFN) tariff rate for the same commodity; the tariff applicable to countries that have normal trade relations with the US. While the simple average of Mexico's share of US imports in over 7,000 commodities increased from 5.0 to 7.0 per cent since NAFTA, its average share in over 1500 commodities for which no special preference is afforded increased more modestly from 4.2 to 5.0 per cent. Up to half of the increase in US imports sourced from Mexico can be attributed to its preferential treatment.

The simple average Canadian share of US imports has also increased by 2.0 percentage points since the Canada-US Free Trade Agreement (FTA) came into effect in 1989. Figure 4 also suggests that Canada's share of US trade was increased by the FTA/NAFTA. For commodities where the MFN tariff rate is zero, and therefore there is no preference for Canada, Canadian goods now account for a smaller share of US imports than they did in 1989. But where there is a preference, Canada now captures substantially larger shares of US imports. Although US tariffs are typically low, trade appears to be quite sensitive to even small trade preferences.

Preferential Trade Areas (PTAs) have received a great deal of analytical and empirical attention since Viner (1950) distinguished between the trade creationary and trade diversionary effects of preferential tariff liberalization. Much of this attention is driven by the ambiguous welfare implications of PTA's. Favorable effects ("trade creation") result from removing distortions in the relative price between domestically produced commodities and commodities produced in other members of the PTA. Unfavorable effects ("trade diversion") come from the introduction of distortions between the relative price of commodities produced by PTA members and non-members (Frankel, Stein and Wei 1996). Research has also been motivated by the question of whether PTA's help or hinder movement towards the first best of global free trade (for example, Baldwin 1996, Levy 1997, Bagwell and Staiger 1999).

This paper seeks to shed light on the extent to which actual PTA's affect trade. Most studies examining the impact of actual PTA's are either simulations or examine changes in the direction of aggregate trade between countries or regions following the introduction of the PTA. Examples of these for NAFTA are Gould (1998) and Garces-Diaz (2001). Gould finds that NAFTA has increased US-Mexico trade, but has had no effect on US-Canada or Mexico-Canada trade. Garces-Diaz finds that Mexico's export boom is not attributable to NAFTA.

Research at an industry level includes two papers on NAFTA by Krueger (1999, 2000), who studies North American trade patterns at the 3 and 4 digit industry level. Krueger finds no evidence that NAFTA has had any impact on intra-North American trade. Head and Ries (1999) study the industry rationalization effects of tariff reductions and find that on balance, NAFTA has had little net effect on the scale of Canadian firms. In studies of MERCOSUR, the PTA formed between Brazil, Argentina, Uruguay and Paraguay, Yeats (1997) finds that the fastest growth in intra-MERCOSUR trade was in commodities in which members did not display a comparative advantage, inferred from the lack of exports of these commodities outside MERCOSUR. This was interpreted as evidence of the trade diversionary effects of MERCOSUR. Chang and Winters (2000) look to Brazilian import price data to examine whether preferential tariffs have depressed the prices of excluded countries' exports. They find the rather extraordinary result that due to the tariff preference, Argentinian competition has led to significant and substantial reductions in American, Japanese, Korean and most other countries' export prices to Brazil.

I attribute the difference in this paper's findings from Krueger(1999, 2000) to two factors. Firstly, two more years of data have become available. More importantly, this paper looks to the level of commodity detail at which tariffs are set, rather than at a more aggregate level. This allows the use of better tariff data. Much of the cross–commodity variation in tariff preferences occurs even within quite detailed industry sectors. Focussing at the commodity level minimizes the loss of variation in tariff preferences, reduces the problems of aggregating across commodities, and allows for a greater ability to control for unobserved factors that may be affecting North American trade.

This paper is organized as follows. Section 2 provides a brief review of NAFTA. Section 3 introduces a simple general equilibrium model of preferential trade liberalization that is used to motivate the empirical examination of NAFTA. Section 4 describes the data. Section 5 presents and discusses the empirical results. Section 6 concludes.

2.2 NAFTA

The Canada-United States Free Trade Agreement (FTA) that came in to effect on January 1, 1989 provided for the gradual elimination of tariffs and for reductions in non-tariff barriers to trade. By January 1, 1998, all US and Canadian tariffs on goods produced in the US and Canada were eliminated, with the exception of over-quota tariffs on several hundred agricultural products (primarily sugar, dairy, poultry, peanuts and cotton). The FTA was incorporated into the North American Free Trade Agreement (NAFTA) on January 1, 1994. NAFTA was designed to increase trade and investment among the United States, Canada and Mexico. Almost all tariffs on goods originating in the US, Canada and Mexico will be eliminated by January 1, 2008. NAFTA did not affect the phase-out of tariffs for US-Canada trade under the FTA. Some US tariffs applied to Mexican goods were, however, transitionally increased by NAFTA.

Prior to 1994, Mexico as a developing country was a beneficiary of the Generalized System of Preferences (GSP). Under the GSP, the US and other developed countries allow duty-free access for the output of developing countries in several thousand commodities, accounting for just under 10 per cent of Mexican exports to the US in 1993. With NAFTA, the US ceased to confer GSP benefits on Mexico.

Outside of Europe, NAFTA covers a much larger amount of trade than any other regional trading arrangement (Baldwin, 1996), and there are prospects for NAFTA's incorporation into a free trade agreement covering the all of the Americas. While NAFTA is not a "deep" integration like the European Union and the Australia-New Zealand Closer Economic Relations Trade Agreement, it contains provisions that go beyond mere removal of tariffs and quantitative trade restrictions, including disciplines on the regulation of investment, transportation and financial services, intellectual property, government purchasing, competition policy, and the temporary entry of business persons (Hufbauer and Schott, 1993).

2.3 A Simple Model and the Empirical Strategy

This paper seeks to exploit the cross-commodity variation in the tariff preference that is afforded to goods originating in NAFTA partners to identify NAFTA's effect on North American trade patterns. The paper focuses on where the US sources its imports of different commodities from. It seeks to explain changes in US import patterns using the preference afforded to commodities of Canadian and Mexican origin. The idea is that where Canada and Mexico are afforded no special preference (where the MFN tariff rate is zero, for instance), NAFTA's only impact should come through a general equilibrium effect on factor prices, or through reductions in "border effects" due to NAFTA provisions that go beyond tariff liberalization. For commodities where NAFTA causes a preference to open up for Canadian and Mexican goods, the preference should have an additional effect causing US consumers to substitute towards Canadian and Mexican goods and away from other sources of supply. This effect can be illustrated using a simple model.

A. Model Description

There are n almost identical countries each producing a continuum of commodities. All commodities are produced competitively using labor under constant returns to scale. Trade is driven by preference for variety and output being differentiated by country of origin. Initially every country imposes ad-valorem tariffs on all imports, which are rebated as a lump sum to consumers. Pairs of countries then enter into preferential trading agreements whereby each country lowers tariffs on imports from its partner country, but does not adjust the tariff on imports from other countries. This causes consumers to substitute towards the output of the preferred country and away from all other sources of supply, including domestic production. The model assumptions are set out in detail below.

1. There are n almost-identical countries, denoted by $C = 1, .., n$.

2. There is 1 factor of production, labor, supplied inelastically. The total labor supply in each country is 1.

3. There is a continuum of industries z on the interval [0,1]. In each country, every industry produces a commodity competitively under constant returns to scale. Each commodity has a unit labor requirement of 1.

4. Consumers in each country are assumed to have identical Cobb-Douglas preferences over the output of each industry with the function of income spent on industry z being $b(z)$ (Equation 1). Expenditure shares for each industry are therefore constant for all prices and incomes. All income is spent so the integral of $b(z)$ over the interval $[0,1]$ is 1 (Equation 2).

$$U = \int_0^1 b(z) \ln Q(z)\, dz. \tag{2.1}$$

$$\int_0^1 b(z)\, dz = 1. \tag{2.2}$$

5. An Armington demand structure is assumed. Each commodity is not a homogeneous good but is instead differentiated according to the country of origin. $Q(z)$ can be interpreted as a sub-utility function that depends on the quantity of each variety of z consumed. I choose the CES function with elasticity of substitution $\sigma_z > 1$. Let $q^D(z_c)$ denote the quantity consumed of commodity z produced in country C. $Q(z)$ is defined by Equation 3:

$$Q(z) = \left(\sum_{c=1}^{N} q^D(z_c)^{\frac{\sigma_Z - 1}{\sigma_Z}} \right)^{\frac{\sigma_Z}{\sigma_Z - 1}} \tag{2.3}$$

6. Tariffs. Initially every country imposes an ad-valorem tariff $t(z)$ on imports of commodity z, which is rebated as a lump-sum to consumers.

7. Preferential Trade Agreements. The world divides itself into $\frac{n}{2}$ symmetric trade blocs. Pairs of countries enter into preferential trading agreements whereby each country levies a tariff $t^P(z) \leq t(z)$ on imports from its partner country, but does not adjust the tariff on imports from other countries.

B. Equilibrium Prior to Preferential Trade Agreements

In general equilibrium, consumers maximize utility, firms maximize profits, all labor is fully employed and trade is balanced. Because of the symmetry of countries and the assumptions of constant returns to scale and perfect competition, all wages and prices (exclusive of tariffs) are equal in all countries and can be normalized to 1. Tariffs raise the price paid by domestic consumers for imported goods to $1 + t(z)$. Let $T_1(z)$ denote tariff revenue collected in country 1 on imports of commodity z, let Y_1 denote income in country 1, and $q_1^D(z_c)$ denote consumption in country 1 of commodity z produced in country c. From the perspective of country 1, income is equal to the sum of factor income (wages) plus tariff revenue.

$$T_1(z) = \sum_{c \neq 1} t(z) q_1^D(z_c). \tag{2.4}$$

$$Y_1 = 1 + \int_0^1 T_1(z)\, dz. \tag{2.5}$$

Consumers in country 1 maximize utility subject to expenditure being equal to income. Due to the unit substitution elasticity between industries, the share of income spent on commodity z is constant at $b(z)$:

$$q_1^D(z_1) + \sum_{c \neq 1} q_1^D(z_c)(1 + t(z)) = b(z) Y_1 \tag{2.6}$$

Differentiating with respect to consumption levels of each commodity, we find that the tariff on imported goods causes domestic consumers to substitute towards domestically produced varieties. The amount of substitution depends on the level of the tariff and on the elasticity of substitution between varieties:

$$\forall z, \forall_{c \neq 1}, \quad \frac{q_1^D(z_1)}{q_1^D(z_c)} = (1 + t(z))^{\sigma z}. \tag{2.7}$$

Equilibrium conditions for all other countries are symmetric. All countries produce equal quantities of each commodity. Tariffs raise the price of imported goods relative to domestically produced varieties, and consumers substitute away from imported goods accordingly. Table 1 summarizes the share by value (exclusive of tariffs) or, equivalently, the share by quantity that each country's production commands of Country 1's consumption and imports of a arbitrary commodity z. Countries 2,..,n each account for a $\frac{1}{n-1}$ share of country 1's imports of each commodity. Their share of consumption of z in country 1 is declining in the tariff and in the elasticity of substitution.

Table 1: Source of Country 1's Consumption and Imports (Share)

Country of Origin	Consumption of z	Imports of z
1	$\frac{1}{1+(n-1)(1+t(z))^{-\sigma z}} > \frac{1}{n}$	–
2	$\frac{1}{n-1+(1+t(z))^{\sigma z}} < \frac{1}{n}$	$\frac{1}{n-1}$
$3, .., n$	$\frac{1}{n-1+(1+t(z))^{\sigma z}} < \frac{1}{n}$	$\frac{1}{n-1}$

C. Equilibrium After Preferential Trade Liberalization

Now assume that the world divides itself into the $\frac{n}{2}$ symmetric preferential trade areas detailed in the model description, including one between countries 1 and 2. Due to the symmetry of the arrangement, all wages and therefore prices (exclusive of the tariffs) remain equal and can be normalized to 1. But the definition of tariff revenue in Equation 4 and Equations 6 and 7 from the consumer's utility maximization problem need to be modified to account for the preferential trade liberalization:

$$T_1(z) = t^P(z)\, q_1^D(z_2) + \sum_{c>2} t(z)\, q_1^D(z_c)\,. \tag{2.8}$$

$$q_1^D(z_1) + q_1^D(z_2)\left(1 + t^P(z)\right) + \sum_{c>2} q_1^D(z_c)\left(1 + t(z)\right) = b(z)\, Y_1 \tag{2.9}$$

$$\forall z, \forall_{c>2}: \quad \frac{q_1^D(z_1)}{q_1^D(z_c)} = (1 + t(z))^{\sigma z}; \quad \frac{q_1^D(z_1)}{q_1^D(z_2)} = \left(1 + t^P(z)\right)^{\sigma z}. \tag{2.10}$$

The "market share" effects of the preferential liberalization from the perspective of country 1 are summarized in Table 2. Now that the output of country 2 receives preferential tariff's in country 1, country 2 accounts for an increased share of country 1's consumption and imports of each commodity. A fraction of the increased share of consumption comes from a reduced share of domestic suppliers ("trade creation"), and the rest comes from a reduced share of goods imported from countries outside the trade bloc ("trade diversion"). The size of the increased share in an arbitrary industry z depends positively on the size of the tariff preference in the industry $\frac{1+t(z)}{1+t^P(z)}$, and positively on the elasticity of substitution between varieties of z. That country 2 experiences no decrease in shares of country 1's markets is a relatively special result of this model, driven by the preservation of relative factor prices due to the continuing symmetry of countries.

Table 2: Source of Country 1's Consumption and Imports (Share) After Liberalization

Country of Origin	Consumption of z	Imports of z
1	$\frac{1}{1+(1+t^P(z))^{-\sigma}Z+(n-2)(1+t(z))^{-\sigma}Z}$	–
2	$\frac{1}{1+(1+t^P(z))^{-\sigma}Z+(n-2)(1+t(z))^{-\sigma}Z}$	$\frac{1}{1+(n-2)\left(\frac{1+t(z)}{1+t^P(z)}\right)^{-\sigma}} > \frac{1}{n-1}$
$3,..,n$	$\frac{1}{(1+t(z))^{\sigma}Z+\left(\frac{1+t(z)}{1+t^P(z)}\right)^{\sigma}Z+n-2}$	$\frac{1}{\left(\frac{1+t(z)}{1+t^P(z)}\right)^{\sigma}+n-2} < \frac{1}{n-1}$

D. Empirical Strategy

This model forms the basis of the empirical examination of the effects of NAFTA. Controlling for σ, the change in where the US sources its imports of different commodities after the FTA/NAFTA should be systematically related to the tariff preference that the US gives to goods of Canadian or Mexican origin. The empirical work commences with reduced form equations of the form:

$$y_{czt} = x'_{cz}.\pi_{ct} + \delta_c.pref_{cz} + \alpha_{ct}pref_{cz} + \varepsilon_{cz}, \tag{2.11}$$

where c denotes countries of origin, z denotes commodities and t time; y_{czt} is either the share of US imports of commodity z that is sourced from country c ($share_{czt}$), or the growth rate of total US imports of commodity z (g_{zt}); x_{cz} is a set of controls with potentially time-varying effects π_{ct}; and $pref_{cz}$ is the preference in the year 2000 that the US affords to country c for imports of commodity z. The α_{ct} are the time-varying effects of the tariff preference, and are normalized to zero in 1988 for Canada and in 1993 for Mexico (the years prior to Canada's entry into the FTA and Mexico's entry into NAFTA respectively). For $c =$ Canada and $t \geq 89$, α_{ct} measures the impact of NAFTA's preference for Canadian goods on the share of US imports sourced from Canada. For $c =$ Mexico and $t \geq 94$, α_{ct} measures the impact of NAFTA's preference for Mexican goods on the share of US imports sourced from Mexico. Because the preference is phased in, α_{ct} should grow through the transition period.

For the growth rate regressions, where g_{zt} is the dependent variable, α_{ct} measures the impact of NAFTA's preference on the growth of trade, a measure of trade creation due to NAFTA.

2.4 Data

Since 1989 the US has collected its trade data according to the Harmonized Tariff Schedule (HTS), a schedule that is now standard for many countries up to the 6 digit level. The US International Trade Commission (USITC) maintains a database at the 10 digit level of US imports classified by commodity, country of origin, import program, month and port of arrival. US tariffs are almost invariably set at the 8 digit level, comprising about 14,000 commodities by the year 2000. Fine changes in detailed commodity classifications often lead to discontinuity in the data. To reduce this I focus at the 8 digit rather than the 10 digit level. I am able to track bilateral trade in 7,091 commodities annually from 1989 to 2000. Because Canada entered into the FTA with the US in 1989, it is necessary to collect data for earlier years. Prior to 1989, trade data was collected according to a different commodity schedule, the TSUSA. Concordances are available for this data, but I am only able to track 4203 commodities continuously from 1980 to 2000. Almost all of the extra attrition occurs between 1988 and 1989.

For each year I calculate the share of US imports of each commodity measured by customs value (that is, exclusive of tariffs, freight and insurance) that originate in each of the trading partners of the US. The change in the simple average of Canada's and Mexico's share of US imports by commodity is summarized in Table 3 for three periods: 1989 to 1993; 1993 to 2000; and 1989 to 2000. In 1989 to 1993 during the FTA but before NAFTA, the average of Canada's US import market shares increased by 1.3 percentage points, while Mexico's increased by a more modest 0.3 percent. From 1993 to 2000, Canada's average share increased by a further 0.7 percent, while Mexico's increased by a further 2.0 percent. The data also contains information on physical quantities imported for a large number of the commodities, allowing the calculation of unit price variables. Where possible, I calculate the price of Canadian and Mexican goods relative to the price of goods sourced from the rest of the world, denoted rp_{czt}.

The tariff rates are also available from the USITC. While most tariffs are ad-valorem, there are still several hundred specific tariffs applied. The USITC calculates the ad-valorem equivalent of any specific tariffs. The distribution of MFN tariffs in 2000 is illustrated in Figure 5. The simple average of tariff rates is low at 6 per cent, but importantly there is a large amount of dispersion, with the standard deviation of MFN tariff rates being 12 per cent. Under NAFTA, all but a few hundred of these tariffs have been eliminated for Canada and are in the process of being eliminated for Mexico, creating a large variation in the preference given to goods of Canadian and Mexican origin (Figure 6).

Complicating matters somewhat was the existence of preferential treatment for some Mexican and Canadian goods prior to the FTA/NAFTA. In 1965, Canada and the US negotiated the Auto-Pact, allowing duty-free trade in many automotive goods. The Auto Pact was incorporated into the FTA. Mexico was also a beneficiary of the Generalized System of Preferences (GSP), under which the US (and other developed countries) gave developing countries preferential access to their markets. The US gave duty free access to the output of developing countries for several thousand commodities, although goods where developing countries may have gained most from preferential access were often excluded (notably many agricultural items and textiles, clothing and footwear), and the preference could easily be removed under "competitive needs limitations" to the GSP. Upon entry into NAFTA, Mexico was no longer entitled to claim GSP benefits for trade with the US.

For each commodity, I calculate the preference afforded to Canadian and Mexican goods as the MFN tariff rate applicable to that commodity in January 2000 less the tariff rate applicable to Canadian and Mexican goods respectively. The distribution of these preferences is illustrated in Figure 6. To account for the pre-existing preference under the GSP for Mexico, I define the variable $GSP93$ that takes a value equal to the MFN tariff rate if Mexico was entitled to GSP preference for that commodity in 1993, and zero otherwise. To similarly account for the preference given to Canada under the Auto Pact, I define the variable $AP89$ that takes a value equal to the MFN tariff rate if goods could be entered duty free under the Auto Pact, and zero otherwise.

The preferences given to Canadian and Mexican production are systematically related to some of the characteristics of the commodities. This is to some extent evident from Figures 3 and 4 which, for Canadian goods especially, show a systematic negative relationship between the preference and Canada's market share. Given that the most protected sectors are agriculture and simple manufactures like textiles, apparel and footwear, the highest preferences are mostly in these sectors. This is especially true for simple manufactures because much agricultural protection was preserved under NAFTA. Where the preference exceeds 20 percent for either Mexican or Canadian goods, 70 percent of the commodities are textiles, clothing or footwear, 17 percent are agricultural commodities, and the remainder are light trucks, glassware, bags, brooms and cheap watch movements.

The NAFTA preferences are strongly biased towards commodities in which developed countries have a comparative disadvantage. This effect was investigated by examining the relationship between the relative price of Canadian output and the NAFTA preferences for Canadian goods. The unit import price data contains some very extreme values that suggests that much of it is not measured well. Given that most tariffs are ad-valorem, customs agents may be less concerned with physical quantities. To reduce the impact of extreme observations, extreme values were discarded in some regressions, the cut-off alternatively being where the absolute value of the log relative price equalled 2 or 1. Table 4 reports results from regressing $\ln rp_{czt}$ on $\ln pref_{cz}$ in 1993 and 2000. The results strongly suggest that the relative price of Canadian goods was and is substantially higher in commodities where there is a large NAFTA preference. This is consistent with the hypothesis that NAFTA preferences are skewed towards "developing country goods" and suggests that NAFTA may have caused Canada to expand its share of US imports in commodities where it is a relatively high cost producer.

2.5 Results

A. Market Share Results

Figures 7 and 8 plot Mexico's and Canada's share of US imports classified according to the year 2000 preference extended by the US to goods produced in Mexico and Canada respectively. The "no treatment" goods are those for which the tariff for Mexican or Canadian goods is identical to the tariff applied to goods from countries with which the US has normal trade relations. The "low treatment" goods are those for which Mexico and Canada benefited from a preference of up to and including 10 per cent in January 2000, while the "high treatment" goods are those where the preference exceeded 10 percent. The Figures are very suggestive. In the five years prior to Mexico's entry into NAFTA, its share of all three classes of commodities is fairly stable, although there is a gradual decline for the no-treatment commodities and a slight increase for the high-treatment goods, especially in 1993. Some of this increase in high-treatment goods could be ascribed to anticipation effects, because NAFTA was foreshadowed in 1989 and the agreement was ratified in 1993. After 1993 there is a very pronounced change in Mexico's exports to the US. Its share of the high-treatment commodities jumps immediately, and almost trebles by 2000. Mexico's share of low-treatment goods begins to increase in 1995, and has increased by 75 per cent by 2000. Its share of no-treatment goods increases much more modestly, rising only 20 per cent by 2000.

Figure 8 for Canada is less stark but is still very suggestive. The unfortunate thing about Figure 8 is that discontinuity in the data between 1988 and 1989 has led to a particularly severe loss of data for the high treatment goods, consistent with anecdotal evidence that fine changes to classifications are often used as a protectionist device. But the FTA/NAFTA's effect is still apparent. In the years leading up to the FTA, Canada's share of US imports was declining, although this trend had largely abated by the late 1980s. Since 1988, Canada's share in the no-treatment goods has continued to decline, and is 4.3 per cent lower in 2000. However, its share of low-treatment and high-treatment goods has recovered sharply, up by 33 and 30 per cent respectively by 2000.

Table 5 and Figures 9 to 14 report OLS estimates of Equation 11. The time-varying effect of the tariff preference has been normalized to zero in the year preceding entry into the FTA or NAFTA. The dependant variable is $share_{czt}$. Because of saturation of the model with respect to c, the model is estimated separately for Canada and Mexico, the dependence between ε_{czt} across countries has not been exploited. Column 1 and Figure 9 report results for 1980-2000 of a fixed effects model with dummies for each commodity and for each year. The only control variable is the Auto Pact variable. The interaction between the NAFTA preference and Canada's share of US imports only becomes significantly positive from 1996. By 2000, each 1 per cent of preference has led to an increase of 0.25 percentage points in Canada's share of US imports. A little disturbingly, there is a significant negative relationship in two of the pre-treatment years, 1982 and 1983. Column 2 and Figure 2 report results for the same years but instead of time and commodity dummies the model includes interactions between time dummies and 97 HTS 2-digit industry dummies. The industries are listed in Table 7. The estimated NAFTA effect is faster and stronger, with significant positive effects at the 10 per cent level evident from 1992. By 2000, each 1 per cent of preference has led to an increased share of 0.38 percentage points. The significant negative relationships reported in column 1 for 1982 and 1983 have disappeared.

Column 3 and Figure 11 is the same model as column 1 and Figure 9 but estimated for the 7091 commodities that could be tracked continuously from 1989. The time-varying effect of the preference has been normalized to zero in 1989. The estimates are similar to column 1 but significant positive effects are evident from 1992. This may be due to the inclusion of many more high-treatment commodities. Column 4 and Figure 12 are the analogues of column 2 and Figure 10, only using the 7091 commodities from 1989 to 2000. The estimated effects are again very similar. In all four regressions, each 1 per cent of preference is associated with an increase of 0.24 to 0.38 percentage points in Canada's share of US imports. In a later section of this paper, estimates of the elasticity of substitution σ are sought.

Column 5 and Figure 13 report results for 1989-2000 of a fixed effects model for Mexico with dummies for each commodity and for each year. The only control variable is the GSP variable. The interaction between the NAFTA preference and Mexico's share of US imports becomes significantly positive in the first year of NAFTA, 1994. By 2000, each 1 per cent of preference has led to an increase of 0.30 percentage points in Mexico's share of US imports. Column 6 and Figure 14 report results for the same years but instead of time and commodity dummies the model includes interactions between time dummies and 97 HTS 2-digit industry dummies. The estimated NAFTA effect is slower and weaker, with significant positive effects at the 10 per cent level evident from 1996. By 2000, each 1 per cent of preference has led to an increased share of 0.18 percentage points.

Columns 7 and 8 report estimates of the effect of Mexico's loss of GSP preferences upon its entry into NAFTA, from the same regressions reported in columns 5 and 6 respectively. The regression reported in Column 7 contains only commodity and time dummies, while the regression in Column 8 contains all interactions between time and 2-digit industry dummies. The GSP effect is normalized to zero in 1993, the last year that Mexico could claim GSP benefits. Column 7 suggests that prior to NAFTA, Mexico was increasing its share in commodities for which the US conferred GSP benefits. Upon Mexico's entry in to NAFTA and the loss of GSP benefits, this trend is immediately reversed. Each 1 per cent loss of GSP benefits is associated with a 0.25 percentage point decline in Mexico's share of US imports. The estimates in Column 8 are similar in magnitude but less precisely estimated.

B. Trade Creation and Trade Diversion

The results reported in Figures 7 to 14 and Table 5 suggest that NAFTA preferences have had a pronounced effect on the source of US imports. But the results do not tell us whether this increased share for Canada and Mexico is the result of new international trade displacing US domestic production ("trade creation") or whether it is simply displacement of imports from other sources ("trade diversion"). The model presented in Section 3 predicts that it will be a little of both. I do not have data on US production matched to the tariff schedule, so instead I examine direct evidence of trade creation by performing OLS regression on Equation 11 with g_{zt}, the growth rate of total US imports of commodity z, as the dependent variable. Greater trade liberalization, even if it is preferential, should produce faster growth in trade.

Unfortunately the data in the model is systematically biased against finding evidence of trade creation from NAFTA, and therefore is biased towards concluding that Canada's and Mexico's increased share of US trade is predominantly trade diversion. The reason for this is that the data fails to account for the evolution of the normal trade relations or MFN tariff rate over time. For most commodities, but not all, this has been decreasing. The problem with the uneven evolution of the MFN rate is that Mexico and Canada may enjoy the greatest preferences in commodities where the US has been slowest to adjust its MFN rate. Greater preferences for Canada and Mexico may not only reflect greater preferential trade liberalization, but slower trade liberalization on a multilateral basis. It is therefore unclear that the growth rate in trade at the commodity level should be positively related to NAFTA preferences.

Table 6 reports the regression results. The regressions reported in columns 1 and 2 are the analogues of those in columns 1 and 2 in Table 5. They seek to find any evidence of faster trade growth following Canada's entry into the FTA in 1989. There is no evidence of this effect. Columns 3 and 4 are the analogues of columns 5 and 6 in Table 5, and were produced to find evidence of faster trade growth following Mexico's entry into NAFTA. Again there is none. But for the reasons argued above, this should not be taken as evidence that NAFTA has only had a trade diversionary effect.

C. Elasticity of Substitution

The model presented in Section 3 can be used to derive estimates of the typical elasticity of substitution $\sigma(z)$ using the observed change in Canadian and Mexican market shares. This parameter is of interest because it helps determine the effect of trade impediments on the volume of trade and because it is a critical ingredient of welfare analysis of trade liberalization. If we define $R(z)$ to be country 2's share of country 1's imports of commodity z post-PTA divided by its pre-PTA share then from Tables 1 and 2 we can derive Equation 12:

$$\ln R(z) - \ln \frac{n-1-R(z)}{n-2} = \sigma_z \ln \left(\frac{1+t(z)}{1+t^P(z)} \right) \tag{2.12}$$

Estimates of the mean σ_z can be obtained by running OLS on Equation 12, where $R(z)$ is calculated using 1988 and 2000 shares for Canada and 1993 and 2000 shares for Mexico. It should be noted that the regression can only be run for commodities where trade is observed in both years. The second term in Equation 12 should be reasonably close to zero if n is large, but in any case it can be approximated by noting that $n-1$ is the inverse of the pre-PTA share that country 2 obtained of country 1's imports of commodity z. The 1988 Canadian shares and 1993 Mexican shares are used to estimate this second term. The results are reported in Table 8. Without the adjustment for the second term, OLS regressions suggest an average elasticity of 4.8 in the case of goods imported from Canada and 6.3 for goods imported from Mexico. With the adjustment, the estimated elasticities are slightly higher at 5.2 and 7.0 respectively. The higher estimates for Mexico suggest that Mexican output is more concentrated in less differentiated commodities.

These elasticities of substitution suggest that consumers are quite willing to substitute between different varieties of the same commodity. One implication of this willingness to substitute is that small costs to international trade, whether due to natural barriers such as transport costs or artificial barriers such as tariffs, will have a large effect on trade volumes. With a substitution elasticity of 5, the simple average US tariff of 6 per cent will reduce consumption of imported varieties relative to domestic varieties by 25 per cent. With a substitution elasticity of 7, this reduction in relative consumption is 33 per cent.

2.6 Conclusion

This paper seeks to identify an effect for NAFTA by focusing on where the United States sources its imports of different commodities from. NAFTA appears to have a substantial effect on North American trade. Mexican and Canadian shares of US imports have increased most rapidly in commodities where the greatest NAFTA preference was conferred, even though Canada appears to be a high cost producer of many of these commodities. The Canadian share of US imports declined in commodities where it was not given a new preference, while the Mexican share increased much more modestly. The results of this paper suggest that trade flows are very sensitive to even small tariff preferences. The NAFTA preferences can be used to estimate how willing consumers are to substitute between different varieties of the same commodity. The implied average substitution elasticity is approximately 5 for the commodities produced by Canada and 7 for Mexico. Consumers are quite willing to substitute between different varieties of the same commodity. Small changes in trade impediments, whether due to natural or non-natural barriers, could therefore have substantial effects on international trade volumes. Preferential liberalization will have substantial effects on the direction of trade.

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Table 3: Change in Canada's and Mexico's Share of US Imports 1989-2000
(Simple average of market share in 7032 commodities)

Period	Change in Canada's Average Share	Change in Mexico's Average Share
1989-1993	0.013	0.003
	(0.002)	(0.001)
1993-2000	0.007	0.020
	(0.002)	(0.002)
1989-2000	0.020	0.023
	(0.003)	(0.002)

Notes: standard errors appear in parentheses beneath coefficient estimates

Table 4: NAFTA Preferences and the Relative Cost of Canadian Goods

Year	1989	1989	1989	2000	2000	2000
LHS Variable	lrp_{czt}	lrp_{czt}	lrp_{czt}	lrp_{czt}	lrp_{czt}	lrp_{czt}
Keep if		$\lvert lrp_{czt} \rvert<2$	$\lvert lrp_{czt} \rvert<1$		$\lvert lrp_{czt} \rvert<2$	$\lvert lrp_{czt} \rvert<1$
RHS Var.						
$pref_{cz}$	1.353	1.749	1.07	0.501	0.847	2.022
	(0.360)	(0.216)	(0.149)	(0.269)	(0.152)	(0.379)
R^2	0.003	0.016	0.017	0.001	0.006	0.011
N	4577	3986	2970	6429	5385	2659

Notes: robust errors appear in parentheses beneath coefficient estimates

Table 5: Effect of NAFTA Preferences 1

	Canada				Mexico			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pref	*Pref*	*Pref*	*Pref*	*Pref*	*Pref*	*GSP*	*GSP*
Preference*1980	-0.054	0.063						
	(0.077)	(0.140)						
Preference*1981	-0.062	-0.074						
	(0.094)	(0.152)						
Preference*1982	-0.152	-0.045						
	(0.088)	(0.152)						
Preference*1983	-0.249	-0.114						
	(0.085)	(0.148)						
Preference*1984	-0.062	0.013						
	(0.083)	(0.145)						
Preference*1985	-0.076	0.005						
	(0.081)	(0.140)						
Preference*1986	-0.075	-0.022						
	(0.084)	(0.141)						
Preference*1987	0.014	0.041						
	(0.084)	(0.143)						
Preference*1988								
Preference*1989	-0.031	0.033			-0.037	0.020	0.574	0.693
	(0.090)	(0.155)			(0.029)	(0.067)	(0.109)	(0.175)
Preference*1990	-0.057	0.054	0.035	0.040	-0.005	0.011	0.440	0.478
	(0.075)	(0.138)	(0.034)	(0.064)	(0.026)	(0.064)	(0.107)	(0.181)
Preference*1991	-0.058	0.094	0.030	0.076	-0.008	0.002	0.274	0.344
	(0.075)	(0.138)	(0.033)	(0.064)	(0.026)	(0.061)	(0.096)	(0.182)
Preference*1992	0.062	0.238	0.092	0.183	-0.012	-0.023	0.106	0.107
	(0.079)	(0.149)	(0.033)	(0.068)	(0.025)	(0.064)	(0.100)	(0.190)
Preference*1993	0.104	0.235	0.102	0.173				
	(0.080)	(0.146)	(0.034)	(0.068)				
Preference*1994	0.106	0.224	0.108	0.186	0.058	0.023	0.178	0.178
	(0.075)	(0.140)	(0.032)	(0.066)	(0.024)	(0.068)	(0.091)	(0.186)
Preference*1995	0.122	0.242	0.142	0.225	0.154	0.111	0.190	0.130
	(0.076)	(0.142)	(0.032)	(0.069)	(0.029)	(0.077)	(0.091)	(0.193)
Preference*1996	0.214	0.279	0.179	0.210	0.210	0.139	0.097	0.017
	(0.079)	(0.143)	(0.033)	(0.069)	(0.029)	(0.08)	(0.097)	(0.205)
Preference*1997	0.229	0.300	0.221	0.264	0.194	0.108	0.124	0.064
	(0.078)	(0.144)	(0.035)	(0.072)	(0.029)	(0.078)	(0.099)	(0.199)
Preference*1998	0.236	0.339	0.249	0.308	0.219	0.151	0.143	0.095
	(0.079)	(0.145)	(0.035)	(0.072)	(0.027)	(0.076)	(0.094)	(0.199)
Preference*1999	0.252	0.355	0.249	0.317	0.282	0.220	0.217	0.158
	(0.078)	(0.144)	(0.034)	(0.070)	(0.031)	(0.08)	(0.099)	(0.200)
Preference*2000	0.262	0.378	0.242	0.286	0.297	0.182	0.249	0.189
	(0.086)	(0.150)	(0.037)	(0.069)	(0.030)	(0.081)	(0.098)	(0.197)
Time and Commodity Dummies	Yes	No	Yes	No	Yes	No	Yes	No
Time*Industry Dummies	No	Yes	No	Yes	No	Yes	No	Yes
Years	21	21	12	12	12	12	12	12
Commodities	4203	4203	7091	7091	7091	7091	7091	7091

Notes: Robust standard errors are reported in parentheses.The dependent variable is the share of US imports by commodity sourced from Canada or Mexico respectively in the given year. Preference in columns 1 through 6 is the difference between the MFN tariff rate and the tariff applicable to goods of Canadian or Mexican origin in January 2000. Preference in columns (7) and (8) is Mexico's loss of GSP benefits upon entry into NAFTA.

Table 6: Effect of NAFTA Preferences 2

	Trade Creation			
	(1)	(2)	(3)	(4)
Preference*1980				
Preference*1981	-0.030	1.225		
	(0.736)	(0.836)		
Preference*1982	0.806	1.431		
	(0.738)	(0.805)		
Preference*1983	0.295	1.538		
	(0.736)	(0.819)		
Preference*1984	0.405	1.384		
	(0.695)	(0.797)		
Preference*1985	2.228	2.237		
	(0.859)	(0.857)		
Preference*1986	1.156	1.760		
	(0.677)	(0.788)		
Preference*1987	-1.698	0.881		
	(0.702)	(0.771)		
Preference*1988				
Preference*1989	-0.417	1.150		
	(0.922)	(1.061)		
Preference*1990	0.232	0.816	-0.173	-0.429
	(0.597)	(0.659)	(0.295)	(0.442)
Preference*1991	-0.219	0.583	-0.147	-0.943
	(0.609)	(0.702)	(0.293)	(0.444)
Preference*1992	0.134	1.419	0.526	0.095
	(0.593)	(0.673)	(0.297)	(0.430)
Preference*1993	-0.002	1.412		
	(0.587)	(0.632)		
Preference*1994	-0.335	0.277	-0.374	-1.164
	(0.606)	(0.687)	(0.296)	(0.437)
Preference*1995	-0.211	0.927	0.141	-0.082
	(0.601)	(0.672)	(0.283)	(0.416)
Preference*1996	-0.306	0.603	0.032	-0.244
	(0.582)	(0.643)	(0.267)	(0.402)
Preference*1997	0.204	1.452	0.292	-0.084
	(0.582)	(0.649)	(0.280)	(0.421)
Preference*1998	-0.149	0.798	0.097	-0.268
	(0.591)	(0.659)	(0.274)	(0.406)
Preference*1999	-0.092	0.698	0.085	-0.551
	(0.571)	(0.632)	(0.267)	(0.406)
Preference*2000	0.120	1.364	0.032	-0.572
	(0.567)	(0.607)	(0.262)	(0.376)
Time and Commodity Dummies	Yes	No	Yes	No
Time*Industry Dummies	No	Yes	No	Yes
Years	21	21	12	12
Commodities	4203	4203	7091	7091

Notes: Robust standard errors are reported in parentheses.The dependent variable is the share of US imports by commodity sourced from Canada or Mexico respectively in the given year. Preference is the difference between the MFN tariff rate and the tariff applicable to goods of Canadian or Mexican origin in January 2000.

Table 7: 2-digit HTS Industries and Value of Imports in 2000

	Industry Description	$m
1	LIVE ANIMALS	1929
2	MEAT AND EDIBLE MEAT OFFAL	3393
3	FISH AND CRUSTACEANS, MOLLUSCS AND OTHER AQUATIC INVERTEBRATES	8153
4	DAIRY PRODUCE; BIRDS' EGGS; NATURAL HONEY; EDIBLE PRODUCTS OF ANIMAL ORIGIN, NES	1064
5	PRODUCTS OF ANIMAL ORIGIN, NESOI	540
6	LIVE TREES AND OTHER PLANTS; BULBS, ROOTS AND THE LIKE; CUT FLOWERS AND ORNAMEI	1160
7	EDIBLE VEGETABLES AND CERTAIN ROOTS AND TUBERS	2649
8	EDIBLE FRUIT AND NUTS; PEEL OF CITRUS FRUIT OR MELONS	3919
9	COFFEE, TEA, MATE AND SPICES	3200
10	CEREALS	806
11	MILLING INDUSTRY PRODUCTS; MALT; STARCHES; INULIN; WHEAT GLUTEN	313
12	OIL SEEDS AND OLEAGINOUS FRUITS; MISCELLANEOUS GRAINS, SEEDS AND FRUITS; INDUSTI	853
13	LAC; GUMS; RESINS AND OTHER VEGETABLE SAPS AND EXTRACTS	493
14	VEGETABLE PLAITING MATERIALS AND VEGETABLE PRODUCTS, NESOI	53
15	ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE	1398
16	EDIBLE PREPARATIONS OF MEAT, FISH, CRUSTACEANS, MOLLUSCS OR OTHER AQUATIC INVE	2202
17	SUGARS AND SUGAR CONFECTIONERY	1480
18	COCOA AND COCOA PREPARATIONS	1408
19	PREPARATIONS OF CEREALS, FLOUR, STARCH OR MILK; BAKERS' WARES	1778
20	PREPARATIONS OF VEGETABLES, FRUIT, NUTS, OR OTHER PARTS OF PLANTS	2678
21	MISCELLANEOUS EDIBLE PREPARATIONS	1247
22	BEVERAGES, SPIRITS AND VINEGAR	8339
23	RESIDUES AND WASTE FROM THE FOOD INDUSTRIES; PREPARED ANIMAL FEED	615
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES	1127
25	SALT; SULFUR; EARTHS AND STONE; PLASTERING MATERIALS, LIME AND CEMENT	2097
26	ORES, SLAG AND ASH	1641
27	MINERAL FUELS, MINERAL OILS AND PRODUCTS OF THEIR DISTILLATION; BITUMINOUS SUBST.	133730
28	INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOUS METALS, OF R/	6909
29	ORGANIC CHEMICALS	30495
30	PHARMACEUTICAL PRODUCTS	12177
31	FERTILIZERS	1714
32	TANNING OR DYEING EXTRACTS; TANNINS AND DERIVATIVES; DYES, PIGMENTS AND OTHER C	2716
33	ESSENTIAL OILS AND RESINOIDS; PERFUMERY, COSMETIC OR TOILET PREPARATIONS	2750
34	SOAP ETC.; LUBRICATING PRODUCTS; WAXES, POLISHING OR SCOURING PRODUCTS; CANDLE	1493
35	ALBUMINOIDAL SUBSTANCES; MODIFIED STARCHES; GLUES; ENZYMES	1248
36	EXPLOSIVES; PYROTECHNIC PRODUCTS; MATCHES; PYROPHORIC ALLOYS; CERTAIN COMBUS	267
37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS	2734
38	MISCELLANEOUS CHEMICAL PRODUCTS	4367
39	PLASTICS AND ARTICLES THEREOF	19088
40	RUBBER AND ARTICLES THEREOF	10187
41	RAW HIDES AND SKINS (OTHER THAN FURSKINS) AND LEATHER	1168
42	ARTICLES OF LEATHER; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR	7157
43	FURSKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF	331
44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL	15453
45	CORK AND ARTICLES OF CORK	175
46	MANUFACTURES OF STRAW, ESPARTO OR OTHER PLAITING MATERIALS; BASKETWARE AND V	302
47	PULP OF WOOD OR OTHER FIBROUS CELLULOSIC MATERIAL; RECOVERED (WASTE AND SCRA	3381
48	PAPER AND PAPERBOARD; ARTICLES OF PAPER PULP, PAPER OR PAPERBOARD	15390
49	PRINTED BOOKS, NEWSPAPERS, PICTURES AND OTHER PRINTED PRODUCTS; MANUSCRIPTS,	3491

50	SILK, INCLUDING YARNS AND WOVEN FABRICS THEREOF	294
51	WOOL AND FINE OR COARSE ANIMAL HAIR, INCLUDING YARNS AND WOVEN FABRICS THEREO	414
52	COTTON, INCLUDING YARNS AND WOVEN FABRICS THEREOF	2113
53	VEGETABLE TEXTILE FIBERS NESOI; YARNS AND WOVEN FABRICS OF VEGETABLE TEXTILE FI	185
54	MANMADE FILAMENTS, INCLUDING YARNS AND WOVEN FABRICS THEREOF	2103
55	MANMADE STAPLE FIBERS, INCLUDING YARNS AND WOVEN FABRICS THEREOF	1171
56	WADDING, FELT AND NONWOVENS; SPECIAL YARNS; TWINE, CORDAGE, ROPES AND CABLES /	851
57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS	1469
58	SPECIAL WOVEN FABRICS; TUFTED TEXTILE FABRICS; LACE; TAPESTRIES; TRIMMINGS; EMBR(	592
59	IMPREGNATED, COATED, COVERED OR LAMINATED TEXTILE FABRICS; TEXTILE ARTICLES SU	792
60	KNITTED OR CROCHETED FABRICS	1005
61	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, KNITTED OR CROCHETED	26405
62	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, NOT KNITTED OR CROCHETED	32801
63	MADE-UP TEXTILE ARTICLES NESOI; NEEDLECRAFT SETS; WORN CLOTHING AND WORN TEXTI	4583
64	FOOTWEAR, GAITERS AND THE LIKE; PARTS OF SUCH ARTICLES	14854
65	HEADGEAR AND PARTS THEREOF	1246
66	UMBRELLAS, SUN UMBRELLAS, WALKING-STICKS, SEAT-STICKS, WHIPS, RIDING-CROPS AND P	284
67	PREPARED FEATHERS AND DOWN AND ARTICLES THEREOF; ARTIFICIAL FLOWERS; ARTICLES	1092
68	ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS	3433
69	CERAMIC PRODUCTS	4074
70	GLASS AND GLASSWARE	4393
71	NATURAL OR CULTURED PEARLS, PRECIOUS OR SEMIPRECIOUS STONES, PRECIOUS METALS	29923
72	IRON AND STEEL	14665
73	ARTICLES OF IRON OR STEEL	14150
74	COPPER AND ARTICLES THEREOF	5113
75	NICKEL AND ARTICLES THEREOF	1541
76	ALUMINUM AND ARTICLES THEREOF	9187
78	LEAD AND ARTICLES THEREOF	213
79	ZINC AND ARTICLES THEREOF	1342
80	TIN AND ARTICLES THEREOF	339
81	BASE METALS NESOI; CERMETS; ARTICLES THEREOF	1107
82	TOOLS, IMPLEMENTS, CUTLERY, SPOONS AND FORKS, OF BASE METAL; PARTS THEREOF OF I	4554
83	MISCELLANEOUS ARTICLES OF BASE METAL	4686
84	NUCLEAR REACTORS, BOILERS, MACHINERY AND MECHANICAL APPLIANCES; PARTS THEREO	180908
85	ELECTRICAL MACHINERY AND EQUIPMENT AND PARTS THEREOF; SOUND RECORDERS AND R	186099
86	RAILWAY OR TRAMWAY LOCOMOTIVES, ROLLING STOCK, TRACK FIXTURES AND FITTINGS, AN	1828
87	VEHICLES, OTHER THAN RAILWAY OR TRAMWAY ROLLING STOCK, AND PARTS AND ACCESSO	163854
88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF	18167
89	SHIPS, BOATS AND FLOATING STRUCTURES	1178
90	OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICA	36620
91	CLOCKS AND WATCHES AND PARTS THEREOF	3485
92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES THEREOF	1423
93	ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF	839
94	FURNITURE; BEDDING, CUSHIONS ETC.; LAMPS AND LIGHTING FITTINGS NESOI; ILLUMINATED	23833
95	TOYS, GAMES AND SPORTS EQUIPMENT; PARTS AND ACCESSORIES THEREOF	19254
96	MISCELLANEOUS MANUFACTURED ARTICLES	2865
97	WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES	5858
	TOTAL	1168447

Table 8: Estimates of the Elasticity of Substitution

	Canada	Canada	Mexico	Mexico
Years	1989-2000	1989-2000	1993-2000	1993-2000
Adjustment	No	Yes	No	Yes
RHS Var.				
$\ln(1+t)-\ln(1+t^P)$	4.83	5.22	6.27	7.01
	(0.54)	(0.74)	(0.87)	(0.94)
ln(1+AP89)	-9.28	-14.82		
	(2.37)	(3.21)		
ln(1+GSP93)			-7.20	-7.82
			(1.71)	(1.84)
N	4814	4814	3038	3038

Notes: robust standard errors appear in parentheses beneath coefficient estimates

Figure 1: Share of Total US Imports 1989-2000

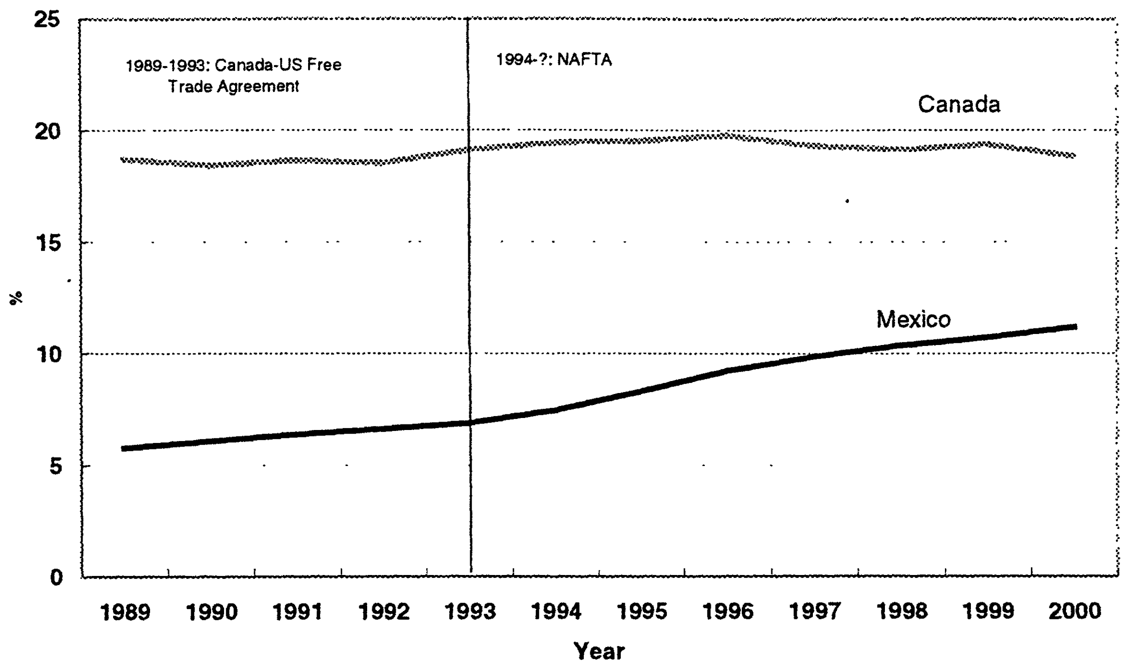


Figure 2: Share of Total US Imports 1989-2000

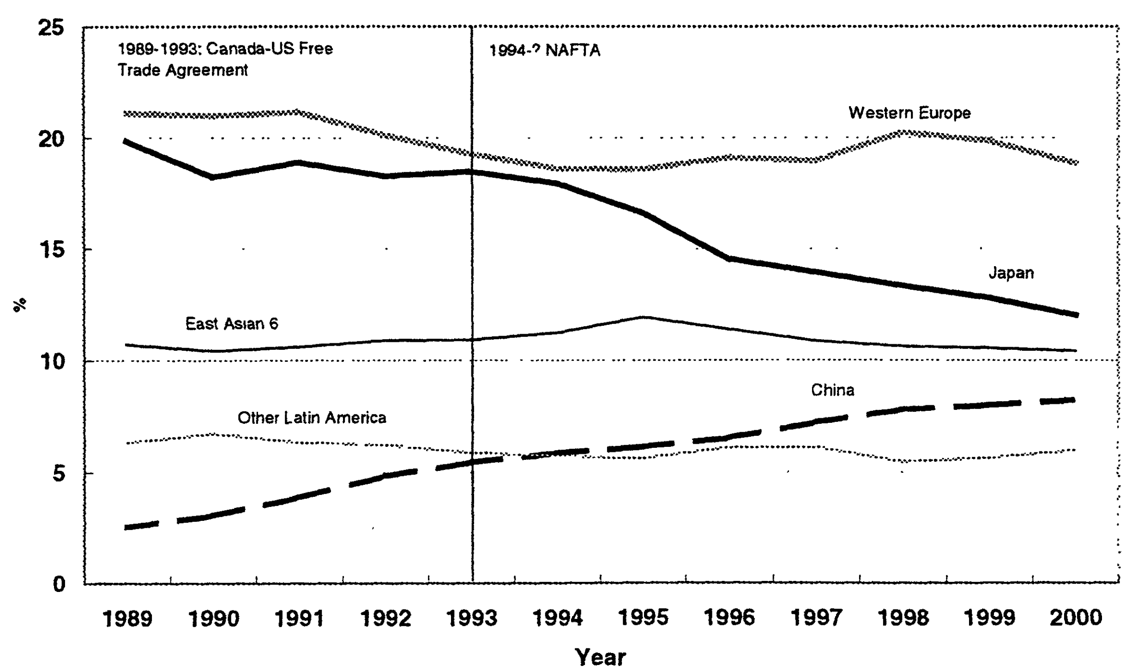


Figure 3: Mexico's Share of US Imports Classified by Tariff Preference

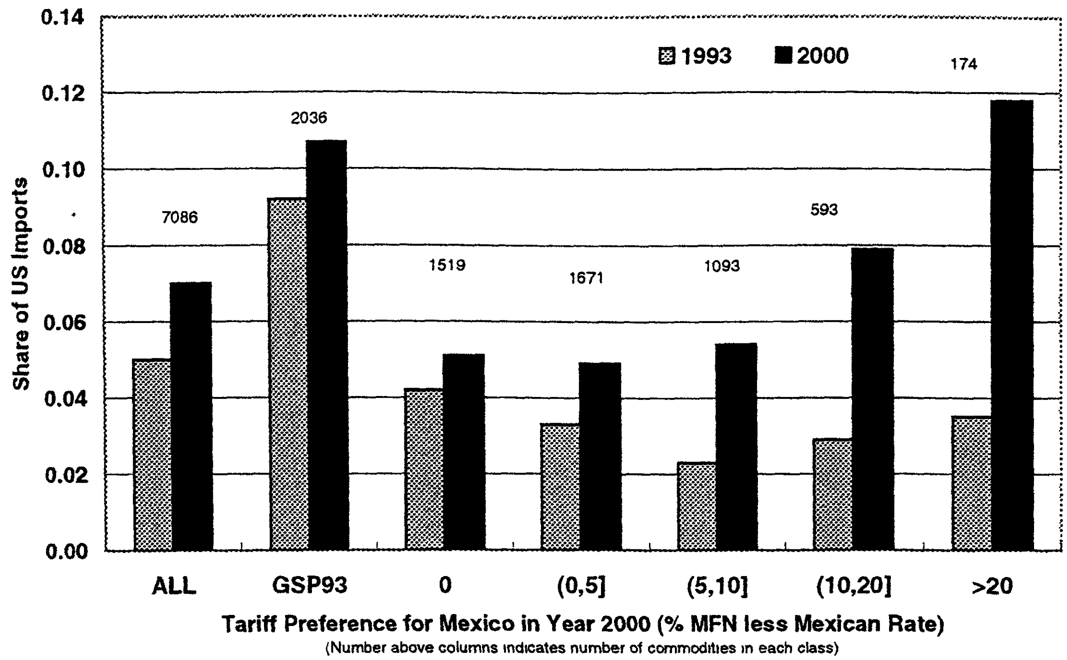


Figure 4: Canada's Share of US Imports Classified by Tariff Preference

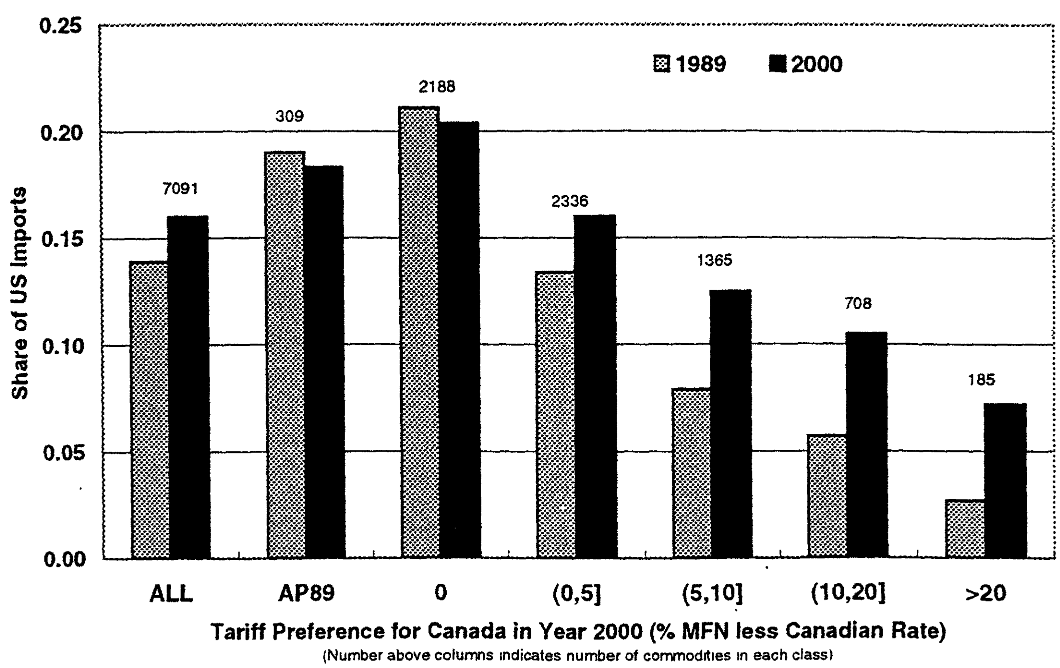


Figure 5: US Import Tariffs in 2000

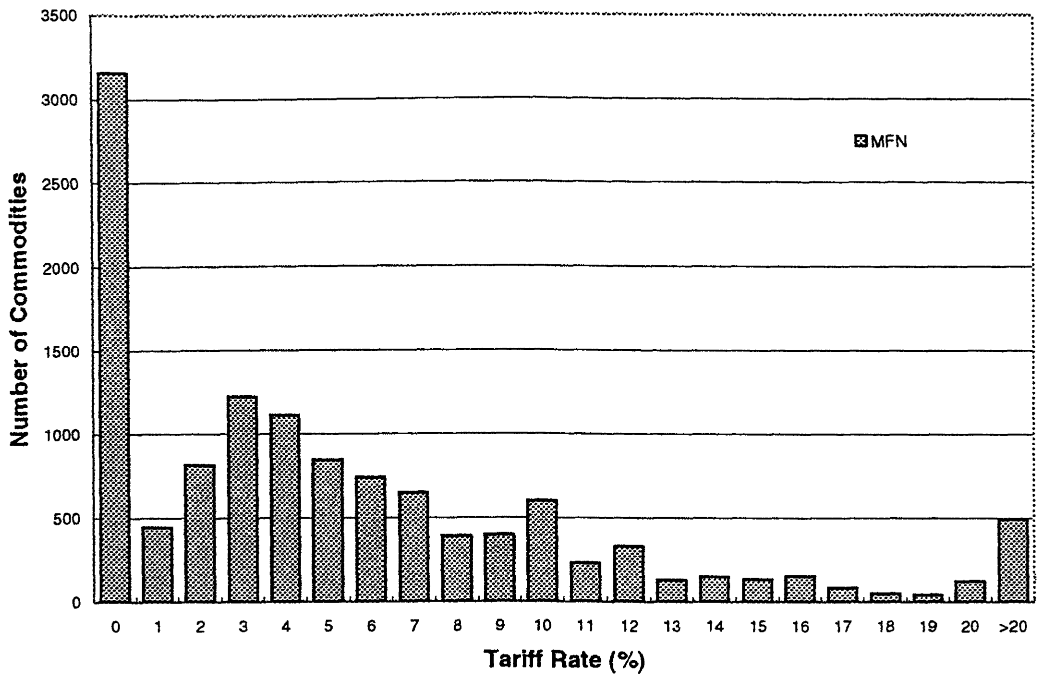


Figure 6: US Import Tariffs: NAFTA Preferences in 2000

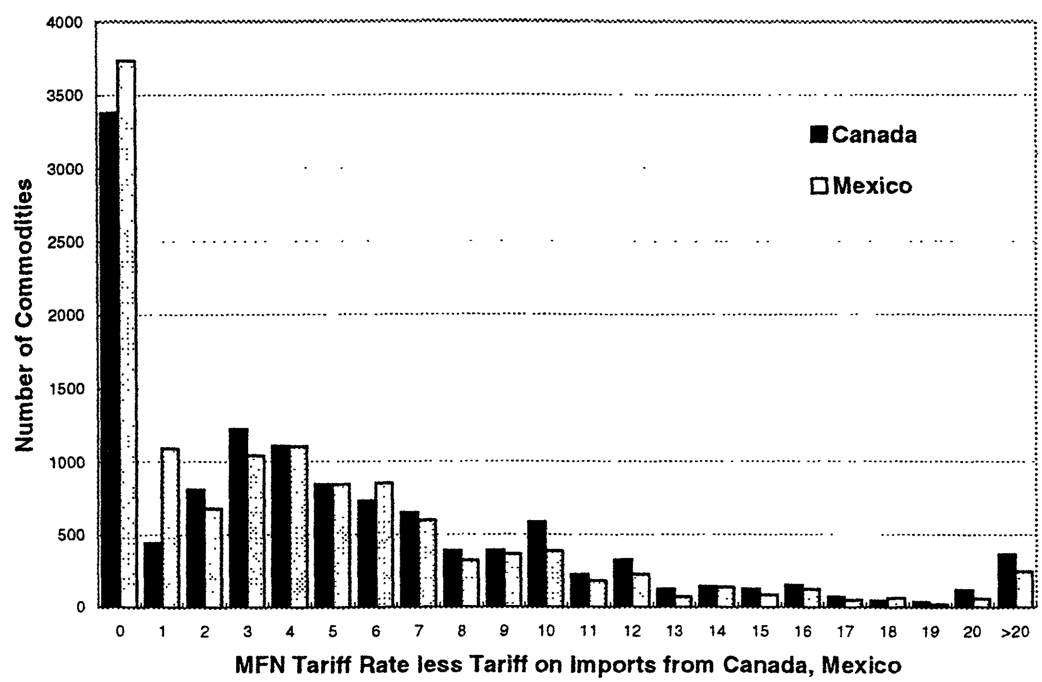


Figure 7: NAFTA's Impact on Mexico's Share of US Imports

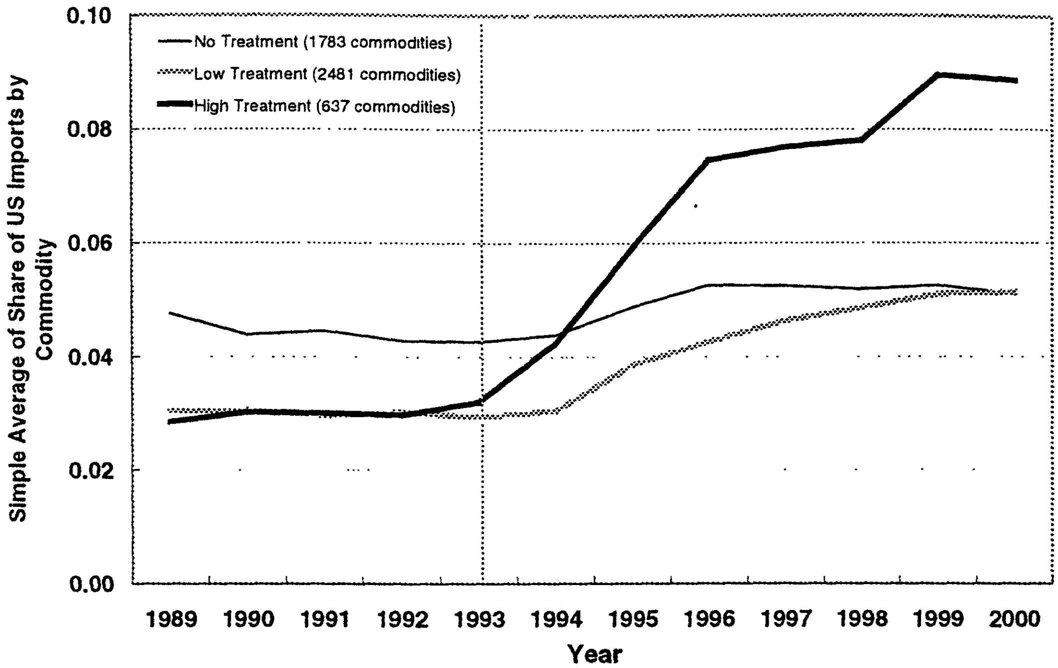


Figure 8: NAFTA's Impact on Canada's Share of US Imports

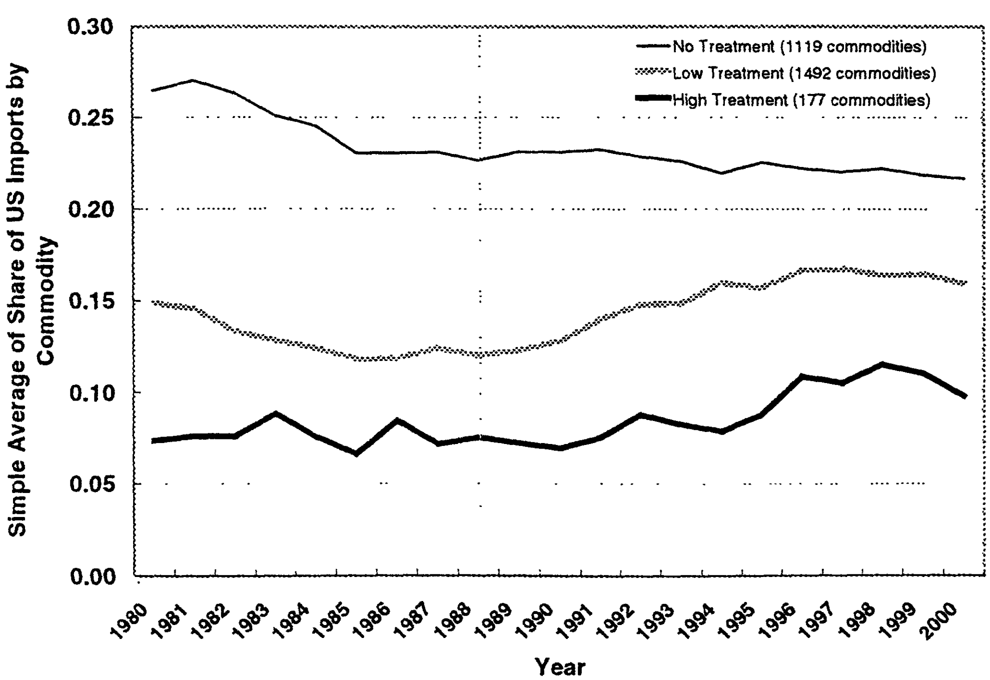
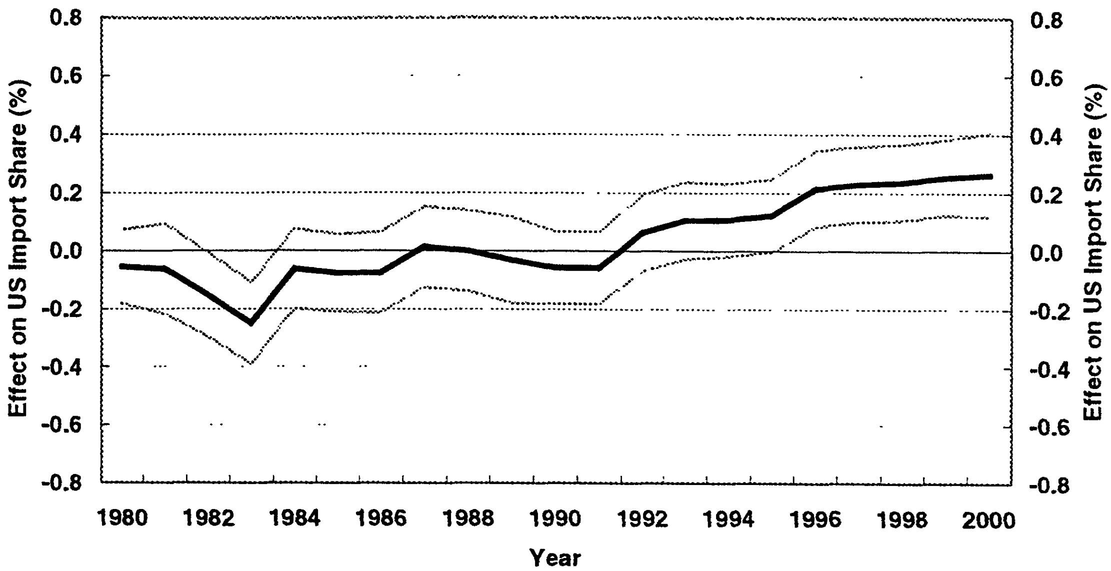
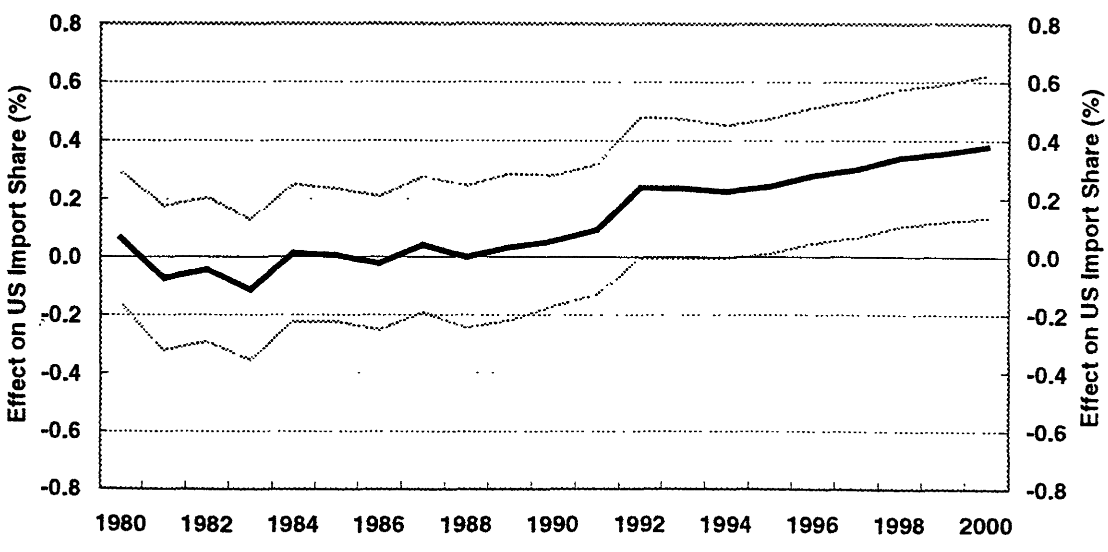


Figure 9: Impact of 1% NAFTA Preference on Canadian Share of US Imports*



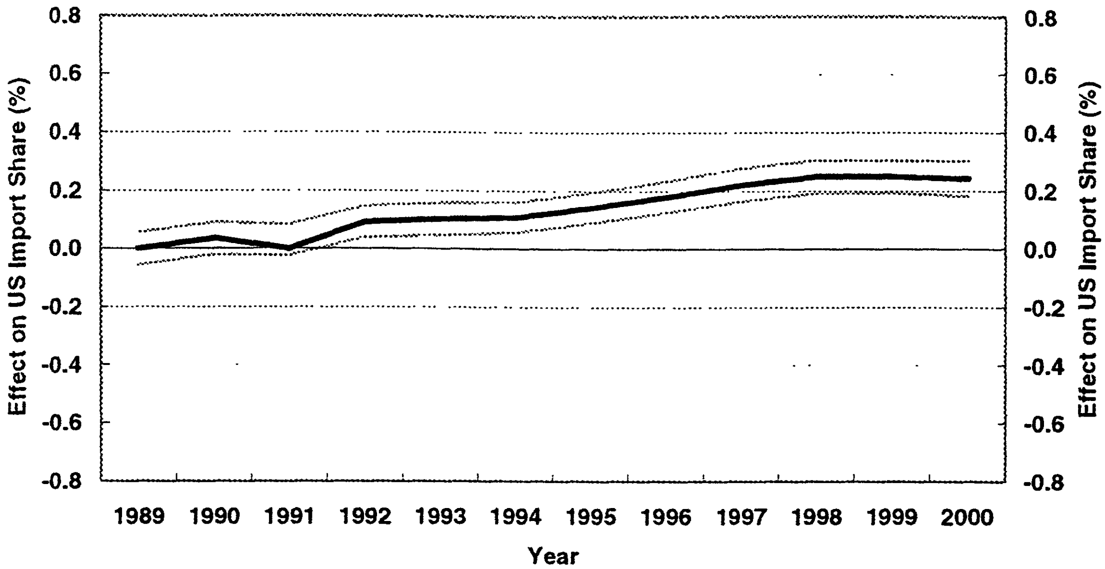
(*Central Estimate plus 90% Confidence Interval; Model includes commodity and time dummies; 4203 commodities tracked from 1980 to 2000)

Figure 10: Impact of 1% NAFTA Preference on Canadian Share of US Imports*



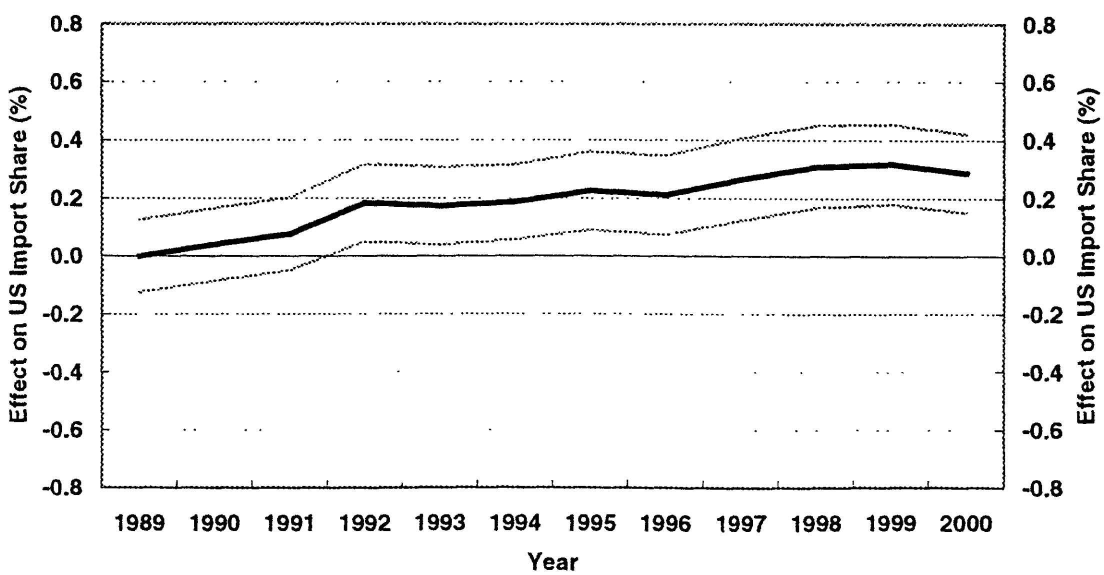
(*Central Estimate plus 90% Confidence Interval; Model includes industry and time dummies and their interactions; 4203 commodities tracked from 1980 to 2000)

Figure 11: Impact of 1% NAFTA Preference on Canadian Share of US Imports*



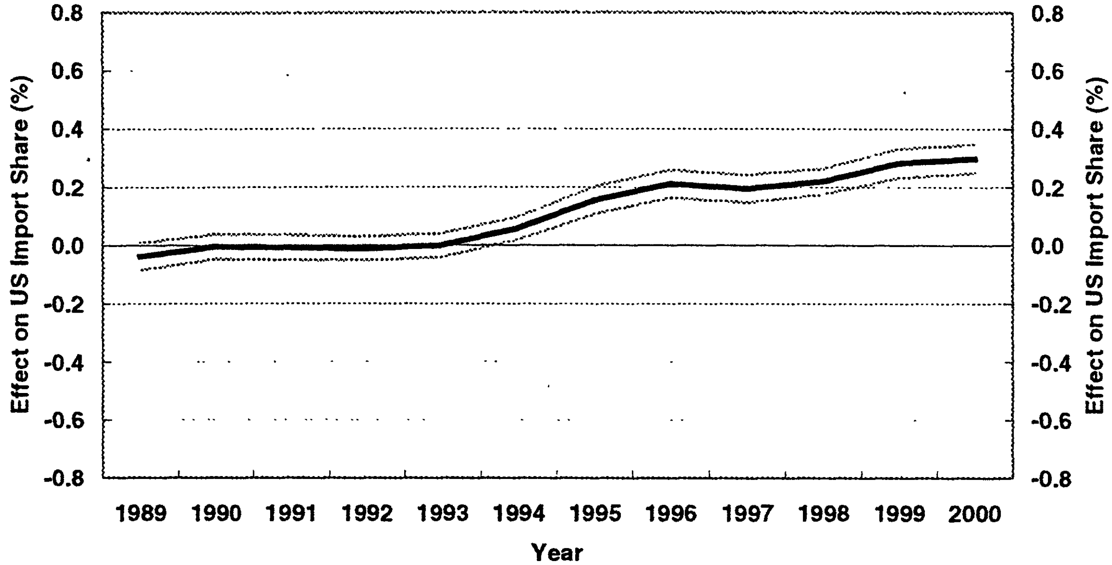
(*Central Estimate plus 90% Confidence Interval; Model includes commodity and time dummies; 7091 commodities tracked from 1989 to 2000)

Figure 12: Impact of 1% NAFTA Preference on Canadian Share of US Imports*



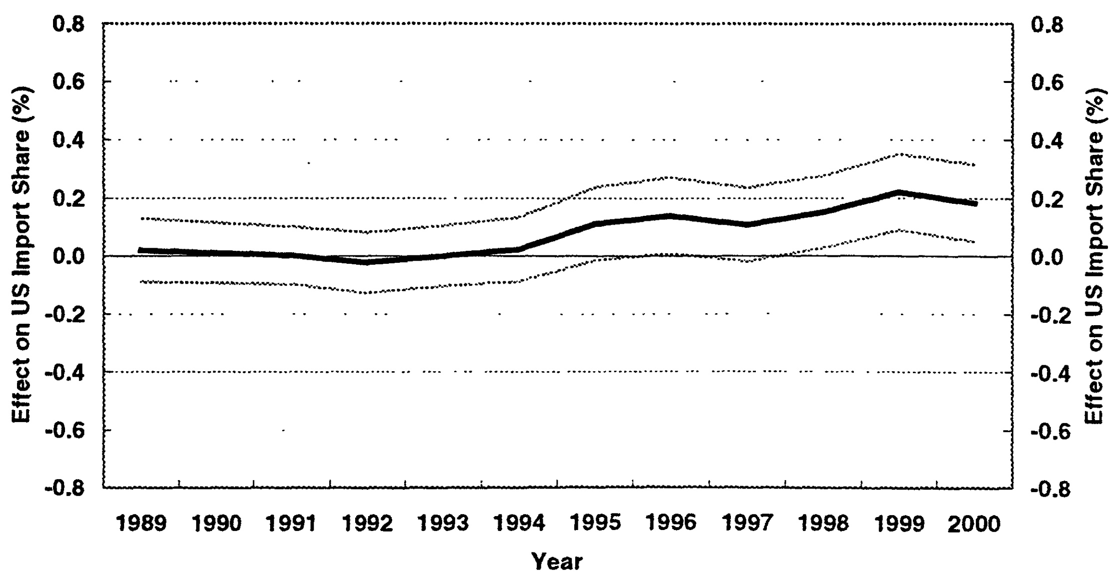
(*Central Estimate plus 90% Confidence Interval; Model includes industry and time dummies and their interactions; 7091 commodities tracked from 1989 to 2000)

Figure 13: Impact of 1% NAFTA Preference on Mexican Share of US Imports*



(*Central Estimate plus 90% Confidence Interval; Model includes commodity and time dummies; 7091 commodities tracked from 1989 to 2000)

Figure 14: Impact of 1% NAFTA Preference on Mexican Share of US Imports*



(*Central Estimate plus 90% Confidence Interval; Model includes industry and time dummies and their interactions; 7091 commodities tracked from 1989 to 2000)

Chapter 3

International Trade Costs and the Structure of International Trade

Summary 3 *Chapter 3 examines the effect of international trade costs on the volume of trade. It extends the model in Chapter 1 to allow trade costs to vary by country and commodities. An arbitrary country imports more commodities from countries where bilateral trade costs are lower, and imports more from larger countries. It also sources specific commodities disproportionately from trading partners that possess in relative abundance the productive factors that are used relatively intensively in the production of that commodity. Useful products of the empirical examination are estimates of the willingness to substitute between different varieties of goods within an industry. The implied elasticities of substitution are mostly high, typically ranging between 6 and 16. With such high elasticities of substitution, small costs to international trade will sharply reduce trade volumes.*

3.1 Introduction

Empirical models of international trade based on "border effects" and "gravity" best describe observed trade patterns. Countries trade much more with themselves than they do with each other (McCallum 1995, Wei 1996, Helliwell 1998), and the international trade that does occur tends to be with proximate countries (See Deardorff 1985 for a survey). These effects are not purely confined to quantities; the dispersion of prices for similar goods increases with the distance, even within national boundaries (Engel and Rogers 1996, Parsley and Wei 2000). The effects of borders and distance are considered to be much greater than can be explained by observable costs of trade. Explanations of the low level of international trade include the existence of informal trade barriers such as the weak enforcement of international contracts (Anderson and Marcouiller 1999), inadequate information about international trading opportunities (Portes and Rey 1999), and the importance of business and social networks (Rauch 1999). Only Hummels (1999b) suggests that observed trade costs are most of the story.

This paper investigates whether observed trade costs are a substantial contributor to the low level of international trade. It develops a model where transport costs, country size and factor proportions dictate the international pattern of specialization. Transport costs cause locally abundant factors to be relatively cheap, which attracts industries that intensively use those factors. The pattern of specialization in production in turn determines the commodity structure of international trade. Conditional on the pattern of specialization in production, transport costs and consumer willingness to substitute between goods determine the volume of international trade.

These predictions are examined using detailed bilateral trade data for the US. Trading partner size, observed transport costs, and the abundance of skilled labor have very substantial effects on the structure and volume of international trade. Although the model does not yield closed-form solutions for the structure of trade, one important parameter of the model can be estimated; the elasticity of substitution between varieties of goods within an industry. Estimates of this elasticity are typically 6, consistent with Hummels (1999b), but can be much higher depending on how observations with zero trade are modelled. With these elasticities, even small international trade costs, whether due to natural or artificial barriers, will have a pronounced effect on international trade volumes. The median normal-trade-relations tariff applied by the US is 5 percent. The median international freight cost by country of origin and commodity is equal to 11 percent of the Free On Board (FOB) value of the commodity. If there was an elasticity of substitution of 6 across all goods, these trade costs would reduce trade volumes by 60 percent relative to a nearly-frictionless world.

The structure of the model is most closely related to Romalis (2000), which was in turn developed from the models in Dornbusch, Fischer and Samuelson (1980) and Helpman and Krugman.[1] The closest theoretical paper to this is due to Deardorff (2001), who uses a general framework that encompasses all perfectly competitive models to study "locational comparative advantage". Deardorff proves that a negative correlation must exist between relative autarky prices in the exporting country, inclusive of incipient trade costs, and bilateral trade flows. The closest empirical papers are Hummels (1999b), who finds that observed trade costs explain much of the low volume of trade in many goods, and Romalis (2000), who uses trade costs to find that factor proportions are an important determinant of the commodity structure of international trade.

The paper is organized as follows. Section 2 develops the model. Section 3 describes the data and discusses the empirical models. Section 4 concludes.

3.2 The Model

A. Model Description

The model is an extension of Romalis (2000). It is a many-country version of the Heckscher-Ohlin model with a continuum of goods. Countries differ in their relative factor abundance. Factor proportions will be one force generating international trade. I combine this with the Krugman (1980) model of intraindustry trade driven by scale economies and product differentiation. Scale economies are the second force generating international trade. Finally I add 'iceberg' international trade costs, which differ according to where the commodity is produced and where it is consumed . The international trade costs have two effects. They determine the commodity structure of production by generating a departure from Factor Price Equalization (FPE), and together with the assumptions on consumer willingness to substitute between different commodities, trade costs determine the volume of bilateral trade. The model assumptions are set out in detail below.

[1] See, for example, Helpman and Krugman (1985) for models with imperfect competition and more than one factor.

1. The world is arranged into C continents equally spaced around the equator. Apart from location, each continent is identical. On each continent there are 2 countries, 1 each in the North and South.[2] Southern variables, where needed, are marked with an asterisk.

2. There are two factors of production supplied inelastically; skilled labor and unskilled labor earning factor rewards s and w respectively. The total labor supply is 1. The proportion of skilled labor is denoted by β. Northern countries are relatively abundant in skilled labor; $\beta > \beta^*$.

3. There is a continuum of industries z on the interval [0,1]. The index z ends up playing a dual role in the paper, because below z will also be used to rank industries by factor intensity. Industries with higher z are more skill intensive.

4. All consumers in all countries are assumed to have identical Cobb-Douglas preferences with the function of income spent on industry z being $b(z)$ (Equation 1). Expenditure shares for each industry are therefore constant for all prices and incomes. All income is spent so the integral of $b(z)$ over the interval [0,1] is 1 (Equation 2).

$$U = \int_0^1 b(z) \ln Q(z) dz. \tag{3.1}$$

$$\int_0^1 b(z) dz = 1. \tag{3.2}$$

5. Monopolistic competition. In the traditional model each industry z produces a homogeneous good. In this model, there are economies of scale in production and firms can costlessly differentiate their products. The output of each industry consists of a number of varieties that are imperfect substitutes for one another. The quantity of variety i in industry z is denoted by $q(z,i)$. $N(z)$ is the endogenously determined number of varieties in industry z:

[2]The model can be easily generalized to include more of each type of country on each continent, provided each continent is identical.

$$N(z) = n(z) + n^*(z). \tag{3.3}$$

As z is no longer a homogeneous good, $Q(z)$ can be interpreted as a sub-utility function that depends on the quantity of each variety of z consumed. The symmetric CES function is assumed with elasticity of substitution greater than 1:

$$Q(z) = \left(\int_0^{N(z)} q(z,i)^\theta di \right)^{\frac{1}{\theta}}, \qquad \theta \in (0,1]. \tag{3.4}$$

Production technology, represented by a total cost function TC, is assumed to be identical Cobb-Douglas in all countries, but there is a fixed cost equal to α units of production. The total cost of producing q units of variety i of commodity z is:

$$TC(q(z,i)^S) = s^z w^{1-z}(\alpha + q(z,i)^S) \tag{3.5}$$

Average costs of production decline at all levels of output, although at a decreasing rate. This cost function has the convenience of generating factor shares that do not depend on factor rewards. The total cost function also gives the dual role for the index z, because z denotes both the industry *and* skilled labor's share of income in that industry. Finally, there is free entry into each industry, so in equilibrium profits are zero.

6. International trade is assumed to be more costly than domestic trade. International trade costs are modelled as a transport cost. To avoid the need to model a separate transport sector, transport costs are introduced in the convenient but special iceberg form: τ units of a good must be shipped for 1 unit to arrive in any other country ($\tau \geq 1$). Domestic trade is assumed to be costless ($\tau = 1$). For international trade, $\tau = \tau(d)$ is an increasing function of the distance d between countries.

B. Equilibrium in an Industry

In general equilibrium consumers maximize utility, firms maximize profits, all factors are fully employed and trade is balanced. The model solution proceeds in two steps. The first step is to solve for the partial equilibrium in an arbitrary industry. In particular, I solve for the share of world production that each country commands, conditional on relative production costs. I show that countries with lower costs capture larger market shares. The next step is to show that in general equilibrium, locally abundant factors are relatively cheap. Skilled labor is relatively cheap in Northern countries, and unskilled labor is relatively cheap in Southern countries. The North becomes the low-cost producer of skill-intensive goods, and commands larger shares of these industries. The South is the low-cost producer of low-skill goods, and produces relatively more of these.

The properties of the model's demand structure have been analyzed in Helpman and Krugman (1985).[3] Firstly, we need four additional pieces of notation. Denote the (constant) elasticity of substitution between varieties within an industry by $\sigma = \frac{1}{1-\theta}$; let $\widehat{p}(z,i)$ be the price paid by consumers, inclusive of transport costs, for variety i in industry z, let $I(z)$ be the set of all varieties in industry z, and let national income be $Y = s\beta + w(1-\beta)$. Maximization of $Q(z)$ conditional on expenditure $E(z)$ yields the following demand functions:

$$q(z,i)^D = \frac{\widehat{p}(z,i)^{-\sigma}}{\int_{i' \in I(z)} \widehat{p}(z,i)^{1-\sigma}\, di'} E(z); \qquad i \in I(z). \tag{3.6}$$

A firm's share of industry revenues depends on its own price and on the prices set by all other firms in that industry. It is convenient to define the ideal price index $G(z)$:

$$G(z) = \left[\int_{i \in I(z)} \widehat{p}(z,i)^{1-\sigma}\, di \right]^{\frac{1}{1-\sigma}} \tag{3.7}$$

[3]See Sections 6.1, 6.2 and 10.4 in particular.

Due to the unit elasticity of substitution between industries, a constant function of income $b(z)$ is spent on industry z in every country. An individual Northern firm sets a single factory gate price of p. Its products sell in its own domestic market at p, but in all other markets the transport cost raises the price to $p\tau(d)$. The ideal industry price index G for the Northern country on an arbitrary continent C is given in Equation 8. G^* is symmetric. Implicit in these indices is the assumption that in equilibrium all Northern countries are alike and all Southern countries are alike. Except where needed, the 'z' notation is suppressed.

$$G_C = \left[np^{1-\sigma} + \sum_{C' \neq C} n\left(p\tau(d_{CC'})\right)^{1-\sigma} + \sum_{C'} n^* \left(p^* \tau\left(d_{CC'}\right)\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{3.8}$$

The revenues of a typical Northern firm are given by Equation 9. The three terms reflect revenues in its domestic market, the $C-1$ other Northern markets and the C Southern markets. The equivalent Southern expression is symmetric.

$$pq = bY\left(\frac{p}{G}\right)^{1-\sigma} + \sum_{C' \neq C} bY\left(\frac{p\tau\left(d_{CC'}\right)}{G}\right)^{1-\sigma} + \sum_{C'} bY^*\left(\frac{p\tau\left(d_{CC'}\right)}{G^*}\right)^{1-\sigma}. \tag{3.9}$$

The production and trade structure has also been studied in Helpman and Krugman (1985).[4] Each firm produces a different variety of the product. Each country, if it produces in the industry at all, produces different varieties. Every variety is demanded in every country. Profit maximizing firms perceive a demand curve that has a constant elasticity, and therefore set price at a constant markup over marginal cost:[5]

$$p(z) = \frac{\sigma}{\sigma - 1} s^z w^{1-z} \tag{3.10}$$

[4]See Chapter 7.

[5]The demand curve faced by a firm has a constant elasticity if the set of varieties is of non-zero measure.

With free entry, profits are zero in equilibrium. The pricing rule, the zero profit condition and the special form of the fixed cost produce an equilibrium where all firms produce the same quantity of output:

$$q = q^* = \alpha(\sigma - 1). \tag{3.11}$$

We now have everything we need to solve for the partial equilibrium in this industry. Notation is simplified by defining world income $W = C(Y + Y^*)$, the relative price of Northern goods $\widetilde{p} = \frac{p}{p^*}$ and the expressions $F_1 = 1 + \sum_{C' \neq C} \tau (d_{CC'})^{1-\sigma}$ and $F_2 = \sum_{C'} \tau (d_{CC'})^{1-\sigma}$.[6] Conditional on relative prices, Equations 8 and 9 contain four equations in four unknowns n, n^*, G and G^*. These equations may not have positive solutions for both n and n^*. If they do not, the solution for n and n^* will either be Equation 12 or Equation 13. If $\widetilde{p}$ is low then Equation 12 is the solution; if $\widetilde{p}$ is high then Equation 13 is the solution.[7]

$$n = \frac{b(Y + Y^*)}{p\alpha(\sigma - 1)}, \qquad n^* = 0 \qquad \text{if} \qquad \widetilde{p} \leq \underline{p} = \left[\frac{F_1 F_2 \left(\frac{Y}{Y^*} + 1 \right)}{F_1^2 + F_2^2 \frac{Y}{Y^*}} \right]^{\frac{1}{\sigma}}. \tag{3.12}$$

$$n = 0, \qquad n^* = \frac{b(Y + Y^*)}{p^* \alpha(\sigma - 1)} \qquad \text{if} \qquad \widetilde{p} \geq \overline{p} = \left[\frac{F_1^2 \frac{Y}{Y^*} + F_2^2}{F_1 F_2 \left(\frac{Y}{Y^*} + 1 \right)} \right]^{\frac{1}{\sigma}}. \tag{3.13}$$

If both n and n^* are positive, Equations 8, 9 and 11 solve for $\frac{n}{n^*}$, which is given in Equation 14. This expression is derived by dividing the demand Equation 9 by its Southern equivalent; substituting for q and q^* using Equation 11; substituting for G and G^* using Equation 8; and rearranging. The relative number of Northern firms declines in both the relative price of Northern goods and in the relative size of Southern economies.

[6] F_1 is the quantity of goods a Northern firm sells in all Northern markets divided by its domestic sales; $F_1 > F_2$.

[7] The conditions for $\widetilde{p}$ are derived from Equation 14.

$$\frac{n}{n^*} = \frac{F_1^2 \frac{Y}{Y^*} + F_2^2 - \widetilde{p}^{\sigma} F_1 F_2 \left(\frac{Y}{Y^*} + 1\right)}{\widetilde{p}\left(F_1^2 + F_2^2 \frac{Y}{Y^*}\right) - \widetilde{p}^{1-\sigma} F_1 F_2 \left(\frac{Y}{Y^*} + 1\right)}, \text{ if } \widetilde{p} \in \left(\underline{p}, \overline{p}\right). \tag{3.14}$$

Equation 14 can be used to solve for another useful expression, the share v of world revenues in that industry that accrue to firms in each Northern country. When solving for v, we have to account for the indirect demand for goods used up in transit. Each Northern firm's revenue is given by pq, where q is the quantity produced, not the quantity consumed. Equation 15 is the definition of v. Equation 16 is the solution for v.

$$v = \frac{npq}{C\left(npq + n^* p^* q^*\right)} \tag{3.15}$$

$$v = \begin{cases} \frac{1}{C} & \text{if} \quad \widetilde{p} \in (0, \underline{p}] \\ \frac{1}{C}\left[\frac{-\widetilde{p}^{\sigma} F_1 F_2\left(\frac{Y}{Y^*}+1\right)+F_1^2 \frac{Y}{Y^*}+F_2^2}{-\left(\widetilde{p}^{\sigma}+\widetilde{p}^{-\sigma}\right) F_1 F_2\left(\frac{Y}{Y^*}+1\right)+\left(F_1^2+F_2^2\right)\left(\frac{Y}{Y^*}+1\right)}\right] & \text{if} \quad \widetilde{p} \in (\underline{p}, \overline{p}) \\ 0 & \text{if} \quad \widetilde{p} \in [\overline{p}, \infty) \end{cases} \tag{3.16}$$

The revenue share v declines in the relative price of Northern goods $\widetilde{p}$ and increases with the relative size of Northern economies $\frac{Y}{Y^*}$. The sensitivity of market share v to relative price increases with the elasticity of substitution σ and with the number of countries. Equations 6 and 8 can be used to solve for the FOB share of imports of a given commodity z into the Northern country C' that are produced in the Northern country C:

$$\widetilde{v}_{c'z} = \frac{\tau\left(d_{CC'}\right)^{1-\sigma}}{F_1 - 1 + \frac{n^*}{n}\widetilde{p}^{\sigma-1} F_2} \tag{3.17}$$

$$\ln\left(\widetilde{v}_{c'z}\right) = (1-\sigma)\ln\left(\tau\left(d_{CC'}\right)\right) - \ln\left(F_1 - 1 + \frac{n^*}{n}\widetilde{p}^{\sigma-1}F_2\right) \tag{3.18}$$

Market share responds negatively to trade costs, positively to relative GDP $\frac{Y}{Y^*}$, which enters indirectly through $\frac{n^*}{n}$, and negatively to relative price, which enters both directly and indirectly through $\frac{n^*}{n}$. But by Equation 10, relative price is equal to relative production costs, which depend on factor prices. This generates the role for factor abundance; I next demonstrate that in general equilibrium, locally abundant factors are relatively cheap. Therefore the relative price of Northern goods declines with the skill intensity of the industry, and every Northern country captures larger shares of more skill intensive industries. A similar expression can be derived for imports from Southern countries. An interesting feature of Equation 18 is that the elasticity of substitution σ between varieties in an industry enters very simply into the coefficient on the log of bilateral trade costs $\tau\left(d_{CC'}\right)$, although this trade cost also appears in a small way in the second term. By using explicit estimates of actual trade costs, this paper recovers estimates of σ.

C. General Equilibrium

All factors must be fully employed in all countries in equilibrium. With assumed preferences, the function of world income spent on each industry is invariant to prices and income. With the assumed production technology, factor shares in each industry are invariant to factor prices. Skilled labor's share of revenues in industry z is constant and equal to z. The balance goes to unskilled labor. Equations 19 to 22 are, respectively, the full employment conditions for: skilled labor in the North; unskilled labor in the North; skilled labor in the South; and unskilled labor in the South. The left side of each equation is factor demand, the right is factor supply. The wages of unskilled labor in the South have been normalized to 1. National income equals national expenditure in every country, so trade is balanced.

$$\int_0^1 \frac{1}{s} z b(z) W v(z)\, dz = \beta. \tag{3.19}$$

$$\int_0^1 \frac{1}{w}(1-z) b(z) W v(z)\, dz = 1 - \beta \tag{3.20}$$

$$\int_0^1 \frac{1}{s^*} z b(z) W(\frac{1}{M} - v(z)) dz = \beta^*. \tag{3.21}$$

$$\int_0^1 (1-z) b(z) W(\frac{1}{M} - v(z)) dz = 1 - \beta^*. \tag{3.22}$$

So long as C is finite, the failure of FPE can be demonstrated by contradiction.[8] With FPE, $\widetilde{p}(z) = 1$ by Equation 10, and $v(z)$ is constant over z by Equation 16. By Equations 18 to 21, relative factor demands in the North equal relative factor demands in the South. But the relative supply of these factors is not equal by assumption. Therefore we cannot have full employment equilibrium with FPE.

The North has more skilled labor; the South more unskilled labor. Full employment requires the North to either (i) have a larger share of skill-intensive industries, or (ii) use skilled labor more intensively in each industry than in the South. For the North to obtain a larger share of skill-intensive industries, Equation 16 requires that $\widetilde{p}(z)$ declines in z. By Equation 10, $\widetilde{p}(z)$ declines in z if and only if $\frac{s}{w} < \frac{s^*}{w^*}$.[9] Factor demands obtained by differentiating Equation 5

[8] In the limit as $C \rightarrow \infty$, factor price equalization is again achieved. This is shown by proving that equilibrium in an arbitrary industry requires production costs to be the same in both the North and the South. The reason for FPE returning is simple. The domestic market becomes increasingly less important as C gets larger. In the limit everything is exported, so that transport costs affect locally scarce and abundant factors equally.

[9] This can be proved by differentiating the log of $\widetilde{p}(z)$.

with respect to factor prices show that for any industry, the North will use skilled labor more intensively than the South if and only if $\frac{s}{w} < \frac{s^*}{w^*}$. Therefore skilled labor must become relatively cheap in the North, and unskilled labor relatively cheap in the South. The relative price $\widetilde{p}(z)$ declines in z, and every Northern country's share of world production in an industry rises with the skill intensity z of the industry.

The model can be extended to more factors, as in Romalis (2000). This follows from the partial equilibrium in an industry depending only on relative costs and relative incomes, and only indirectly through these variables do factor endowments and factor intensities affect how countries specialize. Extensions therefore require a model of how factor prices and national income depend on factor endowments.

3.3 Empirical Examination

A. Overview and Data Description

Equation 18 is the basis of trade based examinations of the model. A given country sources its imports disproportionately from countries where the international trade costs are lower. It sources specific commodities disproportionately from countries that possess in abundance the factors that are intensively used in the production of that commodity. It sources more imports from larger countries. Unfortunately there is no closed form solution for the impact of most of these explanators; very simple approximations will be estimated instead.

The model's prediction can be examined using detailed commodity trade data, estimates of international trade costs, and estimates of factor intensity and factor abundance. I use 1988 data from Robert Feenstra's NBER Trade Database on US manufacturing imports classified by 4-digit SIC industry and country of origin. Data from 1988 is used to match the year for which I have the most factor abundance data. There are over 400 industries and 150 trading partners. The shares of US imports by SIC industry are then calculated for each country.

International trade costs τ are estimated for each country and each commodity by dividing CIF (Cost Including Freight) measures of imports by FOB (Free On Board) import measures. The problem with this measure is that τ is only observable where imports are non-zero. The observations where there are no trade are extremely likely to be systematically related to the variables of interest. For example, where transport costs are high, it is more likely that no trade is observed. Where a commodity embodies extreme proportions of a factor that is scarce in a country, the US is unlikely to import any of that commodity from that country. In other words, the zero's are informative.

Three approaches are taken to the missing τ problem. The first approach is simply to ignore the problem, and estimate only where there are observations on τ. The second approach is an instrumental variables approach. I estimate the missing trade cost data using observed trade cost data. Trade costs are then certainly measured with error. I then use distance between capital cities or distance and industry dummies as instruments for the mismeasured trade costs. I assume that the expected trade cost is an additive function of the industry z and the country of origin c. Equation 23 is estimated by OLS, and the missing observations on τ are replaced by their expected value $\widehat{\tau}$.[10] The median transport cost, including estimated values, is almost 11 percent of the FOB value.

$$\tau_{cz} = \alpha c + \beta z + \epsilon_{cz} \tag{3.23}$$

The third approach is to treat the whole observation as missing and use the Heckman procedure to model the selection and estimate the primary equations. The selection equation is motivated by the model. Factor proportions and the size of the country of origin will be determinants of whether we observe any trade.

The model assumes that there are no factor intensity reversals. Indeed, a property of the model is that factor shares are fixed for each industry. With this assumption, factor intensity

[10] The R^2 of this regression is 0.22.

can be consistently ranked using factor share data for just one country. I choose US data both for reasons of availability and because the estimates are likely to be the most satisfactory due to the US being the largest and most diverse industrial economy. All factor intensity data are factor share data derived from the US Census of Manufactures for 1992.

For each industry I calculate the sum of value added and raw materials inputs. Raw material inputs are derived from detailed data on intermediate inputs by industry. This data is screened to keep only food, forestry and mining industry output. Raw material intensity *raw* is measured as the value of raw material inputs divided by the sum of raw materials and value added. Capital intensity *capital* is estimated as (value added - total compensation)/(value added +raw materials). Total compensation is apportioned between skilled labor and unskilled labor according to the proportion of production and non-production workers in the industry, where following Berman, Bound and Griliches (1994) I assume that non-production workers are skilled and production workers are unskilled.[11] Skill intensity *skill* is skilled labor's share of total compensation divided by the sum of raw materials and value added. The intensity of unskilled labor is simply 1 minus the share of the other factors.

The model relates market shares to trade costs, factor intensity and factor abundance. The abundance of skilled labor is measured by the human capital to labor ratio from Hall and Jones (1999), which is based on education levels reported in Barro and Lee (2000). The abundance of capital is measured by the investment based measure of the capital to labor ratio sourced from Hall and Jones. The Hall and Jones measures are available for a large number of countries, 123 in total. Raw material abundance is measured by total land area divided by the total labor force sourced from the World Bank World Development Indicators 2000 CD-ROM, a simple but imperfect estimate of the abundance of agricultural and mineral resources. All measures of abundance are relative to the US. Factor abundance and factor intensity data is available for 120 countries and 370 industries.

[11]This classification has limitations, since, for example, cleaners (that have not been outsourced) will be classified as skilled workers while skilled production workers will be classed as unskilled workers. The measure is correlated with other skill measures, such as average wage levels and, at higher levels of aggregation where data is available, education levels.

B. Estimation and Results

The empirical work commences with equations of the form:

$$\ln \widetilde{v}_{cz} = (1 - \sigma) \ln \tau_{cz} + x'_{cz}\pi + \varepsilon_{cz} \tag{3.24}$$

where x'_{cz} is a vector of controls suggested by the model, including the log of GDP in dollars in country c, factor intensities of commodities, factor abundance of countries, and all interactions between factor intensities and factor abundance. The results for the full sample are reported in Table 1, while Table 2 reports results for the sample excluding the two countries that border the US; Canada and Mexico.

The columns labeled OLS1 and OLS2 report OLS regressions on Equation 24 where observations for which $\widetilde{v}_{cz} = 0$ are simply omitted. OLS1 omits controls for factor intensities and factor abundance while OLS2 includes these controls. The elasticity of the import share with respect to the GDP of the country of origin is approximately 1. The trade cost enters extremely significantly, with an elasticity of about -6, suggesting an elasticity of substitution between varieties within an industry of 7. Excluding Canada and Mexico has a slight effect on the results, the implied elasticity of substitution from these regressions is approximately 6.

Simply ignoring observations where there is no trade is likely to lead to understatement of the impact of GDP and trade costs, because zero imports are much more likely to occur for small countries and for countries where trade is more costly. In the columns headed OLS3 and OLS4 I have assumed that the customs officials have overlooked a very small amount of trade; $\ln \widetilde{v}_{cz}$ is assumed to be -20 in each case, typically implying between ten cents and ten dollars worth of imports. OLS2 is simply OLS on Equation 24, with $\ln \widetilde{v}_{cz}$ left censored at -20. As expected, the elasticities increase in absolute value, with the largest effects being on trade costs. The elasticity of the import share with respect to GDP is now 1.6, reflecting the tendency of small countries to specialize in a few commodities. The elasticity with respect to trade costs is now around -14, suggesting an elasticity of substitution of 15. Excluding Canada and Mexico reduces the implied elasticity of substitution slightly to around 14.

The columns IV1 through to IV4 report the results of instrumental variables estimation. Two sets of instruments are used for the mismeasured trade cost variable. Firstly, distance between capital cities in the country of origin and Washington D.C. is used in IV1 and IV3. It is assumed that distance is correlated with trade costs, and only effects the volume of trade through the costs of international trade, broadly defined. Secondly, distance combined with industry dummies for each 4-digit SIC are used in IV2 and IV4. Trade costs vary widely by industry. The results using distance alone as an instrument result in extremely high estimates of the elasticity of substitution, ranging from 79 to 129. Including industry dummies as an instrument produces much lower implied elasticities of about 15 for the full sample and 13 when Canada and Mexico are excluded.

The columns headed Heckit use the Heckman procedure to model the selection and estimate the primary equations. The selection equation is motivated by the model. Factor intensities, factor abundance, all interactions between factor intensities and factor abundance, and the size of the country of origin are determinants of whether we observe any trade. The estimates imply elasticities of substitution of about 6.

An interesting feature of Tables 1 and 2 are the high estimates of the willingness of consumers to substitute between different varieties within the same industry. The implied elasticities of substitution typically range from 6 to 16. The higher estimates are achieved in some models when considering observations where there are no imports. High estimates may in part reflect the existence of economies of scale in distribution, such as some fixed cost for importing or marketing a variety, or transport and insurance costs that do not increase proportionally with the size of the shipment. Once demand for a variety becomes too low, it simply might not be worth importing at all.

At the lower end of estimates, suggesting an elasticity of substitution of 6, the median transport cost of 11 percent is sufficient to reduce imports of a commodity relative to domestic production by almost 50 percent. Adding in the median tariff of about 5 percent, this reduction becomes 60 percent. At the higher end of estimates, with an elasticity of substitution of 15, this reduction becomes 80 and 90 percent respectively. Modest international trade costs could be substantially reducing international trade volumes.

3.4 Conclusion

The results of this paper suggest that international trade costs play an important role in restricting the volume of trade and in determining from where countries source their imports. One useful product of the empirical examination are estimates of the willingness of consumers to substitute between different varieties of similar commodities. All of the estimates are high, with the elasticity of substitution typically ranging from 6 to 15. High elasticities of substitution imply that even small costs to international trade can have a substantial effect on trade volumes.

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Table 1: Effect of Trade Costs τ on Trade Volumes
Full Sample
Dependent Variable: $L\nu_{cz}$

Variable	OLS1	OLS2	OLS3	OLS4	IV1	IV2	IV3	IV4	Heckit
Lgdp	0.958	1.027	1.713	1.570	1.332	1.567	1.497	1.907	1.036
	(0.008)	(0.013)	(0.009)	(0.017)	(0.031)	(0.017)	(0.020)	(0.010)	(0.012)
$L\tau$	-5.824	-6.101	-15.53	-12.52	-91.65	-13.59	-78.42	-14.24	-5.537
	(0.196)	(0.241)	(0.347)	(0.395)	(3.670)	(0.456)	(2.011)	(0.405)	(0.191)
Inv(Mills)									-4.566
									(0.489)
Factor Proportions Controls	NO	YES	NO	YES	YES	YES	NO	NO	YES
Observations with missing τ included	NO	NO	YES	YES	YES	YES	YES	YES	YES
Distance in instruments	NO	NO	NO	NO	YES	YES	YES	YES	NO
Industry dummies in instruments	NO	NO	NO	NO	NO	YES	NO	YES	NO
N	23658	18765	59160	41093	41093	41093	54375	54375	41749
R^2	0.403	0.448	0.412	0.494		0.494		0.438	

Notes: robust errors in parentheses beneath coefficient estimates. For Heckit model, ordinary standard errors are reported.

Table 2: Effect of Trade Costs τ on Trade Volumes
Sample Excluding Canada and Mexico
Dependent Variable: $L\nu_{cz}$

Variable	OLS1	OLS2	OLS3	OLS4	IV1	IV2	IV3	IV4	Heckit
Lgdp	0.924	0.964	1.669	1.505	1.326	1.504	1.475	1.867	0.975
	(0.008)	(0.013)	(0.009)	(0.017)	(0.041)	(0.017)	(0.023)	(0.010)	(0.026)
$L\tau$	-5.203	-5.235	-14.79	-11.46	-127.72	-11.95	-88.85	-12.70	-5.092
	(0.191)	(0.232)	(0.343)	(0.385)	(9.262)	(0.430)	(3.069)	(0.385)	(0.283)
Inv(Mills)									-3.955
									(0.511)
Factor Proportions Controls	NO	YES	NO	YES	YES	YES	NO	NO	YES
Observations with missing τ included	NO	NO	YES	YES	YES	YES	YES	YES	YES
Distance in instruments	NO	NO	NO	NO	YES	YES	YES	YES	NO
Industry dummies in instruments	NO	NO	NO	NO	NO	YES	NO	YES	NO
N	22799	18020	58290	40339	41093	40339	53505	53505	40995
R^2	0.379	0.437	0.388	0.477		0.477		0.415	

Notes: robust errors in parentheses beneath coefficient estimates. For Heckit model, ordinary standard errors are reported.

Appendix A

Data for Chapter 1

Factor Abundance: For the Heckscher-Ohlin regressions I use Human-Capital-to-Labor ratios and Capital-to-Labor ratios from Hall and Jones (1999). This data is available for 123 countries for the year 1988. Raw material abundance is estimated by total land area divided by the total labor force in 1998 sourced from the World Bank World Development Indicators 2000 CD-ROM. All measures of abundance are relative to the US.

For the 1972 to 1998 Rybczynski regression I use Barro and Lee (2000) data for average total years of education and average years of college education for the population aged 15 to 65. For each country I calculate the average years of total education and college education relative to US levels. I then use the growth of these measures between 1970 and 1995 as my estimates of the change in relative skill abundance. The data on international tests of students in mathematics and science are from Barro and Lee (2000). I sum the two scores and divide the sum by its mean of 1000. Change in capital to labor ratios relative to the US are calculated using Penn World Tables 5.6 data for capital per worker (KAPW) for 1972 and 1992.

Factor Intensity: Factor intensity estimates are fully described in Section 3A of the text.

GDP Per Capita at PPP: World Bank World Development Indicators CD-ROM for 1998. Penn World Tables 5.6 for earlier years (pwt.econ.upenn.edu).

Imports: Trade data for the USA comes from the USA Trade CD-ROM for 1998; from Robert Feenstra's NBER Trade Database for 1972, 1980 and 1990; and from the United Nations

Commodity Trade Statistics for 1960. The Feenstra database is already mapped into SIC classifications. The 1998 data is mapped from HS into SIC classifications using a concordance maintained by Jon Haveman (www.haveman.org). The 1960 data is mapped from SITC R1 to SIC using a concordance adapted from the SITC R2 to SIC concordance maintained by Jon Haveman. Only manufacturing industries are used (SIC codes 2000 to 3999).

Appendix B

Full Employment Conditions for Three Factor Model in Chapter 1

Equations 1 to 6 are the full employment conditions for the three factor model. The equations are respectively for: skilled labor in the North; capital in the North; unskilled labor in the North; skilled labor in the South; capital in the South, and unskilled labor in the South. The wages of unskilled labor in the South have been normalized to 1. The left side of each equation gives factor demand, while the right gives factor supply.

$$\int_0^1 \int_0^{1-z} \frac{1}{s} zb(kz)Wv(kz)dkdz = \beta. \tag{B.1}$$

$$\int_0^1 \int_0^{1-z} \frac{1}{r} kb(kz)Wv(kz)dkdz = \gamma. \tag{B.2}$$

$$\int_0^1 \int_0^{1-z} \frac{1}{w}(1-z-k)b(kz)Wv(kz)dkdz = 1-\beta-\gamma. \tag{B.3}$$

$$\int_0^1 \int_0^{1-z} \frac{1}{s^*} zb(kz)W\left(\frac{1}{M}-v(kz)\right)dkdz = \beta^*. \tag{B.4}$$

$$\int_0^1 \int_0^{1-z} \frac{1}{r^*} kb(kz)W\left(\frac{1}{M}-v(kz)\right)dkdz = \gamma^*. \tag{B.5}$$

$$\int_0^1 \int_0^{1-z} (1-z-k)b(kz)W\left(\frac{1}{M}-v(kz)\right)dkdz = 1-\beta^*-\gamma^*. \tag{B.6}$$