The Rise of Vertical Specialization Trade

Benjamin Bridgman*

Bureau of Economic Analysis

March 26, 2009

Abstract

Vertical specialization (VS) trade, trade in goods that incorporate imported inputs, has grown rapidly since the 1960s. While the share of trade in inputs has not increased, the types of inputs have shifted from raw materials to manufactures. I argue that changes in trade costs is an important explanation for these facts. I present a three stage vertical specialization trade model. In the simulated model, manufacturing and VS trade grow twice as fast as overall trade growth. Falling trade costs explain much of observed trade growth. Falling trade costs lead to a rapid expansion of manufactured parts trade relative to materials. Raw materials production is more strongly linked to endowments than manufacturing, making it more difficult to substitute domestic for foreign sources of materials. Therefore, materials will be traded even when trade costs are high. Further, trade costs have shifted from protecting manufacturing (including parts) to a more neutral pattern of protection.

JEL classification: F1.

Keywords: Trade costs; Vertical specialization; Manufacturing trade.

*Preliminary. The views expressed in this paper are solely those of the author and not necessarily those of the U.S. Bureau of Economic Analysis or the U.S. Department of Commerce. Address: U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC 20230. email: Benjamin.Bridgman@bea.gov. Tel. (202) 606-9991. Fax (202) 606-5366.
1 Introduction

The share of merchandise output that is internationally traded has significantly increased in the last fifty years. The share of U.S. goods output that is exported tripled between 1960 and 2006. At the same time, the structure of trade has changed. Vertical specialization (VS) trade, trade in goods incorporating imported inputs, has expanded rapidly. VS trade in the United States grew from 6 percent of exports in 1972 to 14 percent in 1997 (Feenstra 1998, Hummels, Rapoport & Yi 1998, Hummels, Ishii & Yi 2001).

Why has VS trade increased so much? As documented by Chen, Kondratowicz & Yi (2005), this growth is not due to a large increase in the share of intermediate goods trade. They find that share of trade accounted for by intermediate goods has been nearly constant since 1972. While this fact may be initially somewhat surprising, a glance at the types of goods traded 50 years ago explains why. Trade in the early postwar period and earlier was dominated by intermediate goods, particularly raw materials such as ores and lumber. In 1963, the only industries with more than 10 percent of domestic supply from imports were mining and forestry industries (Walderhaug 1973).

However, there has been a significant change in the types of intermediate goods traded. Figure I shows the share of U.S. imports made up of industrial supplies using the BEA’s end use nomenclature. Imports are dominated by such supplies early in the period, making up almost two thirds of imports. In the mid-1960s, the composition of imports began to shift significantly. Industrial supplies fell from over half of imports in the 1965 to less than a quarter in the 1990s. (The spike in share in the mid-1970s is due to the run up in oil prices, as demonstrated by the non-fuel supplies share.)

While raw materials trade became less important, trade in manufactured goods has expanded rapidly (Bergoeing, Kehoe, Strauss-Kahn & Yi 2004). U.S. manufacturing export share of GDP grew by 140 percent between 1960 and 2006. This fact is puzzling given that manufacturing has fallen as a share of output. The share of manufacturing output that is exported quadrupled during that period. Early on, when manufacturing was a large part of production, there was little trade in manufactured goods. Later,
when manufacturing declined in importance, trade became dominated by trade in these goods. Bergoeing et al. (2004) argue that “New Trade Models” emphasizing increasing returns and monopolistic competition, such as Krugman (1979) and Helpman (1981), or non-homothetic preferences (Markusen 1986) are quantitatively unable to deliver the empirical increase in trade.

This paper argues that the rise of manufacturing and VS trade are related. It examines the importance of changes in trade costs for the changes in the composition of international trade, specifically the increasing importance of VS and manufacturing trade. The 1960s coincide with the implementation of the Kennedy Round along with other trade deals, such as the U.S.-Canada Auto Pact, that shifted trade policy away from protecting manufacturers. Tariffs were low on these raw materials and high on manufactured goods. The Kennedy Round focussed on cutting tariffs on manufactures. This round of the GATT was notable both for the size of the tariff reductions and the fact that it widely covered manufactures. Since then, trade policy has gone from being biased against manufactured goods to being more neutral.
Prior to the Kennedy Round, trade was dominated by low value raw materials. Raw materials were imported despite being expensive to ship because the ability to produce them is strongly linked to endowments. Therefore, materials cannot not reliably be replaced domestically and were essential for production. Manufactured goods are easier to replace with a domestic good since they are less dependent on endowments.

This paper presents an expanded version of the tractable general equilibrium model with Ricardian trade in intermediate goods found in Bridgman (2008a). There are two countries with three layers of production: Raw materials which are inputs to intermediate goods, which in turn are inputs to final consumption goods. All three types of goods may be traded, but incur an iceberg transportation cost and may face tariffs. I calibrate the model and run simulations using data on freight costs and tariffs.

The simulated model generates most of the empirical growth in trade and the change in composition, accounting for about nearly all of the increase in both total and manufacturing trade. Manufacturing and VS trade growth is much faster than overall trade growth. While overall share of goods output that is traded more than doubles between 1967 and 2002 in the baseline simulation, manufacturing trade share triples. VS trade also grows rapidly, doubling from 1972 to 1997. In the 1960s, manufactured goods faced higher tariffs than raw materials. Beginning with the Kennedy Round of the GATT, manufactured goods tariffs fell more rapidly than non-manufactured goods. Lower trade costs on manufactured parts led to an rapid expansion of VS trade.

While VS trade grows rapidly, the share of trade that is in intermediate goods does not increase. Intermediate goods trade shifts from being dominated by raw materials to manufactured parts. Raw materials production tends to depend on local geographical conditions in a way that manufacturing does not. Mines can only be sited where ore exists naturally. Geography is also important for agricultural and forestry goods. Manufacturing is much less tied geographic conditions. Therefore, raw materials will be traded even when trade costs are high. Combined with the fact that trade costs for raw materials fell less, most of the new trade in goods is due to new trade in manufactured parts.
The paper also contributes to the historical measurement of the structure of trade protection. Examples include Anderson (1972) and Irwin (2007). It presents estimates of trade costs of goods by final and intermediate uses. Supplementary tables used in the calculation of the input-output (IO) tables provide estimates of trade costs by IO commodity. These supplementary tables can be combined with the IO tables to generate estimates of the structure of protection. U.S. foreign trade statistics do not provide detailed data on freight costs before 1974, so historical data on this issue are very thin (Hummels 2007).

This paper contributes to the large literature investigating postwar trade growth, including Rose (1991), Krugman (1995), Baier & Bergstrand (2001), and Bergoeing & Kehoe (2003). Models incorporating VS trade, such as Yi (2003) and Bridgman (2008a) have been successful at resolving the puzzle that tariffs have not fallen enough to generate the observed trade growth given estimates of the Armington elasticity (Armington 1969), the aggregate elasticity of substitution between domestic and foreign goods. (Erkel-Rousse & Mirza (2002) provide a summary of this literature.) However, they have not emphasized the structure of trade expansion. While Bergoeing et al. (2004) speculate that a VS model could generate that change in composition, they do not pursue the issue.

This paper is also part of a literature examining the impact of the structure of protection on economic performance. Estevadeordal & Taylor (2008) argue that openness of inputs and capital goods improves growth. Lehman & O'Rourke (2008) argue that high agricultural tariffs reduce growth. Beginning with Balassa (1965), a related literature measures effective protection, the protection on an industry’s value added.

A number of papers have examined the importance of intermediates trade for a number of issues including development (Jones 2008, Goldberg, Khandelwal, Pavcnik & Topalova 2008), firm productivity (Amiti & Konings 2007) and the border effect in gravity equations (Yi 2008). Grossman & Rossi-Hansberg (2008a) and Grossman & Rossi-Hansberg (2008b) examine the growth of trade in intermediate services, or off-shoring. Theoretical models of vertical specialization trade include Dixit & Grossman

5
(1982) and Sanyal (1983). Unlike these papers, I examine the change in the composition of intermediates trade.

2 The Structure of Protection

This section examines the structure of protection from tariffs and transportation costs for intermediate and final goods. One way to distinguish between the two types of goods is to partition goods into one category or the other. This approach is used by Estevadeordal & Taylor (2008), for example. This approach is relatively easy to implement, particularly since the Brussels Tariff Nomenclature used by a large number of countries during the Twentieth Century does this partitioning. In reality, goods are not intrinsically intermediate or final goods: A tire can either depending whether it is sold to General Motors or a consumer. Further, trade statistics do not distinguish to whom goods are sold, so we cannot distinguish directly.

An alternative approach (when the data are available) is to use the input output tables to split goods by use, the approach used by Campa & Goldberg (1997) and Hummels et al. (1998). I use this method to estimate the rates of protection on goods by use. The tariff and transportation margins on imports are calculated as a supplementary table in the compilation of the input-output tables, since the margins need to be allocated to their producing industries: Wholesale trade for tariffs and transportation services for transportation. This table is not reported for all benchmark years, but they are for 1967 (pre-Kennedy Round) and 1972 (post-Kennedy Round). They can also be calculated for 1997 and 2002.

These margins are matched to the direct transactions table. I assume that imported commodities are used at the same rate for intermediate and final production as aggregate supply of that commodity. (This assumption is used by the OECD to split the IO tables into domestic and foreign sources.) That is, the imported share of a commodity is the same for both final and intermediate goods. I drop transactions originating from
services industries. The trade weighted import cost is given by:

\[
\frac{\sum_i \tau_i y_i^{Imp} \cdot s_i}{\sum_i y_i^{Imp} \cdot s_i}
\]

(2.1)

where \(\tau_i\) is the tariff rate, \(y_i^{Imp}\) is imports of good \(i\) and \(s_i\) is the share of the domestic supply of good \(i\) that is used as an intermediate input. Freight costs \(f_i\) are weighted in a similar fashion.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Imports</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>7.1</td>
<td>5.9</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Freight</td>
<td>7.4</td>
<td>5.3</td>
<td>5.3</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Interm. (Mfg.)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>7.1</td>
<td>5.8</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Freight</td>
<td>7.3</td>
<td>4.9</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Interm. (Non-Mfg.)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>4.1</td>
<td>3.1</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Freight</td>
<td>10.8</td>
<td>9.9</td>
<td>10.6</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Final</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>8.6</td>
<td>6.4</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Freight</td>
<td>5.8</td>
<td>4.7</td>
<td>4.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>

As can be seen from Table 1, tariffs prior to the Kennedy Round protected manufacturers and allowed raw materials to enter at relatively low tariffs. (The Kennedy Round was agreed to in 1967 and implemented over the next five years, so the 1967 to 1972 comparison gives an indication of its effects.) This tariff structure was a long standing feature of trade policy (Irwin 2007). Since then, trade policy has become more neutral with all goods facing similar, low tariffs.
The discriminatory tariff rates are to a large degree undone by higher freight costs for non-manufactured goods. Most raw materials are bulky and low value. This finding is consistent with the findings of Yeats (1977). As found in Hummels (2007), freight rates have not fallen as rapidly as tariffs. There are significant differences across types of goods. Freight costs for manufactured goods have fallen by much more than for raw materials. Manufactured goods freight costs fell in half while raw materials show no downward trend. This finding is consistent with the containerization revolution reducing the cost of non-bulk items (Levinson 2006).

The overall protection profile (tariffs plus freight) has gone from somewhat protecting manufacturing and final goods producers to protecting raw materials producers. The tariffs on all goods have declined nearly to zero. Freight for manufacturing has fallen while it has not for materials.

Why would tariffs on parts, an input, be high? Firms that produce final goods often produce parts as well. Firms lobbying for protection in final goods may have an incentive to protect upstream production. Whether final goods maker also makes its own parts or outsources the task depends on a number of issues, including government policy and productivity. (For example, General Motors has vertically integrated and disintegrated a number of times over the years.) However, the technology to manufacture parts is likely to be more similar to final goods manufacturing than raw materials production, so is more likely to be vertically integrated. Therefore, firms lobbying for protection for final manufactured goods may also ask for manufactured parts protection.

Since these are trade weighted measures, they suffer from some well-known limitations. High trade cost goods are likely to be traded less than low trade cost goods. (See Anderson & van Wincoop (2004) for a survey of the problems of aggregating trade costs.) A particular issue with this measure in this context is that there has been significant trade growth along the extensive margin: trade in new goods (Kehoe & Ruhl 2002).

---

1The significant decline in freight costs in 2002 is largely due to the run up in oil prices. Bridgman (2008b) shows that freight rates for oil are negatively related to oil prices, since rates are charged by volume.
Therefore, there are a significant number of goods whose trade costs are not measured in the early years. Bridgman (2008b) shows that for freight, lower trade costs induce lower value goods to be traded which masks changes in trade costs. In the calibration of the model, I will make an adjustment for this effect.

3 Model

3.1 Households

There are two countries each with a representative household. Households have preferences over a consumption good represented by:

\[ U = \left| \sum_{j=1,2} \phi^j_i (C^i_j)^\rho \right|^{\frac{1}{\rho}} \]  \hspace{1cm} (3.1)

where \( C^i_j \) denotes consumption good \( j \in \{1, 2\} \) for country \( i \in \{1, 2\} \), \( \phi^i_j = \phi \) if \( j = i \) and \( \phi^i_j = 1 - \phi \) and if \( j \neq i \). The associated prices are \( P^i_{c,j} \). Each country is endowed with labor \( N^i \). The wage is \( W^i \).

3.2 Raw Materials Sector

Each country can use labor \( N^i_m \) to produce a raw material good \( M^i_j \) with a price \( P^i_{m,j} \). Each country can only produce the good with its name: \( j = i \). Output is given by \( Y^i_m = A^i_m N^i_m \).

3.3 Manufactured Parts Sector

There is a continuum of manufactured parts \( x^i(z) \) with a price \( P^i_{x,j}(z) \) for \( z \in [0,1] \). Each country is endowed with technologies that combine materials inputs \( M^i_j, j \in \{1, 2\} \) and labor \( N^i_x(z) \) to produce parts. Total output of part \( z \) is given by:

\[ Y^i_x(z) = A^i_x(z)(N^i_x(z))^\alpha\left(\sum_j (M^i_j(z))^\sigma\right)^{\frac{1}{\sigma}}(1-\alpha). \]  \hspace{1cm} (3.2)
The productivity parameters are given by $A^1(z) = \frac{1}{(1+z)^\theta}$ and $A^2(z) = \frac{1}{(2-z)^\theta}$, a variant of the mirror image technology in Bridgman (2008a) which is based on Dornbusch, Fischer & Samuelson (1977) and Eaton & Kortum (2002).

### 3.4 Consumption Goods Sector

Manufactured parts can be assembled into consumption goods using labor $N^i_c$. As with material goods, each country can only produce the good with its name: $j = i$. The total output is given by the technology:

$$Y_{c,j}^i = A_c^i(N^i_c)^{\alpha_c}(\int_0^1 \ln(x^i(z))dz)^{1-\alpha_c}$$

for $i = 1, 2$ and $j = i$. The associated price is $P_{c,j}^i$.

### 3.5 Transportation Sector

The countries may trade the goods they produce with each other by incurring an iceberg transportation cost specific to that good: $f_k$ for $k \in \{m, x, c\}$.

### 3.6 Government

The countries each have a government that can impose an ad valorem (net of transport fees) tariff $\tau_k^i$ on traded goods $k \in \{m, x, c\}$. The government gives the domestic representative household transfers $T^i$ and maintains budget balance.
4 Equilibrium

4.1 Definition

Households sell labor and purchase goods. They maximize $U$ subject to the budget constraint

$$\sum_j P^{i}_{c,j} C^i_j = W^i N^i + T^i$$  \hspace{1cm} (4.1)

Materials firms buy labor and sell materials. They face competitive markets and solve:

$$\text{Max} P^{i}_{m,m} A^i_m N^i_m - W^i N^i_m$$  \hspace{1cm} (4.2)

Manufactured parts firms face competitive markets and solve:

$$\text{Max} P^{i}_{m,i} A^i_{x} (N^i_x(z))^\alpha (\sum_j (M^i_j(z))^\sigma)^{1-\alpha} - W^i N^i_x(z) - \sum_j P^{i}_{m,j} M^i_j(z)$$  \hspace{1cm} (4.3)

For $j = i$, consumption goods firms solve:

$$\text{Max} P^{i}_{c,i} A^i_{c} (N^i_c(z))^\alpha_c (\int_0^1 \ln(x^i(z))dz)^{1-\alpha_c} - w^i N^i_c - \int_0^1 P^i(z)x^i(z)dz$$  \hspace{1cm} (4.4)

Transportation firms buy domestic goods and sell exports. Materials exporters face competitive markets and solve:

$$\text{Max} P^{i}_{m,i} M^i_{-i} - P^{i}_{m,i} M^i_{i}(1 + f_m)$$  \hspace{1cm} (4.5)

where $P^{i}_{m,i}$ is the price of the materials in the other country. Parts and consumption goods exporters solve a similar problem.

Feasibility for each consumption good requires that for $j = 1, 2$:

$$f^i_c C^i_{-j} + \sum_{i=1,2} C^i_j = Y^i_c$$  \hspace{1cm} (4.6)

where $-j$ is the other country. The term $f^i_c C^i_{-j}$ is the amount of consumption used to pay the iceberg cost to ship the good. There is a corresponding feasibility constraint for
parts that are exported and materials production. Labor feasibility requires that labor sum to the total population.

\[ N^i = N^i_c + N^i_m + \int_0^1 N^i_x(z)dz \quad (4.7) \]

The definition of equilibrium is standard.

**Definition 4.1.** Given tariffs, an equilibrium is consumption, parts and materials goods allocations and prices in each period such that:

1. Households solve their problem,
2. Materials, parts, consumption goods and transportation firms solve their problem,
3. The government balances its budget,
4. The allocation is feasible.

**4.2 Solution**

The two countries are mirror images in manufactured parts production. There is a symmetric equilibrium with a closed form solution when the parameters are the same in the two countries. Specifically, if the parameters \( N_i, \tau_k, A_k \) for \( k \in \{m, x, c\} \) and are constant across the two countries, there exists an equilibrium where \( C_1 = C_2, C^1_x = C^2_x, P^1_{m,1} = P^2_{m,2}, W^1 = W^2, P^1_{c,2} = P^2_{c,1} \) and \( P^1_{c,1} = P^2_{c,2} \). Prices and quantities in the parts and materials sectors across the countries mirror each other: \( P^1_x(z) = P^2_x(1-z) \), etc. In the rest of the paper, I examine this symmetric equilibrium.

I denote the common parameters and quantities (for example, \( N^i \) and \( W^i \)) by omitting the \( i \) superscript (for example, \( \tau_1 = \tau_2 = \tau \)) and normalize price of country one’s material good to one \( (P^1_{m,1} = 1) \). Define \( z_i \) as the cutoff industry in country \( i \) such that manufactured parts \( z > z_1 \) and \( z < z_2 \) will be imported. Given the functional forms,

\[ z_1 = 1 - z_2 = \frac{2(1 + \tau_x + f_x)^\frac{\beta}{\gamma} - 1}{(1 + \tau + f_x)^\frac{\beta}{\gamma} + 1} \quad (4.8) \]
Parts exports are given by:

\[
\frac{z_2}{(1 + \tau_x + f_x)} \frac{(A_mN + T)(1 + f_x + (1 + \tau_x + f_x)^{1/\rho})}{[1 + \tau_x + f_x + (1 + \tau_x + f_x)^{1/\rho}]}. \tag{4.9}
\]

Consumption goods exports are given by:

\[
C_2^1 = C_2^2 = \frac{A_mN + T}{P_c[1 + \tau_c + f_c + ((1 + \tau_c + f_c)^{\phi/(1-\phi)}/(1-\rho)]} \tag{4.10}
\]

where \(P_{c,1}^1 = P_{c,2}^2 = P_c\).

Tariffs in the United States are collected on the FOB value of goods (the value before transport costs are added). Therefore,

\[
T = \frac{\tau_m A_m N (\frac{1}{1 + \tau_m + f_m}^{1/\sigma})}{[1 + ((1 + \tau_m + f_m)^{1/\sigma})]} (1 - \alpha)(z_1 + (1 + f_x)z_2) + NA_m \tau_x (1 - z_1) + \frac{A_m N \tau_c}{[1 + \tau_c + f_c + ((1 + \tau_c + f_c)^{\phi/(1-\phi)}/(1-\rho)]} \tag{4.11}
\]

5 Results

5.1 Calibration

This section presents the parameter selection for the model. In the calibration, I follow the convention of Yi (2003) and Bridgman (2008a) and interpret the two countries as the United States and the rest of the industrialized countries (the EC plus Japan).

The value for the share of materials in parts and consumption production \(\alpha\) and \(\alpha_c\) and materials elasticity \(\sigma\) are taken from Jones (2008). The Armington parameter \(\rho\) is taken from Ruhl (2005). The relative productivity parameter \(\theta\) and home bias parameter \(\phi\) are selected by grid search to match the level of VS trade in 1972 and share of manufacturing output that is exported in 1967 respectively given the other parameters. Model VS trade is measured as the sum of the three sources of VS trade: Materials
imports that are exported in parts \(((1 - z_2)P_{1}^{m,2}M_{1}^{2})\), imported parts in exported final goods \(((1 - z_2)P_{21}^{1}C_{21}^{1})\) and imported materials in domestic parts used in exported final goods \((P_{2}^{1}C_{2}^{1}P_{m,2}^{m,2}M_{2}^{2}z_{2})\). Note that this definition does not include goods that are exported that are reimported. While this is an important source of VS trade (see Johnson & Noguera (2008)), it is omitted from the data sources I use.

Tariffs and freight rates are taken from Table 1. I use non-manufacturing intermediate goods for raw materials, manufacturing intermediate goods for parts and manufacturing final goods for final production.

As discussed above, it is well known that trade-weighted measures underestimate total costs since the goods that are the most costly to trade are traded the least. A measure of the size of this bias for tariffs is the Mercantilist Trade Resistance Index (MTRI) proposed by Anderson & Neary (2003), which is the estimated uniform tariff equivalent that generates the observed level of trade. I scale up trade costs by 1.69, the ratio of MTRI that Kee, Nicita & Olarreaga (2005) estimates to trade-weighted tariffs for the United States in 2002. These estimates only cover tariffs. I am not aware of any MTRI estimates for transport costs. Anderson & van Wincoop (2004) note that transport costs are similar to tariffs in magnitude and variability, so a tariff based estimate is likely to be a reasonable proxy for bias in transport cost measures.

The baseline parameters are summarized in Table 2.

Table 2: Baseline Parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\rho)</td>
<td>0.85</td>
</tr>
<tr>
<td>(\theta)</td>
<td>0.24</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>0.5</td>
</tr>
<tr>
<td>(\alpha_c)</td>
<td>0.5</td>
</tr>
<tr>
<td>(\sigma)</td>
<td>-1</td>
</tr>
<tr>
<td>(A_m)</td>
<td>1</td>
</tr>
<tr>
<td>(A_c)</td>
<td>1</td>
</tr>
<tr>
<td>(\phi)</td>
<td>0.545</td>
</tr>
</tbody>
</table>

\footnote{Irwin (2007), using the closely related Trade Resistance Index, estimates the ratio in 1960 was 1.74 which suggests the bias hasn’t changed too much over the sample period.}
5.2 Simulations

This section presents the results of the calibrated model. In interpreting the results, I identify the raw materials sector as non-manufacturing output and the manufactured parts and final goods sectors as manufacturing output.

The model is able to match a number of trade growth facts. It generates both the empirical growth in trade and the change in composition.

Figure 2: U.S. Exports/Value Added, Model and Data 1967-2002

As can be seen from Figure 2, the model does a good job of matching the empirical trade growth. The share of goods production that is exported in the model grows 122 percent from 1967 to 2002, close to the actual growth in export share of 135 percent. Both tariffs and freight costs fall, leading to expanding trade. The model is able to generate a doubling the trade share with a relatively modest the fall in trade costs and Armington elasticity. As noted above, most standard models (that exclude VS trade) are unable to generate such significant trade growth.

The model is able to generate such strong growth because of the rapid expansion of manufacturing trade. The share of manufacturing output that is exported in the model...
grows much faster than total trade, growing by 291 percent between 1967 and 2002. This growth is very close to the 317 percent empirical growth in the share of manufacturing output. This growth is mostly due to increasing trade in manufactured parts. Of the three types of goods, manufactured parts grows the fastest. In 1967, there is almost no trade in parts. By the 1990s, this category is over half of manufacturing trade.

The model overpredicts manufacturing trade growth from 1967 to 1972. This period is when the Kennedy Round was implemented. It takes time for producers to develop new sources of input supply and for final goods exporters to develop new consumers (Arkolakis 2006), so there will be a lag between a change in trade policy and a change in trade patterns. The actual trade share in 1974 is closer to model level in 1972. The model’s “miss” at this point may reflect this lag.

Table 3: Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS Trade 1997</td>
<td>18.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Mat. trade share (67-02)</td>
<td>9.5%</td>
<td>26.0%</td>
</tr>
<tr>
<td>Interm. Trade Share 1972</td>
<td>53.4%</td>
<td>50.4%</td>
</tr>
<tr>
<td>Interm. Share Mfg. Trade 1997</td>
<td>38.4%</td>
<td>30.7%</td>
</tr>
</tbody>
</table>

As a consequence of the rapid rise in manufactured goods trade, VS trade also grows rapidly. VS trade increases from 6 percent in 1972 to almost 19 percent in 1997. The model is not too far off from the estimate in Chen et al. (2005). In the 1960s, manufactured goods faced higher tariffs than raw materials. Beginning with the Kennedy Round of the GATT, manufactured goods tariffs fell more rapidly than non-manufactured goods. Lower trade costs more manufactured parts led to an rapid expansion of VS trade.

While VS trade grows rapidly, intermediate goods trade does not increase significantly. This prediction matches the data in that intermediate goods share of trade is roughly constant over most of the period. The model predicts that 61 percent of trade is intermediate good which is close to its prediction of 55 percent in 2002. The rise of
VS trade in the model is not driven by a relative increase in intermediates trade.

Intermediate goods trade shifts from being dominated by raw materials to manufactured parts. The share of materials output that is exported grows by only 9 percent, even lower than the 26 percent in the data. Almost all the growth in VS trade is due to the rise of parts trade. Raw materials production tends to depend on local geographical conditions in a way that manufacturing does not. The lack of strong comparative advantage is represented by the low value of \( \theta \). Mines can only be sited where ore exists naturally. A steel plant can be placed anywhere. Therefore, raw materials will be traded even when trade costs are high. Combined with the fact that trade costs for raw materials fell less, most of the new trade in goods is due to new trade in manufactured parts. This feature of the model is consistent with empirical finding that goods lower down the supply chain have lower elasticities (Balassa & Kreinin 1967).

The model is consistent with the finding that parts and component trade has grown more rapidly than manufacturing trade (Yeats 2001). Parts are a growing part of manufacturing exports. From only 1992 to 1997, they went from 27 to 31 percent of U.S. manufacturing exports (Athukorala & Yamashita 2006). The model predicts that 38 percent of manufacturing trade is in parts in 1997, which is somewhat higher. However, the measure of parts trade is only that with is labeled as such in the trade data, either because it was coded as part of an Offshore Assembly Program or was classified in a parts category. Therefore, there may be unmeasured parts trade that do not fall into these categories.

While the model is successful at generating a number of moments in the data, it does not fully account for all trade. The model only has three stages, with two in manufacturing. For some complex (and heavily offshored) goods, such as automobiles and aircraft, the production process may be disintegrated into more stages. The model may be underestimating the degree of vertical specialization. The difference may also reflect changes in non-tariff trade barriers. Financial liberalization has encouraged foreign direct investment. Trade among affiliated firms within a single multinational has been an important source of trade growth. Improvements in technology, both production (al-
ollowing better standardization) and communication (allowing better coordination across locations), may have had a role. The results do indicate that changes in trade protection were a major cause of the rise of VS trade.

It is not the case that geography does not matter for manufacturing. Manufacturing plants are more likely to be built within a country close to cheap transportation hubs, such as ports, rivers or rail centers. However, manufacturing is less tied to geographic endowments relative to raw materials. Even industries that use inputs that are closely tied to natural endowments, such as steel and refined sugar, are often placed far from the sources of those inputs. For example, Japan became a major steel producer despite not producing iron ore domestically. It imports the ore from Australia. The center for cane sugar refining in the United States was New York City. New Orleans, a major port close both to domestic and imported raw sugar sources, was a minor producer (Glaeser 2005).

The results may explain why trade among industrial countries has increased, despite having similar industrial structures. In the 1960s, when trade is dominated by goods that depend heavily on endowments, less developed countries (LDCs) that are dominated by raw materials production make up more of world trade. Since they do not have a significant industrial base, they are less able to take part in the rise of VS trade. In addition, the early rounds of the GATT did not include many LDCs, further isolating them from VS trade. This explanation does not rely on increasing returns or agglomeration economies, as in Krugman (1980), to explain the concentration of trade among similar countries.

In fact, it is precisely because productivity differences in parts production between industrialized countries are small that causes relatively small declines in trade costs to have such a large impact on trade growth. Since the productivity differences in tradeable goods between rich and poor countries are large (Herrendorf & Valentinyi 2007), even high trade barriers (such as those used by import substitution programs) are not sufficient to prevent poor countries from specializing in materials production.
6 Conclusion

The results suggest that trade policy is a significant source of the rise in VS and manufacturing trade, accounting for about two thirds of observed growth in both total and manufacturing trade. The reduction of trade barriers to low levels has allowed trade in goods where the productivity advantage across counties is small to grow. In addition, a more neutral protection structure allowed for the offshoring of manufactured parts production. The results also explain why trade among industrial countries has increased, despite having similar industrial structures.
A Data

Imports One digit end use category, from the BEA website.

Exports Export share of output by type is from BEA’s Tables 1.2.5 and 4.1.

Import Margins The import margins are reported in U.S. Department of Commerce (1977) for 1967 and Ritz, Roberts & Young (1979) for 1972. The 1997 and 2002 margins are estimated by using the concordance from the BEA website to convert the Census data on duties and freight, collected in Feenstra (1994) and the U.S. International Trade Commission website into the IO classification. The IO tables are taken from the BEA website.

References


Arkolakis, Costas (2006), Market access costs and the new consumers margin in international trade, mimeo, Yale University.


Bergoeing, Raphael & Timothy J. Kehoe (2003), Trade theory and trade facts, Staff Report 284, Federal Reserve Bank of Minneapolis.


Bridgman, Benjamin (2008b), The extensive margin and trade weighted import costs, mimeo, Bureau of Economic Analysis.


Johnson, Robert C. & Guillermo Noguera (2008), Accounting for intermediates: Production sharing and trade in value added, mimeo, U.C. Berkeley.


Kehoe, Timothy & Kim Ruhl (2002), How important is the new goods margin in international trade?, mimeo, University of Minnesota.


Lehman, Sibylle & Kevin O’Rourke (2008), The structure of protection and growth in the last 19th century, Working Paper 14493, NBER.


Ruhl, Kim J. (2005), Solving the elasticity puzzle in international economics, mimeo, University of Texas.


