The Dissertation Committee for Shalah Maryam Mostashari

certifies that this is the approved version of the following dissertation:

Trade Growth, the Extensive Margin,

and Vertical Specialization

Committee:

____
Dean Corbae, Supervisor

____
Peter Debaere, Supervisor

____
Jason Abrevaya

____
Kripa Freitas

____
David Kendrick

____
Stephen Magee

Trade Growth, the Extensive Margin,

and Vertical Specialization

by

Shalah Maryam Mostashari, B.A.; M.S.

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Dedication

To my family

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Trade Growth, the Extensive Margin,

and Vertical Specialization

Shalah Maryam Mostashari, Ph.D.

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Supervisors: Dean Corbae and Peter Debaere

This dissertation consists of three essays in International Trade. The first essay studies the impact of changing tariffs on the range of goods countries export to the United States. The empirical analysis shows that tariffs tend to have a statistically significant but small impact: at best 5 percent of the increasing extensive margin for 1989-1999 and 12 percent for 1996-2006 is explained by tariff reductions. This suggests the extensive margin has not amplified the impact of tariffs on trade flows to such an extent that the relatively moderate tariff reductions since WW II can explain the strong growth of world trade.

The second essay investigates the sector and country determinants of the range of goods that countries export to the United States. Besides relating the traditional determinants of comparative advantage, sectors' factor intensities interacted with countries' factor abundance to the extensive margin in a sector, the empirical

investigation includes interactions between sector-level measures of intermediate intensity and trade frictions. Consistent with hypotheses about fragmentation, the results show that closer countries and countries with lower tariffs imposed on them export a wider range of goods in sectors that have large intermediate cost shares. The impact of trade frictions is, however, far less pronounced for the more skilled-labor intensive sectors that are characterized by use of a greater range of intermediates.

The third essay studies the impact of trade liberalizations on U.S. bilateral trade from 1989-2001 with a focus on the influence of exporting country liberalizations which matter when exports are produced with imported intermediates. Guided by extensions of the Eaton and Kortum (2002) model which allows for production to involve the use of imported intermediates, the essay estimates a structural equation that links U.S. bilateral trade flows to both intermediate tariffs imposed by countries exporting to the United States and U.S. tariffs. The empirical estimates suggest that especially for less developed countries their own liberalizations have been quantitatively much more important in explaining bilateral trade growth with an effect 3 times larger than the impact of U.S. liberalizations.

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Chapter 1: Introduction

Sustained growth in international trade has characterized the world economy since WW II while world tariff reductions have been moderate, suggesting elasticities of trade to tariffs that are counterfactually large. Recent researchers have argued that growth in the range of goods that countries export, the extensive margin, as well as growth in internationally fragmented production processes following trade liberalizations are behind the magnified response of trade to tariffs. This dissertation quantifies the contribution of tariff liberalization to trade growth along the extensive margin and under internationally fragmented production.

The first essay studies the impact of changing tariffs on the range of goods countries export to the United States. The empirical analysis shows that tariffs tend to have a statistically significant but small impact: at best 5 percent of the increasing extensive margin for 1989-1999 and 12 percent for 1996-2006 is explained by tariff reductions. This suggests the extensive margin has not amplified the impact of tariffs on trade flows to such an extent that the relatively moderate tariff reductions since WW II can explain the strong growth of world trade.

The second essay investigates the sector and country determinants of the range of goods that countries export to the United States. Besides relating the traditional determinants of comparative advantage, sectors' factor intensities interacted with countries' factor abundance to the extensive margin in a sector, the empirical investigation includes interactions between sector-level measures of intermediate intensity and trade frictions. Consistent with hypotheses about fragmentation, the results show that closer countries and countries with lower tariffs imposed on them export a wider range of goods in sectors that have large intermediate cost shares. The impact of trade frictions is, however, far less pronounced for the more skilled-labor intensive sectors that are characterized by use of a greater range of intermediates.

The third essay develops and estimates a structural equation that links bilateral trade flows under multi-stage production to both intermediate tariffs imposed by exporting countries and importing country tariffs. The model is estimated using U.S. bilateral trade and tariff data for the period 1989-2001. Both the model and the results suggest that countries gain a comparative advantage in producing intermediate intensive goods if they have low trade barriers on intermediate products. Furthermore, the results show that especially for less developed countries their own liberalizations have been quantitatively much more important in explaining bilateral trade growth with the United States than U.S. liberalizations.

What follows is a detailed investigation of the aforementioned topics. Each chapter focuses on assessing the contribution of tariff liberalization in explaining the strong growth of trade in models that allow for a changing range of goods to be traded, for international fragmentation, or both.

Chapter 2: Do Tariffs Matter for the Extensive Margin of International Trade? An Empirical Analysis[1]

2.1 Introduction

Sustained growth of international trade has characterized the world economy since World War II. Explaining this steady growth, however, presents a major quantitative challenge. While continued trade liberalizations are often credited for increasing trade, overall, tariff reductions have been relatively moderate.[2] Consequently, the elasticity of exports to tariffs that is needed to attribute aggregate trade expansion to tariff reductions is larger than what traditional models suggest. In this lively debate, a new hypothesis has attracted considerable attention. Researchers have observed non-negligible increases in the range of goods that countries export, the extensive margin, following trade liberalizations, and have conjectured that these increases are behind the magnified impact of tariff reductions.[3] In a similar vein, Yi (2003) has argued that significant increases in the extensive margin are linked with vertical specialization in the wake of tariff reductions. What used to be trade in final goods often becomes, after a tariff reduction, an internationally fragmented production process in which a product

[1] This chapter was joint work with Peter Debaere. See Debaere and Mostashari (2010a).
[2] Yi (2003) notes that the world average manufacturing tariff dropped by only 11 percent between 1962 and 1999, but the share of manufacturing exports in GDP rose by a factor of 3.4.
[3] Helpman, Melitz, and Rubinstein (2008), Hummels and Klenow (2005), Evenett and Venables (2002), Besedes and Prusa (2003), Kang (2004), Feenstra and Kee (2004) and Felbemayr and Kohler (2006) show that countries differ in the varieties they trade, in the range of countries they trade with, and that these patterns change over time. Kehoe and Ruhl (2003), Ruhl (2004), and Hilberry and McDaniel (2002) show evidence of an increase in the extensive margin after the North American Free Trade Agreement (NAFTA). See also Klenow and Rodriguez-Clare (1997) for an analysis of changing varieties in Costa Rica.

crosses borders multiple times at different stages of its making. This phenomenon suggests that even moderate tariff reductions, which give way to increased vertical specialization, result in pronounced trade expansion by way of the extensive margin. This paper quantifies the exact contribution of tariff liberalizations to the changing range of goods that countries export.

The analysis proceeds by investigating with disaggregate bilateral U.S. trade and tariff data the link between tariffs and the changing range of goods that countries export to the United States. Different from Kehoe and Ruhl (2003) or Hilberry and McDaniel (2002), the analysis is not restricted to only include countries that become directly involved in formal trade agreements, but considers all countries that export to the United States. The focus is on changes in the extensive margin occurring between 1989 and1999; however, for all statistical and econometric analysis the study alternatively considers the time period from 1996 to 2006, finding largely consistent results. The investigation first documents the extent to which countries change the range of goods that they export to the United States and reveals substantial extensive margin growth across most countries: For example, for around 85 percent of the countries that export to the United States, over 40 percent of all goods categories that these countries exported in 1999 were not exported in 1989. In terms of trade volumes, for around 50 percent of these countries, over 40 percent of the volume of 1999 trade was from goods that were not exported in 1989. At the same time, however, U.S. tariff liberalization was relatively moderate, on average around 1 percent between 1989 and 1999. The empirical analysis investigates the extensive margin changes by modeling the probability that a good is exported to the United States controlling for various factors that are thought to influence trade volumes. The results show that tariff changes in the United States tend to affect the extensive margin in a statistically significant but quantitatively moderate way. Consideration is given to different levels of commodity aggregation, different time periods, different samples of the data, and alternative econometric specifications, but the results show that tariff changes can only account for at most 12 percent of the extensive margin growth observed in the data.

The findings of this analysis are in line with recent research that has, to some extent, challenged the quantitative importance of the impact of trade liberalization on the volume of trade. Early on, in a careful study of the Canada-U.S. free trade agreement that was implemented in 1989, Trefler (2001, 2004) argued that most of Canadian import growth was not due to tariff cuts. In particular, for the 213 industries studied, only 5 percent of import growth was due to tariff reductions; the results for intra-firm trade were even smaller. There is also a large literature of demand elasticity estimates for international trade models of countries that trade differentiated products with varying degrees of substitutability. However, the estimates tend to be much smaller than the ones needed to rationalize the trade growth observed in the data. [4] Our findings of a limited response to tariffs specifically along the extensive margin of trade can also be linked to

[4] Yi (2003) for example argues a demand elasticity of 10 or more is needed to rationalize the world trade growth in recent decades; Anderson et al. (2005), argue that only an elasticity of 17 can match world bilateral trade patterns, and Feinberg and Keane (2009) need an elasticity in the range of 25 to 30 to explain the increase of intra-firm trade as a fraction of total sales for Canadian Multinationals between 1983 and 1996. However, actual estimates of these elasticities are much smaller. For example, Broda and Weinstein's (2006) median estimate of the elasticity of substitution is in the order of 3.1; Romalis's (2007) demand elasticities range between 6.2 and 10.9. For a good discussion, see Ruhl (2004).

recent plant-level studies. Bernard and Jensen (2004a,b) and Das, Roberts and Tybout (2007) find that there are large fixed costs for firms that begin to export. These fixed costs rationalize why moderate tariff reductions primarily induce an increase in exports at the intensive rather than the extensive margin. Econometric and anecdotal evidence, from Feinberg and Keane (2006, 2009) and Keane and Feinberg (2007), points in the same direction. In particular, Feinberg and Keane (2009) find that firms' decisions to engage in either intra-firm trade in intermediates or arm's-length trade are unrelated to reductions in tariffs, so that tariff reductions do not matter at all for the increase of trade along the extensive margin. Instead, Keane and Feinberg (2007) argue that technical change in the form of better logistics management, such as just-in-time management, is primarily driving the increase in intra-firm trade. Also Lileeva and Trefler (2007) argue that tariff cuts can be effective especially in conjunction with new technologies such as just-in-time delivery.

The remainder of this paper is organized as follows. Section 2 discusses the data and descriptive statistics. Section 3 provides the theoretical setting and econometric model. Section 4 contains the empirical results and alternative specifications. Section 5 concludes.

2.2 Data and Descriptive Statistics

Data Sources

This essay studies bilateral U.S. imports using the United States International Trade Commission's *U.S. Imports/Exports (Dataweb)* which records bilateral trade flows for the U.S. at the 10-digit Harmonized Tariff Schedule (HTS) level. While the primary focus is on the decade between 1989 and 1999, the findings are robust to changes in the time frame between 1996 and 2006. The objective is to consider changes in the ranges of manufacturing goods that countries export to the United States and to quantify the importance in U.S. tariff changes. As Pierce and Schott (2009) have documented, there is significant instability in both the U.S. import and export code classifications, which poses a particular challenge when attempting to define a distinct set of goods over time. In the preferred specification, the focus, therefore, is on manufacturing categories that were consistently defined over the time period between 1989 and 2007, thus omitting goods that have been redefined or reclassified.[5] Goods are distinguished at the 6-digit level since distinctions of goods at the 10-digit level are in many instances too fine to be meaningful with respect to a country's ability to export a particular commodity.[6] To ensure omitting reclassified goods does not drive the results, as an alternative the study employs the methodology of Pierce and Schott (2009) to concord 10-digit goods over time. The results are quantitatively and qualitatively similar for samples at the 10-digit level that include all goods (properly concorded) versus samples that only consider the consistently defined goods. Appendix A.1 and A.2 describes the concordance method and shows the results for the alternative specifications. All categories that were redefined are dropped when aggregating to the 6-digit level since including redefined goods would necessitate a higher level of aggregation. This is because the redefined classification for

[5] The focus of this paper differs from Xiang (2005), who exploits changes in goods classifications to identify new goods.
[6] For example, the only difference between HTS10 category 6405100030 (OTH FTWEAR W UPPERS LEATHER/COMPOSITION LEATHER MN) and 6405100060 is whether the item is for women or men.

many 10-digit goods belongs to different 6-digit categories, thereby requiring the aggregation of multiple 6-digit categories. Note that the 10-digit-level econometric results are statistically somewhat less significant than the 6-digit-level estimates. The final sample is of 3,328 HTS 6-digit goods categories. The sample of countries includes all countries for which the United States maintained normal trade relations, and which did not undergo any type of restructuring over the sample period. There are a total of 177 countries.[7]

Tariff data are taken from the United States Trade Commission's *Tariff Database.* These data originate for commodity descriptions at the HTS 8-digit level and are also aggregated to the 6-digit level. The database includes the *ad valorem*, specific, and estimated *ad valorem* equivalent tariffs based on the Most Favored Nation (MFN) status. In addition, the file indicates commodities that are eligible for tariff preference programs and the applicable tariffs under these programs. As a measure for trade barriers, this study employs the estimated *ad valorem* equivalent tariff for a particular country applicable under the relevant preference program. If a country/good qualifies for more than one preference program, then the minimum tariff of all qualifying programs is used.

In the descriptive statistics and econometric analysis, several variables are taken from the *Penn World Tables 6.3,* and data from the World Bank on average manufacturing tariffs of countries that export to the United States. Because of lack of data

[7] The only exceptions are East and West Germany whose trade volumes were aggregated for 1989.

in one or both of these sources, the econometric estimates and statistics that involve these data are limited to a smaller sample of countries.[8]

Evolution of U.S. Tariffs

Over the sample period, U.S. tariff variation for a given good across countries can be attributed to several preferential arrangements and bilateral free trade agreements (FTAs). The United States–Israel FTA took effect in 1985 and provided for the elimination of duties for merchandise entering the United States from Israel. While the Canada–U.S. Free Trade Agreement (CUSFTA) entered into force in 1989, it was supplanted by the North American Free Trade Agreement (NAFTA) in 1994. In addition to these, the Caribbean Basin Initiative (CBI) offered preferential and sometimes duty-free treatment for a range of products to qualifying nations and territories. The Andean Trade Promotion Act (ATPA), which entered into force in 1993, applied to qualified goods exported by Bolivia, Columbia, Ecuador, and Peru. In addition, the United States offered duty-free treatment for a range of goods to qualifying less-developed countries under the Generalized System of Preferences (GSP); furthermore, a wider range of goods are offered duty-free treatment to the least developed of these countries (GSPLDC). Note that access to GSP and GSPLDC preferences, changes over time, with some countries gaining access and others graduating from the preference program. For all other countries that are granted normal trade relations (NTR) status, the United States charges the MFN rate.

[8] See Appendix A.3 for a list of countries included in the analysis.

In order to study the changes in U.S. tariffs between 1989 and 1999, this paper first looks at the changes in tariffs by countries or groups of countries based on the relevant preference program. The data reveal that actual U.S. tariff decreases have been small. The most pronounced average manufacturing tariff decreases within a given preference program occurs for Canada, which experienced a 4.78 percentage point decrease (from 4.8 1989 to 0.02 in 1999) and Mexico, which experienced a 3.12 percentage point decrease (from 3.51 in 1989 to 0.39 in 1999). Average tariff rates for those countries who received the MFN tariff experienced an average decrease of 1.42 percentage points (from 5.65 in 1989 to 4.23 in 1999). GSPLDC countries experienced a decrease on average of 1.11 percentage point (from 3.42 in 1989 to 2.32 in 1999). Since all the ATPA countries qualified for GSP status for years prior to 1993, their decrease is about 1.27 percentage points (from 3.42 in 1989 to 2.15 in 1999). Israel (from .63 in 1989 to .02 in 1989), GSP countries (from 3.42 to 2.92), and CBI countries (from 2.09 in 1989 to 2.05 in 1999) experienced changes of less than 1 percentage point.

In sum, the largest changes in tariffs occur for the NAFTA countries. The rapid increase of Mexico's and Canada's trade with the United States in the wake of NAFTA has been well documented by Romalis (2007) and others. In addition, Kehoe and Ruhl (2003) and Hilberry and McDaniel (2002) have emphasized the importance of changes in the extensive margin of trade after NAFTA and other trade liberalizations. Less effort, however, has gone into comparing countries that have benefited from trade liberalizations to those that have not, and specifically into assessing across the board the extent to which countries export goods (to the United States) that they did not previously trade. In what follows, a comparison is made between the number of newly traded goods by countries that experienced substantial decreases in U.S. tariffs to that of other U.S. trading partners that for the most part did not experience the same sweeping tariff reductions.

Newly traded goods across countries

In this section, a study is made of the changes in the range of goods exported to the United States between 1989 and 1999. A commodity is considered traded in a particular year if there are positive exports to the United States in that HTS 6-digit category. Table 2.1 summarizes a few key statistics. First attention is given to the experience of Mexico and Canada, the NAFTA countries. This focus is warranted since earlier literature, especially Kehoe and Ruhl (2003) and Hilberry and McDaniel (2002), has reported significant changes in the extensive margin in the wake of NAFTA. Panel A of Table 2.1 focuses on the 1989 to 1999 time frame. As can be seen, there is, especially for Mexico, a significant increase in the extensive margin. Mexico exports 2,572 of the 3,328 goods categories in 1989, 1999, or both. Yet 26 percent of those goods were newly traded post-NAFTA, and 10 percent of those goods stopped being traded post-NAFTA. Note that the share of newly traded goods for Canada is less at 8 percent. In itself, this lower number is not so surprising, since Hummels and Klenow (2005) have shown that the range of goods that are exported is larger for bigger and more developed countries. Moreover, given the finite number of goods, extensive margin *growth* should be more manifest for less-developed countries. The last two lines of Panel A contain the most striking finding. For many other countries whose tariffs with the United States did not decrease dramatically, one finds comparably large shares of newly traded goods. For example, China exports 2,504 of all goods categories in 1989, 1999, or both, and 34 percent of these traded goods are newly traded in 1999. In addition, when each of the rest of the countries' goods is treated as a separate observation, 30 percent of the traded goods were newly traded in 1999.[9] The last two columns give the trade volume share of disappearing and new goods: the share of disappearing goods' trade in 1989, and the share of newly traded goods in 1999.[10] In Panel B of Table 2.1, changes in the extensive margin for the same countries for the period from 1996 to 2006 are reported. As one can see, there persists significant change in the extensive margin in this latter time frame.

Figure 2.1 is a plot of the share of goods newly traded in 1999 in terms of the number of HTS 6-digit categories against average changes in tariffs.[11] Extensive margin growth of exports to the United States is not limited to countries experiencing systematic U.S. tariff reductions. Furthermore, for a given tariff reduction, the importance of newly traded goods varies substantially across countries.[12]

2.3 Econometric Analysis

[9] In terms of the categories of goods traded, for over 80 percent of the sampled countries newly traded goods constitute over 40 percent of all the goods categories which a country exports to the United States in 1999. In terms of the total value of a country's 1999 exports, newly traded goods still constitute over 40 percent of the value of exports for over 50 percent of the countries.

[10] The continuously traded goods share of trade volume for 1989 is one minus the disappearing goods' share and for 1999 one minus the new goods' share.

[11] The graph in terms of value shares is fairly similar.

[12] In addition it is also possible to measure the importance of net extensive margin change in real trade growth. The extensive margin share of real trade growth is that share accounted by the net change in real trade volumes of goods whose trade status changed (the real trade of newly traded goods at the end of the sample less the value of real trade in the first period for goods that were no longer traded). Using this measure, extensive margin growth accounts for approximately 9.3 percent of real trade growth for the 1989 to 1999 sample, and for around 10.8 percent of real trade growth for the 1996 to 2006 sample.

In order to study the changing range of goods that countries export and to quantify the contribution of tariffs to those changes, the econometric model investigates the probability that a good is exported to the United States in 1999 controlling for whether or not it was exported to the United States in 1989. This specification, which exploits the cross-country sample variation by including goods-specific effects, allows one to assess the importance of changing tariffs and other relevant variables to changing trade status.

In particular, the variable y_{iz} is indicator variable that is 1 when country *i* exports good *z* to the United States in 1999 and 0 if it does not. Specifically,

$$(2.1) \qquad y_{iz} = 1[y_{iz}* > 0]$$

$$(2.2) \qquad y_{iz}* = \beta_1 + \beta_2 \Delta \ln(1+\tau_{iz}) + \beta_3 status89_{iz} + X_i^{'}\lambda + \alpha_z + \varepsilon_{iz} \, ,$$

where $y_{iz}*$ is a latent variable whose value determines whether or not a good will be exported in 1999; $\Delta \ln(1+\tau_{iz})$ is the change in the natural log of the gross *ad valorem* equivalent tariff imposed by the United States on good *z* and country *i* between 1989 and 1999, and $status89_{iz}$ is an indicator variable, which is 1 if good *z* was exported by *i* to the United States in 1989. X_i is a vector of country-specific explanatory variables, which includes the change in the natural log of GDP and GDP per capita between 1989 and 1999 to capture the effects of changing size and development level that are known to be important for the extensive margin.[13] Also included is the natural log of the exporting countries' average manufacturing tariffs since this may affect a country's ability to acquire intermediate goods and consequently affect its competitiveness in exporting final

[13] See Hummels and Klenow (2005).

goods, as suggested by the vertical specialization literature. The vector X_i also includes several measures of bilateral trade resistance (distance from the United States, common language with the United States, whether the country is landlocked or an island, and finally, whether the country shares a border with the United States). Lastly, because GSP preferences (a zero tariff) are given to countries primarily because they are not competitive, this could be an important source of endogeneity for U.S. tariffs; therefore, a dummy variable which is 1 if the country is a GSP beneficiary is also included.[14] Since there may be good-specific variables that make it more or less likely that a good is exported from many countries, the model allows for good specific heterogeneity.[15] Finally, the model is estimated by way of a probit model with a full set of goods dummies to capture the good-specific effects; however several alternative econometric models are used to check the robustness of these results. Concentrating on manufacturing industries each specification is estimated separately for 12 sectors of the economy. Since many of the explanatory variables only vary by country, all specifications are estimated with robust standard errors clustered by country.

2.4 Results

[14] Persistent GSP beneficiaries mostly have no change in tariffs since they get zero tariffs for many goods. The prediction is for a negative coefficient on the GSP dummy because GSP preferences are often given to non-competitive countries.

[15] The number of exporting countries varies a significantly across goods. One could interpret goods effects as capturing characteristics relevant for product cycles (e.g., technology diffusion for standardized production processes). Similarly, since most tariff variation is cross-sectional, the goods effect captures factors that are otherwise in the error term and potentially correlated with tariffs and other variables. The endogenous trade protection literature suggests that non-competitive industries that are susceptible to import competition lobby for tariffs. Without controlling for these factors, higher tariffs may be associated with a greater probability of exporting thus underestimating the negative effect of tariffs.

Table 2.2 presents the results. In this table, only the coefficients and marginal effects of the change in the U.S. tariff variable are reported. Note, however, that the signs on the other variables are mostly in line with expectations.[16] The coefficient estimates for the full sample are contained in the first column of Table 2.2. As one can see, all the coefficients on the U.S. tariff variables are negative as expected. Also, there is significance at the 10 percent level or higher in 9 out of 12 sectors.

To better quantify the implications of these estimates, in the following columns the focus is on the marginal effects computed at the means of the samples. For the full sample of goods, these are reported in Column 2 of Table 2.2. The average marginal effect across industries is around –1.10, suggesting that a 1-percentage-point drop in the tariff rate, say from the 1989 mean tariff rate of .039 to .029 in 1999, increases the probability of exporting a particular good by only .0110 percentage points. As can be seen, the magnitudes of the marginal effects vary a great deal across industries, but are always very small.

To better quantify the magnitude of the effects of the actual tariff changes over the sample period, the net contribution of U.S. tariff changes to extensive margin growth predicted by the model is calculated.[17] By summing the predicted number of newly traded goods due to U.S. tariff changes across all countries and dividing by the predicted

[16] Increases in real GDP per capita tend to increase the extensive margin; however, controlling for changes in real GDP per capita, increases in GDP tend to decrease the probability of export. Distance and trade-friction variables decrease the probability of export, and decreases in countries' own tariffs tend to increase exports. Finally, GSP status decreases the probability of export as expected, but is insignificant in many industries. A good that is exported in 1989 is positively associated with the export status in 1999.

[17] The tariff change contribution is calculated as the expected number of new goods exported due to tariff changes as a share of the expected number of new goods exported. The exact formula is found in Appendix A.4.

number of newly traded goods, the tariff reductions between 1989 and 1999 are found to explain only a small share, about 5 percent, of the newly traded goods that emerge over the period. In this light, it is worth remembering that for the most part the U.S. tariff reductions have been fairly moderate. These findings are in line with the descriptive statistics in Section 2.2: U.S. tariff reductions are unlikely the alpha and omega for why the extensive margin changes.

Next, the sample is divided based on whether or not a good is traded in 1989 or not. This allows one to see if tariffs had larger negative effects on the probability of trade in 1999 for goods that were not exported in 1989 versus those that were. The third column of Table 2.2 presents the marginal effects for goods that were not traded in 1989, and the fourth column for the goods that were traded in 1989. For the goods that were not traded in 1989, the estimated marginal effects are very similar to those reported for the full sample, but with only significant coefficients and marginal effects for 7 of the 12 industries. Here also, the actual tariff changes explain about 5 percent of the newly traded goods. In the complementary sample of goods, those that were exported to the United States in 1989, tariff changes are rarely significant determinants of trade. In fact, in only 3 of the 12 sectors are tariffs significant. As for goods that were traded in 1989, tariffs do not appear to be a primary determinant of trade in the latter period.[18] In other words, for those goods that were not traded in 1989, tariffs affect the probability that the good will be exported in a significant way across more industries.

[18] For the formula used to calculate the expected share of disappearing goods that can be explained by tariffs, see Appendix A.5. Because tariff coefficients are negative and because for most country/good pairs tariffs decreased, the result is that more goods would have disappeared had tariffs not changed

In Columns 5 and 6 the effects of tariffs and other variables are allowed to differ between low-income and high-income countries.[19] For the high-income countries, accounting for around 50 percent of the newly traded goods in the sample, the marginal effects are larger than the estimates for the whole sample of countries.[20] For the least-advanced countries, however, there are very different results. From Column 6, in only 1 sector is the U.S. tariff term coefficient significant. This strongly suggests that tariff reductions in the United States are of little consequence for the extensive margin of trade for developing countries. The stark contrast between developed and developing countries is potentially supportive of recent studies which have argued that tariff reductions by themselves may not have too strong an impact on trade at the extensive margin. In particular, Lileeva and Trefler (2007) argue that tariff reductions in combination with the availability of just-in-time technology may be effective. To the extent that the availability of this technology splits along developed- versus developing-country lines, these findings are consistent with this reading of the evidence.

As a final specification, an alternative criterion for a good to be considered traded and/or newly traded is considered. For a good to be considered traded in 1999, it must have been exported in at least one of the three years between 1997 and 1999, and for a good to be considered traded in 1989, it must have been exported in at least one of the years between 1989 and 1991. Column 7 contains the marginal effects for this specification. Under this alternative definition of a traded good, the U.S. tariffs are more

[19] The lowest income group has a Real GDP per capita in 1989 (measured in 2005 dollars) that is less than $7,600. This cut-off was chosen as it indicated the largest break in per capita income among sampled countries. Results are robust to changes in this cut-off.
[20] The findings for OECD countries are in line with those for high-income countries.

significant with 10 of the 12 industries having negative and significant marginal effects and coefficients. Also, the magnitudes of the marginal effects are larger. Nevertheless, the overall contribution to the extensive margin is still relatively small at around 5 percent.

To ensure that the finding of a small contribution of U.S. tariff liberalization is not the result of the sample time period, also included in Table 2.3 are regression results for the time period between 1996 and 2006. Columns 1 and 2 report coefficient estimates and marginal effects for the full sample. As can be seen over this time period there is a somewhat larger overall contribution of tariff changes at around 9 percent compared to 5 percent over the 1989-1999 period. It should be noted, however, that tariff changes were on average larger for this second sample period: a 1 percentage point decrease for the 1989 to1999 time frame versus a near 3 percentage point decrease for the 1996 to 2006 time frame. Focusing only on goods that were not traded in 1996, one observes a marginally larger but still small contribution of tariffs to extensive margin growth, at around 12 percent. Breaking up the sample into high- and low-income groups, there is little significance on U.S. tariffs for this time frame. In fact, for the high-income group, no sectors have a significant effect of tariffs, and for the low-income group only one.[21] For the alternative criteria for a good to be considered traded, there results the expected and negative coefficients across 6 sectors. Moreover, independent of the time frame the

[21] One possible explanation for the lack of significance in the latter samples of high- and low-income countries could be that after including goods dummies, there is simply not enough variation of tariff changes across countries when the sample of countries is split. In fact, the average tariff change by country has a coefficient of variation of -.877 for the 1989-1999 sample but only a -.344 coefficient of variation for the 1996-2006 sample.

results consistently show small contributions of U.S. tariff liberalization to the extensive margin.

Overall, the contribution of tariff changes to the extensive margin is significant but not too large. This leaves open the question of what then is driving the changes in the extensive margin. According to the model estimates, the single-largest contributing factor to extensive margin growth is the change in natural log of real per-capita GDP which for the full sample of countries in 1999, accounted for approximately 46 percent of the extensive margin growth.

Alternative Econometric Specifications

In this section, results are presented under a number of alternative specifications that still allow for good specific heterogeneity. Both the conditional logit model and the random-effects probit model are able to form conditional likelihoods that have eliminated the good-specific term.[22] Results are also reported for a linear probability model that allows for good-specific heterogeneity.[23]

[22] See Wooldridge (2002) and Hosmer and Lemeshow (1989) for an explanation of these models. A limitation of both the conditional logit and random-effects probit model is in the construction of the marginal effects. Since the good-specific heterogeneity is not observed or estimated, one must make assumptions of its values in calculating the marginal effects.

[23] The main limitation of this model is that predicted probabilities may fall outside the unit interval. Furthermore, marginal effects are held constant regardless of the values of the explanatory variables. Nevertheless, the linear probability model is often thought to give good estimates of the partial effects near the center of the distribution of the explanatory variables. Comparison of the marginal effects of other nonlinear models is usually used as criteria for judging how good the estimates are. See Woolridge (2002). The results for the marginal effects are quantitatively very similar across specifications.

Table 2.4 includes the estimated marginal effects for these alternative specifications for the full sample for both time frames.[24] Marginal effects and predicted values for the conditional logit and random effects probit are estimated assuming the goods effects are zero. As one can see, the results are quantitatively similar to the full sample regressions presented earlier. Tariff changes explain between 4 and 5 percent of the extensive margin growth between 1989 and 1999, and between 10 and 13 percent between 1996 and 2006.

2.5 Conclusion

In this paper disaggregate U.S. bilateral trade and tariff data is used to investigate a prominent hypothesis in recent studies of trade growth. In particular, it has been argued by Yi (2003), Ruhl (2004), and Kehoe and Ruhl (2003) that changes along the extensive margin of trade may reconcile the strong post-World War II trade growth with the overall moderate tariff reductions. The importance of trade growth along the extensive margin for exports to the United States is confirmed. However, the extensive margin of trade has increased significantly between 1989 and 1999 across the board, and not exclusively for countries such as Mexico and Canada, which were directly involved in comprehensive trade liberalizations with the United States. This study directly links the disaggregate variation in tariff changes to this changing extensive margin.

The findings indicate that tariff changes are statistically significant in explaining increases in the extensive margin. At best, 13 percent of newly traded goods can be

[24] Because of the large number of observations coefficients for the textile, apparel, and other articles industries are estimated separately.

attributed to tariff reductions. Interestingly enough, there is a strong disparity between the estimates for developed and developing countries. This indicates that other factors at both the industry and country levels play a much more significant role in explaining changes in the extensive margin. A challenge for future research will be to exactly uncover the driving factors.

Chapter 3: What Determines the Extensive Margin of International Trade? An Investigation of the Cross-Section of U.S. Imports[25]

3.1 Introduction

This essay studies an important dimension of international trade that only recently has been the subject of intense study: the extensive margin of international trade, or the range of goods that different countries export or import to one another. Specifically, this paper investigates what determines the cross-sectional variation of the range of goods that the United States imports from different countries in different industries. The paper studies which sector characteristics are prone to give way to an expanding extensive margin within a sector, and how these interact with the country characteristics of the exporting country. At this point, these determinants are not very well understood, even though the changing range of goods is quite important. More available varieties through international trade tend to increase consumer welfare. Changing extensive margins may reflect the ever-changing and increasing international division of labor that is often linked to the international fragmentation of the production process. Finally, extensive margin growth is a non-trivial source of real trade growth.

The extensive margin is a new frontier of international trade research that fits well within the framework of recent trade models developed to address firm and product heterogeneity. Not so long ago, the smallest unit of analysis in international trade was a sector or industry. With ever new and more detailed datasets becoming available, the

[25] This chapter was joint work with Peter Debaere. See Debaere and Mostashari (2010b).

individual firm and the individual varieties of goods that are traded have attracted more attention. The focus on heterogeneity at the industry and firm level and the changing ranges of goods that countries export has given way to a new set of theoretical questions that the traditional comparative advantage theories and imperfect competition models were hard-pressed to answer: What are the dynamics within a sector? What explains intra-firm trade, and how do we explain the different ways in which firms organize their international production? In return, firm and product heterogeneity have enriched the traditional theories and have made them more general and realistic: Melitz (2003) introduced firm heterogeneity in Krugman's (1980) canonical 'new' trade analysis. Complementing this approach, Bernard, Redding, and Schott (2007) have enhanced the traditional Heckscher-Ohlin model with firm heterogeneity; Eaton and Kortum (2002) and Bernard, Eaton, Jensen and Kortum (2003) have brought heterogeneity in Dornbusch-Fisher-Samuelson's (1977) Ricardian model and in doing so have taken the model beyond its two-country framework.

As has been well documented by, among others, Hummels and Klenow (2005), Evenett and Venables (2002), Besedes and Prusa (2003), Kang (2004), and Feenstra and Kee (2004), the range of goods that countries trade varies significantly across sectors, across destination countries, across countries of origin, as well as across time.[26] As Feenstra (1994) and later Broda and Weinstein (2006) pointed out, this variation poses new challenges for measuring prices, constructing price indices, as well as for assessing welfare gains or losses accurately. The changing extensive margin also matters for how

[26] Recent firm-level studies are investigating the changing product mix within and across firms, see Bernard, Redding and Schott (2008).

one assesses the impact of trade frictions on trade flows, and the policy prescriptions can be different when the adjustment is mainly along the intensive or the extensive margin. In addition, a changing extensive margin can introduce a selection bias in estimates of the impact of trade frictions on the volume of trade, which is why Helpman, Melitz, and Rubinstein (2004) introduced a two-step Heckman procedure with a selection equation that explains the extensive margin in their gravity model of countries' bilateral trade.[27]

The variation of the extensive margin also offers an opportunity to begin addressing phenomena that has not been well understood thus far, such as the growth of world trade. As Yi (2003) has pointed out, the rapid growth in post-WWII trade coinciding with only moderate tariff reductions presents a quantitative challenge: The elasticities of trade to tariffs that are needed to explain the growth of international transactions are too high relative to what traditional models suggest.[28] In order to address this puzzle, Yi put forward the hypothesis that a changing extensive margin due to international fragmentation of production or vertical specialization, could help reconcile the moderate tariff reductions on the one hand, and the rapid trade expansion on the other. Minor trade liberalizations can have a strong impact on international trade flows when production becomes internationally fragmented as new goods may begin being traded and parts of goods may start to cross borders multiple times.

[27] Felbemayr and Kohler (2006) employ a Tobit model.

[28] For example, Yi (2003) argues a demand elasticity of 10 or more is needed to rationalize the world trade growth in recent decades; Anderson, Balistreri, Fox, and Hillberry (2005), argue that only an elasticity of 17 can match world bilateral trade patterns, and Feinberg and Keane (2009) need an elasticity in the range of 25 to 30 to explain the increase of intra-firm trade as a fraction of total sales for Canadian Multinationals between 1983 and 1996. As for the actual elasticity estimates, Broda and Weinstein's (2006) median estimate of the elasticity of substitution is in the order of 3.1; Romalis' (2007) demand elasticities range between 6.2 and 10.9. For further discussion on this issue, see Ruhl (2005).

In previous work, inspired by Yi (2003)'s question, Debaere and Mostashari (2010a) used very detailed international trade and tariff data to study the extensive margin of international trade. In particular, in a probit analysis, they investigated the importance of tariffs in explaining whether or not countries exported a good to the United States.[29] Their findings suggested that from a quantitative perspective, tariffs were only of moderate importance. They found that declining tariffs could explain only about 5 percent of the increase in the extensive margin of U.S. imports between 1989 and 1999. The analysis suggested that much of the actual change seen in the extensive margin was left to country- and good-specific effects. Therefore, this paper seeks to begin to understand what other factors affect the extensive margin of trade.[30]

In order to investigate the role that sector and country characteristics play in determining the range of goods exported within a sector, this paper uses U.S. import data and U.S. production data. Of particular interest are industry characteristics that suggest a greater inclination towards international fragmentation. Therefore, various measures of an industry's use of intermediate goods are used to investigate what country characteristics give way to a comparative advantage in intermediate intense industries. At

[29] Work by Ruhl (2005), Kehoe and Ruhl (2003) and Hilberry and McDaniel (2002) documented how the extensive margin of trade tends to significantly increase in the wake of trade liberalizations such as NAFTA. However, these analyses did not include countries that are not directly affected by trade liberalizations. The detailed cross-country analysis in Debaere and Mostashari (2010a) revealed that many countries, including those not benefiting from significant trade liberalizations by the United States, experienced significant increases in their extensive margin of trade between 1989 and 1999. This observation already suggested what the econometric results confirmed, which was that tariff reductions are not the alfa and omega of a changing extensive margin. Finding similar results, Klenow and Rodriguez-Clare (1997) focus on Costa Rica.

[30] Hummels and Klenow (2005) show that the size and per capita GDP of countries play important roles in determining the range of goods that countries trade. Evenett and Venables (2002) also find that distance matters. Feenstra and Rose (2000) and Xiang (2008) investigate patterns of the extensive margin over time and whether these are consistent with product cycles. These papers, however, do not address what underlying factors drive these patterns.

the same time, the essay investigates how these sector-level intermediate intensity measures interact with measures of institutional quality and trade frictions such as distance and tariffs in determining the extensive margin. The hypothesis is that goods from sectors that are intermediate intense will be more sensitive to trade frictions to the extent that some of these inputs are part of an international production process. In other words, if it is the case that some intermediate inputs are coming from abroad because they cannot be produced at home, or if it is the case that an intermediate in a sector crosses international borders multiple times before it gets assembled into a final product, then one would expect that the extensive margin in such a sector would be quite sensitive to trade frictions.

To investigate this hypothesis, this paper uses two different measures of intermediate intensity and investigates whether or not these industry characteristics amplify or dampen the effects of trade frictions. The first measure is the share of costs spent on intermediates in total expenditures on labor and intermediates. This measure indicates the importance of intermediates relative to labor. The second measure of intermediate intensity is calculated as one minus the Herfindahl index of input concentration which increases with the number of inputs that are used in an industry. These two measures capture very different aspects of fragmented industries. The intermediate cost share term addresses the transactions costs aspects of internationally fragmented production processes since the larger the value of intermediates traded, the greater the potential transportation costs from acquiring intermediates from many foreign countries. The Herfindahl measure, which is related to the degree of complexity, is potentially more dependent on institutional quality since the need to assemble many different intermediate goods from possibly many different suppliers, poses a greater dependence on contract enforcement. This essay also includes other measures that capture additional costs associated with industries that use many intermediate inputs, such as Nunn's (2007) measure of relationship-specific investment requirements, which are similarly more dependent on high quality judicial institutions.

The empirical analysis focuses on the interactions between the sector and country characteristics and how these affect the extensive margin. The methodology is similar to that employed by Rajan and Zingales (1998) and Romalis (2004), who were the first to exploit these types of interactions as sources of comparative advantage. Similar approaches have been adopted by Levchenko (2007), Nunn (2007), and Costinot (2009) who investigate the impact of institutions and the contracting environment on the flows and composition of international trade. They have introduced and tested new sources of comparative advantage through the complementary connections between relationship-specific investments at the industry level and the rule of law at the country level, or the complementary relation between the complexity of industries and the quality of a country's institutions or its endowment of human capital.

This paper differs from previous work in two respects. First, the focus is on the extensive margin. In other words, the objective is to understand to what extent the traditional sources of comparative advantage explain the variation in the range of goods that countries export within a sector. Second, and more importantly, this paper seeks to determine which types of sector characteristics tend to be more prone to respond along the extensive margin to international trade frictions related to distance and higher tariff rates. It is here that the tenuous but interesting link to international fragmentation of production becomes most pronounced. The findings of this paper are that sectors with a higher intermediate input intensity and thus with higher potential for international fragmentation of production are more sensitive to trade frictions. In particular, countries which are closer to the United States and that benefit from lower trade barriers export a larger share of the goods in industries that are more intermediate intensive.

The rest of this paper is structured as follows: In Section 3.2, the empirical model is discussed. In Section 3.3, the data measures and sources as well as some of the stylized facts are discussed. Section 3.4 presents the estimation results before concluding in Section 3.5.

3.2 Empirical Model

This analysis first investigates the importance of the traditional sources of comparative advantage on the extensive margin of trade before extending the model to allow for industries which may be internationally fragmented. The model employed is a modified version of the empirical model employed by Rajan and Zingales (1998), Romalis (2004) and others to add a role for intermediate intensity and to apply the model to the extensive margin. As indicated, this essay is primarily interested in the pattern of trade along the extensive margin, rather than in the actual volume of trade flows. The following regression describes the fairly intuitive starting estimation equation.[31] A measure of countries' range of goods exported to the United States is related to a set of variables that capture factor intensity and factor costs, variables that measure trade costs with the United States, such as tariffs, and a full set of country and industry dummies. The model also allows for a complementary effect of intermediate intensity and intermediate prices to play a role. The primary specification is

(3.1)

$$\pi_{ic} = \mu_i + \mu_c + \beta_1[\alpha_{i,U} A_{c,U}] + \beta_2[\alpha_{i,S} A_{c,S}] + \beta_3[\alpha_{i,K} A_{c,K}] + \beta_4[\alpha_{i,\text{int}} P_c)] + \beta_5 \ln(1+\tau_{ic}) + \varepsilon_{ic}$$

, where π_{ic} denotes the share of total goods (measured as the number of goods) within an industry i that are exported by country c to the United States. μ_i and μ_c denote industry and country fixed effects. The term $\alpha_{i,f}$ is a measure of the factor intensity of factor f in industry i which are assumed to be the same across countries, $A_{c,f}$ is a measure of the factor abundance of factor f in country c. This essay considers three factors of production in the analysis: unskilled labor (*U*), skilled labor (*S*), and capital (*K*). It is well understood that the interactions between the factor abundance measures and the intermediate good intensity variables, $\alpha_{i,f}\ A_{c,f}$, proxy for a country's comparative advantage in producing particular types of goods. For example, one expects a more capital-abundant country,

[31] As a matter of fact, one can directly relate specification (3.1) to and extended version of the Eaton and Kortum (2002) model with multiple sectors and factors of production. Furthermore, the Pareto distribution that characterizes the productivity draws for all goods *within* a sector would be defined at the sector-country level. Our earlier version of the paper contained such an extension, a variation of which can also be found in Chor (2009) and Mostashari (2010).

with higher $A_{c,K}$, to export relatively more in capital-intensive sectors, with higher $\alpha_{i,K}$. Therefore a positive sign is expected for the coefficients β_1, β_2 and β_3 in regression (3.1), such that countries export greater shares of goods in the industries that make intense use of their abundant factors. $\alpha_{i,\text{int}}$ is a measure of intermediate good intensity and P_c is a price index of country *c* that is meant to capture the overall level of prices of intermediate goods.[32] A negative sign is expected for coefficient β_4, such that countries with high intermediate costs will export relatively less in industries that make intense use of intermediates. τ_{ic} is the U.S. tariff that is imposed on country *c* for industry *i* goods. β_5 is also expected to have a negative sign such that countries export less in industries that are subjected to higher tariffs.

The primary focus is to investigate whether or not trade frictions pose a greater deterrent to trade along the extensive margin in industries that are more prone to fragmentation than in other industries. To answer this question, this essay tests the significance of the cross-partial effects of trade friction variables interacted with measures of industry fragmentation. Therefore, the baseline regression (3.1) is extended in the following way:

(3.2) $\pi_{ic} = \mu_i + \mu_c + \beta' \widetilde{A} + \eta(frag_i friction_c) + \varepsilon_{ic}$

[32] The intermediate commodity may be considered to be a composite good assembled from all consumption goods.

, where $\widetilde{A}$ includes all previous variables from regression equation (3.1), $frag_i$ is a measure of the degree of fragmentation in industry *i*, and $friction_c$ is a measure of the degree of trade frictions between country *c* and the United States. If there is a magnified effect of trade frictions in industries characterized by a larger degree of fragmentation, one expects the coefficient η to have a negative sign. As measures of trade friction, two measures are employed: a country's distance from the United States as well as the U.S. tariff imposed on imports from country *c* in industry *i*. Two measures of fragmentation are also considered. The first is the share of total expenditures on labor and intermediates that go to intermediate goods, thereby indicating the importance of intermediate costs relative to labor. A drawback of this measure is that it does not give a sense of the different stages of production or of the number of intermediates that are involved in the production process. Therefore, the second measure of intermediate intensity used is derived from the Herfindahl index of the input concentration, denoted H_i where $H_i = \sum_{j=1}^{n} S_{ji}^{\ 2}$ and S_{ji} stands for the value of input *j* used in sector *i* as a fraction of the total value of inputs used in sector *i*. Since H_i is larger for industries that employ few intermediates, the measure $(1- \ H_i)$ is used, which lies between zero and one and increases with the number of intermediates used.[33] Another appealing aspect of this

[33] The Herfindahl index of input concentration has been used by Clague (1991a,b) as an indicator of how "self-contained" an industry is, which might indicate a reliance on a developed transportation, communication, and distribution infrastructure. Blanchard and Kremer (1997) and Levchenko (2007) use it to measure a good's "complexity" to capture reliance on superior institutions. Nunn (2007) uses it as a measure of the degree of the fragmentation of production.

measure is that it does not give excessive weight to relatively small components that are used in the production process. It should also be noted that use of a broad range of inputs does not necessarily imply a large intermediate share. Therefore, this measure could be high even for an industry where intermediates make up a relatively small portion of overall costs relative to labor. Moreover, these measures address different aspects of fragmented industries.

3.3 Data

To estimate equations (3.1) and (3.2) this paper draws from a range of data sources. U.S. bilateral imports data are taken from the United States International Trade Commission's *U.S. Imports/Exports (Dataweb)* which records bilateral trade flows for the U.S. at the 10-digit Harmonized Tariff Schedule (HTS10) level. As Pierce and Schott (2009) have documented, there was significant instability in both the U.S. import and export code classifications, which poses a particular challenge when attempting to define a distinct set of goods and to concord these with other more aggregate industry variables coming from different time periods. Therefore, this analysis includes only manufacturing categories that were consistently defined over the time period from 1989 to 2007, thus omitting goods that have been redefined or reclassified. The analysis uses 7,324 HTS10 level goods. Using this disaggregate trade data for the sampled countries, first considered is the importance of (net) extensive margin real trade growth to overall real trade growth.[34] Among all non-restructured countries for which the U.S. did not have any formal trade sanctions, net extensive margin growth accounted for approximately 14 percent of real growth in exports to the U.S. between 1989 and 1999.[35]

Tariff data are taken from the United States Trade Commission's *Tariff Database* defined at the 8-digit Harmonized Tariff Schedule (HTS8) level. The database includes the *ad valorem*, specific, and estimated *ad valorem* equivalent tariffs based on the Most Favored Nation (MFN) status. In addition, the file also indicates commodities that are eligible for tariff preference programs and the applicable tariffs under these programs. The measure for tariffs used is the estimated *ad valorem* equivalent tariff for a particular country applicable under the relevant preference program. If a country/good qualifies for more than one preference program, the minimum tariff of all qualifying programs is used.

Trade and tariff data are concorded with the production data of the *Bureau of Economic Analysis* (BEA)'s Input-Output industry classification, so for the analysis a sector i will correspond to one of the BEA's output industries. The total number of goods in a sector i as the total number of HTS10 digit goods categories in that sector. The left-

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[34] The Bureau of Labor Statistics import price indices are used to calculate real trade volumes in 1989 and 1999.

[35] This measure is calculated by the following method. Letting z index goods and c index countries exporting to the United States. d_{11} is an indicator for a good traded in both 1989 and 1999, d_{10} is an indicator for a good traded in 1989 but not 1999, d_{01} is an indicator for a good traded in 1999 but not 1989. $E^c_{z,t}$ are real exports to the United States by country c, in industry z, in year t. Then net extensive margin growth's share of real growth in exports to the United States between 1989 and 1999 is given by.

$$\frac{\Delta EM}{\Delta EXPORTS} = \frac{\sum_z \sum_c (d_{01} * E^c_{z,1999}) - \sum_z \sum_i (d_{10} * E^c_{z,1989})}{\sum_z \sum_c [(d_{01} + d_{11}) * E^c_{z,1999} - (d_{10} + d_{11}) * E^c_{z,1989})}$$

. This measure tells how much of real trade growth is accounted for by goods not previously traded less trade of those goods that were no longer traded in 1999.

hand side variable, the share of goods coming from a country in a sector, is then the number of HTS10 digit goods exported to the United States by that country within the industry over the total number of goods belonging to that industry. The dataset includes all relevant data for 66 countries and 180 industries, which yields a balanced panel of 11,880 observations at the country/industry level for 1999. Table 3.1 lists the countries that are included in the analysis.

Figure 3.1 plots per exporting country the average (across industries) of the left-hand side variable against per capita GDP and in Figure 3.2 against GDP. GDP and per capita GDP are both taken from *Penn World Tables 6.3*. While these relationships will all be subsumed in the country effects in the empirical analysis, the plots do illustrate the consistency of the data with earlier findings reported by Hummels and Klenow (2005). Indeed, more goods are being exported, the higher the exporters' per capita GDP and GDP. Figure 3.3 includes a plot of the average left-hand side variable for exporting countries against the average U.S. import tariff. Contrary to what one might expect, except for Canada and Mexico, there is no strong negative relationship between the extent of the extensive margin of exports and the level of the tariff. Figure 3.3 suggests that tariffs by themselves cannot play a very strong role in explaining the extensive margin of trade.[36]

Focusing the analysis on the sector characteristics and how they interact with country characteristics, this paper draws on many of the data from Nunn (2007). The empirical analysis includes three main production factors besides intermediates: unskilled

[36] See Debaere and Mostashari (2010a).

labor, skilled labor, and capital. As proxies for a country's factor costs of unskilled labor, skilled labor, and capital, this essay like Nunn (2007) and Romalis (2004) uses measures of factor abundance. Making use of Nunn's (2007) data, both human capital stock and the capital stock measures are drawn from Antweiler and Trefler (2002). The human capital stock is the natural log of the ratio of workers completing high school to those not completing high school for 1992. The unskilled labor stock is then the negative of the human capital stock measure, the natural log of the ratio of workers not completing high school to those that did. The capital stock is the natural log of the average capital stock per worker, also for 1992. Because recent papers, including Levchenko (2007), have found institutional quality to be an important source of comparative advantage for industries that are more institutionally dependent, the analysis also takes from Nunn's data the measure of the rule of law originally sourced from Kaufmanm, Kraay, and Mastruzzi (2003). Intermediate costs, $P_{\text{int},c}$, are measured by the natural log of the exporting country's Price Level of GDP taken from *Penn World Tables 6.3.*

Factor intensity measures are taken from the BEA's 1997 Input Output Use Tables and the NBER-CES Manufacturing Industry Database Bartelsman and Gray (1996). The share of expenditures on labor and intermediates attributed to intermediate goods are taken from the BEA 1997 Benchmark IO Use Tables. Henceforth, this measure will be referred to as the intermediate cost share in sector $i, \alpha_{i,\text{int}}$. To get measures of skilled and unskilled labor intensity, labor cost share is calculated from the BEA's 1997 Input Output Use Tables as 1-$\alpha_{i,\text{int}}$. The unskilled labor share is then the share of production wages in total wages, taken from Bartelsman and Gray (1996) that is also used by Nunn (2007), multiplied by labor's cost share. Similarly, skilled intensity is the share of non-production wages in total wages, times labor's share. Capital intensity is measured as total real capital stock divided by total value added.[37]

The measures of fragmentation also come from the BEA 1997 Benchmark IO Use Tables. The first measure is the intermediate cost share described above, $\alpha_{i,\text{int}}$. As one can infer from Figure 3.4, there is quite a bit of dispersion in intermediate shares around an average of 0.76. The second measure of fragmentation *(1- H_i)* has a distribution that is skewed towards higher values, as one can see from Figure 3.5. In the data, the average value of *(1- H_i)* is 0.89. Since Nunn (2007) considers the well-known Grubel-Lloyd (GL) index of intra-industry trade an indicator of fragmentation, this measure is also included in the study. The histogram of the distribution of the GL index is in the lower half of Figure 3.6.[38] The average value of the GL index in the dataset is 0.67. To give a sense of how the various indices relate to the specific sectors, in Table 3.2 the 20 sectors with, respectively, the lowest and the highest intermediate cost shares and the corresponding measures of *(1- H_i)* and the GL index are listed. As one can see, sectors with low intermediate cost shares tend to have high *(1- H_i)* measures, and sectors with high intermediate cost shares tend to have low *(1- H_i)* measures. Table 3.3 shows the correlations of the different measures of intermediate intensity. The intermediate cost

[37] Both capital stock and value added data are taken from Bartelsman and Gray (1996).

[38] The Grubel-Lloyd index for industry *i* is calculated from U.S. international trade data. The formula for the index is $GL_i = 1 - \left[| EX_i - IMP_i | / (EXP_i + IMP_i) \right]$. The Grubel Lloyd index increases with the degree of international intra-industry trade. For example, if the sector exports and imports are of equal value, then the GL index is 1.

share and the *(1- H_i)* term are indeed negatively correlated, so that a larger share of intermediates in a sector does not necessarily imply that there are more stages or components to the sector. Also, the data show that the *(1- H_i)* term tends to be positively correlated with the GL index, which is in line with Nunn (2007).

Table 3.4 presents correlations among the input intensity measures and the share of value added in shipments, taken from Bartelsman and Gray (1996). Probably most telling is the very different correlation between the fragmentation measures and the value added measure. The *(1- H_i)* term, and to some extent the GL index, correlates positively with value added, which is the exact opposite of the intermediate cost share measure. Also the intermediate cost share correlates positively with the capital intensity, whereas the *(1- H_i)* term and GL index correlate negatively with that measure. By construction, the intermediate cost share is negatively correlated with labor's share and consequently, with unskilled and skilled intensity. The opposite is true for the *(1- H_i)* term, which is positively correlated with the labor share terms. In sum, the intermediate share and the *(1- H_i)* term appear to identify different characteristics of fragmented goods. While the intermediate share gets at the overall importance of intermediates relative to labor costs, the *(1- H_i)* term is an indicator of the complexity of an industry and the degree to which many intermediates must be assembled and coordinated in a good's production.

In the empirical analysis, sector characteristics of intermediate intensity are interacted with measures of trade friction such as U.S. tariffs and the distance from the United States. Specifically, the intermediate intensity measures are interacted with the natural log of the gross U.S. tariff and the natural log of the distance from the United States as measured as the great circle distance between countries' capital cities. As indicated, in a world in which fragmentation of production is increasingly pervasive, the expectation is that the friction variables have a greater negative impact for those industries that are more prone to international fragmentation of production.

3.4 Results

Regression results are presented in Tables 5 to 8. In all tables, standardized beta coefficients are reported, so that one can directly compare the relative magnitudes of the interaction terms. Furthermore, all significance levels are reported using robust standard errors.

The results for the baseline regression that is given by equation (3.1) are included in the first column of Table 3.5. As can be seen, all coefficient estimates, except for the interaction between capital intensity and capital abundance, have the expected sign and are significantly different from zero. In other words, there is evidence that supports the traditional patterns of comparative advantage based on factor abundance and factor intensity as relevant determinants of the extensive margin of U.S. imports. The U.S. tariff term negatively affects the range of goods that are exported in a sector, which is also in line with expectations; however, the coefficient on tariffs is not significant in all specifications, which is not surprising in light of the aforementioned previous work that undermines the quantitative importance of the role played by tariffs in determining the extensive margin of exports. Consistent with expectations, there is a negative coefficient on the interaction of the intermediate share and the price index in the exporting country: Higher price levels make intermediate intense industries less competitive.

In the next few columns of Table 3.5, measures of intermediate input intensity interacted with a country measure of judicial quality are introduced. Including these interactions follows Levchenko (2007) and Nunn (2007) who take the quality of a country's institution as a source of comparative advantage. Looking at Columns 2 and 3 in Table 3.5, it is clear that the *(1-* H_i*)* term and the intermediate cost share are getting at very different characteristics of sectors. Countries with strong institutional quality export relatively more goods in industries that require the coordination of a large number of intermediate industries, which is consistent with the existing literature; however, countries with strong institutional quality export relatively less in the industries that have large intermediate shares. Put another way, countries with strong institutional quality export relatively more in high value added industries. In Column 4, the GL index, which is used as a proxy for the *(1-* H_i*)* measure, also produces a positive and significant sign. The results for the extensive margin of trade in Table 3.5 are thus to a large extent in line with what the existing empirical literature finds on international trade along the intensive margin of trade.

In Table 3.6 interactions between the measures of fragmentation and the distance between the exporting country and the United States are introduced. A few striking results stand out. Column 1 reproduces the baseline regression with the basic determinants of comparative advantage, including those relating intermediate intensity to the rule of law that were introduced in Column 3 of Table 3.5. In Column 2, the interaction of bilateral distance to the United States and intermediate cost share measure is added. A negative and significant coefficient for this variable is obtained suggesting that closer countries export larger shares of goods that are more intermediate intense. This result implies an additional sensitivity to trade frictions particular to these types of goods. Note that when interactions between the $(1- H_i)$ term and the GL index with distance are included in Columns 3 and 4, the coefficient estimates are insignificant.

In Table 3.7, the interaction of the intermediate intensity measures with the U.S. import tariff is included. The interaction between U.S. tariffs and intermediate cost shares is significant only when also controlling for the $(1- H_i)$ term. Both interactions imply that countries with higher tariffs tend to export a greater share of goods in less fragmented industries. However, when the GL measure is used as a proxy for the $(1- H_i)$ term, an unexpected positive coefficient attains, suggesting that countries with higher trade barriers tend to export a larger share of goods in industries characterized by greater intra-industry trade.

To extend the analysis of the intermediate intensity, and to see how robust the results are, the analysis considers Nunn's (2007) interaction of rule of law with his index that increases with the investment specificity of intermediate inputs and indicates a greater dependence on institutional quality. Nunn's measure combines U.S. Input Output tables with Rauch's classification of goods into three different types: those that are traded on exchanges, those that are referenced priced and, finally, those that are neither. This is a valuable measure for us, to the extent that it characterizes in greater detail the intensity of the relationship specific investments needed to acquire intermediate goods. In particular, Nunn specifies the fraction of the inputs in a sector that are not traded on exchanges or that are not referenced priced, as a measure for the investment intensity of an industry. In particular, for sector *i*, $Z_i = \sum_j \theta_{ji} R_{ji}$, with θ_{ij} indicates the value of input *j* used industry *i*, and R_{ji} is the proportion of input *j* that is neither sold on an organized exchange nor referenced priced. Z_i then increases with the investment specificity of intermediate inputs and indicates a greater dependence on institutional quality. Following Nunn, in Table 3.8 the measure of relation-specific investments interacted with rule of law is included. In line with studies of international trade patterns along the intensive margin, countries with stronger institutions tend to export more in the sectors requiring more specific investment relationships to acquire intermediate goods. In addition, there is still a negative and significant coefficient of the intermediate cost share interacted with the trade friction variables.[39] There is however no significant impact of the interaction of the trade friction variables with the *(1- H_i)* term. One possible interpretation of this result is that production of goods that are more complex and more reliant on a secure contracting environment is less likely to be fragmented internationally such that distance does not have a magnified effect for these industries. Also, the interactions of the cost share terms and trade frictions are quantitatively larger than the labor and capital

[39] It should be noted that this finding is consistent with theories of vertical specialization. Yi (2010) notes that there are two magnification effects which underlie the stronger explanatory power of the multi-stage production framework. First, as goods cross national borders multiple times, trade frictions impose costs multiple times. Second, Yi (2003) explains that the effective trade cost will increase with the intermediate share when intermediates come from the destination country of the final product. Specifically, Yi (2010) shows that the effective tariff is the actual tariff divided by the share of valued added in total costs. The smaller the value added, or the larger the intermediate share, then the larger is the effective tariff . The intuition for this results is that the tariff is applied to the entire value of the product, not just the value added of the country exporting. Yi (2010) uses this argument to explain how vertical specialization can explain the home bias in trade.

interactions combined. Consistent across all specifications in Tables 5 through 8, the results suggest that the interaction that is most quantitatively important is that of the price index and the intermediate share variable. In particular, going by the final specification, a one standard deviation increase in this term decreases the share of the number of goods that a country exports in an industry by 0.637 standard deviations.

3.5 Conclusion

"International fragmentation of production", "slicing the value chain" and "off-shoring" are all terms that refer to an increasingly internationalized production process that has received growing attention in the academic literature as well as in the press. However, to evaluate international fragmentation empirically is a challenge when one is not able to observe which traded goods are actually intermediates and which are finals. This paper therefore has taken an indirect approach. The analysis relates industry characteristics of the intermediate intensity of a sector to the range of 10-digit goods that are traded within that sector. On the one hand, the interactions between a sector's factor intensities and the factor abundances of the exporting countries reveal that the regular comparative advantage factors also determine the extensive margin within a sector. More importantly, the results suggest that countries that are closer to the United States, as well as countries that are benefiting from lower U.S. tariffs tend to export greater shares of goods in sectors with larger intermediate shares. This finding is consistent with the interpretation that because of international fragmentation of production in these sectors, international trade in these sectors is more sensitive to trade frictions. Note that this paper does not find a significant complementary effect of trade frictions for sectors with more intermediate components, as measured by one minus the Herfindahl index of input concentration, which correspond to sectors that tend to rely more on better institutional quality.

Chapter 4: Vertical Specialization and Trade Growth: Assessing the Role of Tariff Liberalization to U.S. Bilateral Trade 1989-2001

4.1 Introduction

While the pronounced growth of the import share of GDP for the United States and other countries has been well-documented, less attention has gone to detailing U.S. import growth across countries and to the changing distribution of import shares. This paper studies the pattern of U.S. imports between 1989 and 2001. One striking feature of the data is that during this period, almost half of the increase in real manufacturing U.S. imports came from less developed countries, and the growth rates of their exports are substantially larger than those of developed countries. While tariffs are generally thought to play a key role in explaining trade growth, U.S. tariff policy alone cannot explain either the changing distribution of import shares among countries, or the magnified growth of less developed country trade.

One explanation that may rationalize these trade patterns and still leave a role for falling trade barriers to explain trade growth is vertical specialization, as defined by Hummels, Rapoport, and Yi (1998), which specifically refers to when countries use imported intermediates in production of their exports. Under vertical specialization, tariff policies of exporting countries have a significant impact on specialization patterns by increasing or decreasing the costs of foreign intermediates. Yi (2003) formalizes this argument by showing that bilateral reductions of trade barriers cause an intensified response on trade volumes for goods that are vertically specialized since imported intermediate goods become more cheaply acquired by liberalizing countries. Notwithstanding the documented growing importance of internationally fragmented production networks, further evidence of vertical specialization as a possible contender in explaining these trade patterns is implied by the very suggestive way trade policy has evolved across countries over the period 1989-2001: the least developed countries, which experienced the greatest growth rates in exports to the U.S., also experienced the greatest degree of trade liberalization. In order to investigate whether these trade and tariff policy patterns are related under the auspices of vertical specialization, this paper shows how the Eaton and Kortum (2002) model suggests an empirical estimation that relates a measure of bilateral trade flows to relevant cost factors including both exporting and importing country tariffs. The analysis investigates the responsiveness of bilateral U.S. trade to tariff reductions, and to what extent the substantial liberalizations of less developed countries has contributed to the larger trade growth rates of these countries.

Identifying why less developed country export growth has outpaced developed country export growth may be incorporated into the broader question of what explains trade growth. Economists have long seen increases in real trade as being the consequence of multilateral and bilateral trade liberalizations and to technology led declines in transportation costs. Monopolistic Competition or 'New Trade Theory' models, such as Helpman (1987) and Hummels and Levinsohn (1995), can explain trade growth among developed countries through income convergence.[40] In recent years, empirical research

[40] Debaere (2003) shows that the increasing similarity in GDP among OECD country pairs leads to higher bilateral trade to GDP ratios, suggesting some support for Helpman (1987), whose model explains intra-industry trade that is prevalent among developed countries. However, he also shows that Helpman's prediction is rejected for non-OECD countries, among which intra-industry trade is not critical. Baier and

has focused on the changing ranges of goods that countries export, and have observed non-negligible increases in this range among countries undergoing trade liberalizations. This finding has led some to conjecture that trade in new goods is behind the magnified growth in world trade.[41] Still another possibility is increases in outsourcing and vertical production networks.

Recent empirical studies have documented the growing importance of vertical production networks and their contribution to trade growth. Hummels, Rapoport, and Yi (1998) show that vertical specialization, as measured by the value of imported intermediates in exports, or foreign value added in exports, has accounted for a large and increasing share of international trade over the last several decades. Using IO tables for 10 OECD countries and four emerging markets, Hummels, Ishii, and Yi (2001) calculate that vertical specialization accounts for 21 percent of these countries' exports and grew almost 30 percent between 1970 and 1990. They also show that vertical specialization accounts for 30 percent of the growth in these countries' exports. In related work,

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Bergstrand (2001) estimate a gravity equation of bilateral trade derived from a standard trade model. They find that average bilateral tariff rate reductions account for about 25 percent of trade growth in their sample of several OECD countries, but little evidence of income convergence playing a role in explaining trade growth.

[41] Ruhl (2005) shows how permanent tariff reductions, as opposed to temporary business cycle shocks, affect firms' decisions to export such that the failure to account for these new goods produces large aggregate elasticities of exports to tariffs. Kehoe and Ruhl (2003) study trade liberalizations for 18 countries and show how substantial increases in the extensive margin coincided with trade liberalizations. However, recent research has undermined the claim that the extensive margin is behind the magnified response of trade to tariffs. Debaere and Mostashari (2010a) investigate the link between the extent of tariff reductions and the changing extensive margin using disaggregate trade and tariff data for the United States. They find that U.S. tariffs and tariff preferences are statistically significant, but their overall contribution to the extensive margin is small. These findings of a limited response to tariffs specifically along the extensive margin of trade can also be linked to recent plant-level studies. Bernard and Jensen (2004a,b) and Das, Roberts and Tybout (2007) find that there are large fixed costs for firms that begin to export. These fixed costs rationalize why moderate tariff reductions primarily induce an increase in exports at the intensive rather than the extensive margin.

Feenstra (1998) compares several different measures of the international fragmentation of production processes, and argues that all have increased since the 1970's.

Because vertical specialization involves intermediate goods crossing borders multiple times, establishment of this type of trade increases world trade relative to output. Yi (2003) was one of the first to argue that vertical specialization was needed to solve the quantitative puzzle of why aggregate trade responds so strongly to moderate tariff reductions. As Yi (2003) points out, in order to explain the strong response of trade to moderate tariff reductions found in the data, standard trade models require elasticities much higher than those typically estimated or employed in simulations and calibrations. For example, Yi measures developed world tariff decreases for manufactured goods between 1962 and 1999 to be around 11 percentage points, and indicates that if tariff reductions are to explain the observed growth in trade's share of output, standard trade models require elasticities of substitution in the order of 12-15, while computable general equilibrium (CGE) models have elasticities in the order of 3-4.[42] By simulating global tariff reductions, he shows that his two-country model of vertical specialization can generate a nonlinear response of trade to tariff reductions and can explain over 50 percent of the growth of world trade over his sample period without assuming counterfactually large elasticities.

[42] Anderson et al. (2005), argue that only an elasticity of 17 can match world bilateral trade patterns, and Feinberg and Keane (2009) need an elasticity in the range of 25 to 30 to explain the increase of intra-firm trade as a fraction of total sales for Canadian Multinationals between 1983 and 1996. However, actual estimates of these elasticities are much smaller. For example, Broda and Weinstein's (2006) median estimate of the elasticity of substitution is in the order of 3.1; Romalis's (2007) demand elasticities range between 6.2 and 10.9. For a good discussion, see Ruhl (2005).

Yi's (2003) two-country analysis focuses on the developed world: the United States and the rest of the developed world. This paper seeks to exploit the variation in tariff policy across countries, sectors, and time. Between 1989 and 2001, many developing countries underwent both greater trade liberalizations as well as greater growth rates of exports to the United States. In fact, in evaluating the response of U.S. imports relative to output by country to U.S. tariff liberalizations, one finds that the countries with the largest increases in trade relative to trade liberalizations, which suggest trade elasticities inconsistent with CGE models, correspond to those country groups which underwent substantial liberalizations in their own tariff policies; whereas, the elasticites for developed countries, whose tariff liberalizations were modest, are within the projected ranges and relatively small. This finding is a direct consequence of the greater export growth rates of these countries and the fact that the evolution of U.S. tariff policy did not differ systematically across developed and less developed countries.[43] Moreover, the same anomaly which motivates Yi's (2003) analysis is present here, but only for those countries which underwent a large degree of trade liberalization themselves over the sample period.

In order to investigate the response of trade to tariff liberalizations and allow for vertical specialization, an economic model which recognizes intermediate trade is required. Eaton and Kortum (2002) develop a Ricardian model that captures the competing forces of comparative advantage as well as geographic barriers in determining

[43] U.S. tariffs did decrease more for NAFTA countries and also for countries which gained eligibility for GSP status over the sample period. However, for most other countries U.S. tariff decreases were in the order of 2 percentage points.

trade flows. Furthermore, their model explicitly allows for access to intermediate goods to contribute to specialization patterns. This paper extends their model to the industry level and looks at trade volumes over time to exploit the variation in bilateral trade policy across industries and time. It is shown that a simple modification of one of Eaton and Kortum's (2002) key empirical equations produces a measure of bilateral trade that is directly dependent on both importing country tariffs and exporting country tariffs. The results suggest that exporting country tariffs are statistically significant and that their liberalizations have been, on average, relatively more important in stimulating bilateral trade growth than U.S. liberalizations. The liberalizations of the least developed countries in the sample, those countries with 1989 Real GDP per capita (constant 2005 dollars) less than $3000, have on average been three times more important in explaining bilateral trade growth than U.S. tariff liberalizations.

In lieu of the documented growing importance of vertical production networks and outsourcing, identifying the forces that explain the growth of vertical specialization and the changing nature of trade have gained significance.[44] While there is a sizeable literature, both empirical and computational, quantifying the response of trade to tariff liberalizations and changes in production costs in general, little attention has been given

[44] A large literature on outsourcing's role on rising wage inequality in advanced nation has emerged in response to these changing trade patterns. See, for example, Feenstra and Hanson (1996a,b) and Markusen and Venables (1995, 1996a,b) who show how outsourcing can augment the wage skill gap in both locations. Krugman and Venables (1995) find that lowering transport costs can lead to a fall in wage inequality across regions. More recently, Feenstra and Hanson (1997) decompose the effects of outsourcing and skill-biased technological change on wages for the United States between 1972 and 1990. Hsieh and Woo (2003) look at the impact of outsourcing to China on Hong-Kong's Labor Market.

to quantifying the impact of intermediate tariff liberalization on export growth.[45] A few papers which are similar in spirit to the analysis performed here and which find consistent results are Feinberg and Keane (2001), Swenson (2004), and Feenstra and Kee (2007). Feinberg and Keane (2001) examine how bilateral trade flows of U.S. multinational corporations and their Canadian affiliates responded to U.S. and Canadian tariff reductions. They find that Canadian affiliate sales to the United States are negatively correlated with Canadian tariffs. Swenson (2004) examines how outsourcing decisions are affected by changes in country and competitor production costs, by looking exclusively at offshore assembly program (OAP) exports to the US, and likewise allows for intermediate trade costs to influence production costs. Swenson (2004) finds that when a country's costs rise or competitors' costs fall, the share of U.S. OAP activities in that location decline. Feenstra and Kee (2007) measure the response of an index of export variety (of Mexico's exports to the US) to U.S. tariffs under NAFTA as well as Mexcio's tariffs under NAFTA. They find that both have a statistically significant negative influence on Mexico's export variety.

The remainder of this paper is organized as follows. Section 4.2 provides summary statistics of tariff and trade patterns for the United States and other countries during the sample period. Section 4.3 presents the main theory regarding the role of

[45] Computable General Equilibrium (CGE) models have been used extensively to simulate the economic effects of bilateral and multilateral trade liberalizations. See Deardorff and Stern (1990), Brown, Deardorff and Stern (1995), Kehoe and Kehoe (1995), and Whalley (1985). For a survey of the literature on PTA's, see Baldwin and Venables (1995). Romalis (2007) and Clausing (2001) look specifically at the effects of NAFTA and CUSFTA using disaggregate trade and tariff data. In an aggregate study, Baier and Bergstrand (2001) estimate a gravity equation of bilateral trade derived from a standard trade model. More recently Yi (2010) extended the Eaton and Kortum (2002) model to explain how vertical specialization can help explain the home bias in trade.

tariffs and other cost variables in explaining trade patterns allowing for vertical specialization. Sections 4.4 and 4.5 contain the empirical strategy and results. Section 6 concludes.

4.2 Descriptive Statistics

The purpose of this paper is to investigate and quantify the importance of tariff policy under vertical specialization. In this context, tariff reductions can affect trade patterns on two fronts. First, countries which allow freer trade for intermediates and capital goods can decrease the cost of domestic production of final goods that make use of foreign intermediates. Clearly, the impact of a country's own tariff policy will be particularly relevant to export penetration under vertical specialization. That is, if goods did not involve the use of imported intermediates either before or after a decrease on tariffs, then the impact of tariff liberalizations on export growth should be less significant.[46] Second, as is the case even when trade is not vertically specialized, preferential tariffs can divert trade away from possibly more efficient sources if rates are sufficiently lower for preferentially treated countries.

The objective of this section is to characterize the main stylized facts of U.S. trade, and world tariff trends between 1989 and 2001. To do so, the paper first investigates whether or not U.S. imports as a share of output have grown by a large

[46] In addition to vertical specialization, trade policy of exporting countries may influence specialization patterns through other means. For example, several papers have argued the importance of trade in general and particularly of capital goods or other intermediates which have a higher content of technology, as a form of technology diffusion. See, for example, Xu and Wang (1999) and references therein. Coe and Helpman (1995) relate productivity to the import-share weighted R&D of the countries' trade partners, and find a positive regression coefficient.

amount relative to U.S. tariff liberalization. Indeed, if one looks at the growth of trade to output relative to U.S. tariff liberalizations, there is a great deal of variation across countries. In fact, less developed countries are accounting for an ever increasing share of U.S. trade, and constitute a non-trivial source of U.S. import growth. Historically, these countries have been the most protected, and consequently are the countries with the largest room for substantial liberalizations. Upon examination, those countries which experienced the greatest growth rates in exports to the United States also underwent the most pronounced liberalizations. This finding is consistent with the conjecture that increased access to foreign intermediate goods by way of a country's own trade liberalization is an important determinant of export growth.

Sources of U.S. import growth

This paper studies trade patterns over the period the period 1989-2001. Data on U.S. bilateral trade flows for manufacturing goods and tariff data (except for the United States) are taken from the World Bank's *Trade and Production Database, 1976-2004*. GDP data are taken from *the Penn World Tables V.6.3*. U.S. tariff data are taken from the United States Trade Commission's Tariff Database.

In the descriptive statistics that follow, the paper first looks at the change in U.S. manufacturing imports relative to U.S. output over the sample period. For this, imports are limited to those coming from a consistent panel of countries. In other words, all countries that underwent a restructuring or for which the United States had a trade embargo in any year during the sample period are eliminated.[47] Since trade patterns will be linked to bilateral trade policies, the set of countries is further limited to only countries for which these data are available.[48]

The study first investigates whether or not U.S. imports exhibit the same quantitative anomaly characteristic of the post WWII world economy, by looking at the changes in U.S. manufacturing imports relative to output between 1989 and 2001.[49] Table 4.2 shows the evolution of the total U.S. imports relative to U.S. output and U.S. average manufacturing tariffs for the sample. The change in the natural log of the import share of output was approximately 58 percent, from .148 in 1989 to .265 in 2001. However, import weighted U.S. manufacturing tariffs decreased from 5.2 to 3.4 percent, which constitutes a change in the natural log of gross tariffs of approximately -2 percent. Generating this increase from U.S. tariff reduction alone requires an elasticity of the import share of output to gross tariffs of around -33.75 which is large relative to those typically found in CGE models, and those found in the empirical literature.[50]

However, the growth rates in U.S. imports of different countries have been quite varied. Figure 4.1 shows the changes in shares of U.S. imports from Mexico, Canada, China and the rest of the world according to development level. What one observes is a steady increase in the share of U.S. imports from the least developed countries in the

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[47] There is one exception. For Germany, trade data are summed for East and West Germany before unification.

[48] The countries included in the trade statistics are listed in Table 4.1. Similar trade patterns emerge when looking at all U.S. trade partners.

[49] The focus of imports relative to output as a measure of trade growth is primarily because this is the measure for which Yi (2003) derives his magnified and non-linear effects for world tariff liberalization.

[50] Elasticities found in the CGE literature are typically in the order of -2 to -3.5. See Deardorff and Stern (1990) and Whalley (1985). In a gravity model of bilateral trade, Baier and Bergstrand (2001) estimate an elasticity of -6.43. Eaton and Kortum's (2002) estimated elasticity of their geographic barrier ranges from -2.4 to 12.86 depending on the specification.

sample, while the share of U.S. imports from the richest countries experience a steady decrease. In 1989, the countries with less than 10,000 dollars in real GDP per capita (measured in constant PPP 2005 dollars) accounted for approximately 11.6 percent of U.S. imports; however, by 2001, their share had doubled to 23.2 percent. In contrast, high income countries, those with more than 18,000 dollars in real GDP per capita (measured in constant PPP 2005 dollars) experienced a 15.3 percentage point decrease in their import shares.

Finally, if one compares changes in imports relative to U.S. output for particular countries and country groups to U.S. tariffs for these groups, one again finds a great deal of variation across countries. Table 4.3 summarizes the changes of the natural logs of imports relative to U.S. output, U.S. tariffs and the resulting implied trade to tariff elasticities for NAFTA countries, China, and the rest of the world divided by development level between 1989 and 2001. The elasticities are highest for China and other low income countries. While Canada experienced a pronounced increase in trade, of 49 percent, it also enjoyed the largest decrease in average U.S. tariffs, around 4.1 percentage points. Consequently, the elasticity is only -11.84. Mexico's elasticity, on the other hand, is a high -54.02. Imports from China relative to U.S. output, grew by 212 percent. Therefore, China's implied trade to tariff elasticity is extraordinarily high at almost -266.64. However, even if one excludes China, one finds that the least developed countries still have the largest growth rates producing elasticities of -133.68 and -138.9 for the two lowest income groups. For the high income countries, with the exclusion of Canada, the elasticity is -32.8. The substantial variation in the implied responses of trade to tariff reduction suggests that factors other than U.S. tariffs are contributing to the increased penetration of developing country trade. Furthermore, because U.S. tariffs did not decrease very much over this time period, on average around 2 percent, elasticities needed for U.S. tariff policy alone to generate these responses of trade are too large relative to what traditional models would suggest.

Trade liberalizations across countries 1989-2001

To link these findings to the implications of tariff policy under vertical specialization, trends in tariff rates across all sampled countries are considered. Table 4.4 summarizes average annual tariffs across countries and country groups. The particular measure of tariffs used in this table is the simple average MFN tariff across manufacturing goods. The largest decrease comes from the least developed countries with an average change in the natural log of gross tariffs of 41 percent (from a tariff of 80 percent in 1989 to 19 percent in 2001). Lower Middle Income countries decreased their tariff rates by 22 percentage points, or while the upper middle income countries decreased their tariffs by only 5 percentage points. High income countries decreased their average tariffs by 3 percentage points. Tariff data for China is unavailable for the earlier years, but still between 1992 and 2001 tariffs decreased by nearly 33 percentage points. On average Canadian tariffs decreased by 5 percentage points while Mexican tariffs reportedly increased by 6 percentage points. However, because a large percentage of trade among NAFTA countries is with other NAFTA countries, the increase in Mexican tariffs is probably overstated.[51]

With the exception of NAFTA countries, U.S. tariffs decreased moderately, with no systematic difference in the decrease for developed and developing countries.[52] Moreover, the changes in these countries' trade shares are hard to explain by U.S. tariff policy alone. Importantly, the least developed countries which were also the countries with the largest tariff decreases, had the greatest increases in U.S. import shares. While there are many reasons why less developed nations might be gaining relative to developed nations, these findings are at least consistent with the hypothesis that access to intermediates that must be imported may be an important component in explaining specialization patterns. If less developed countries are particularly disadvantaged at producing specialized intermediates, then tariff policy for these countries may be a critical determinant in expanding their exports.

4.3 Theoretical Model

The statistics above suggest that tariff policy of exporting countries may have important consequences for the determination of specialization patterns and also help explain why the least developed countries in 1989 have experienced greater growth rates in U.S. trade shares. In order to investigate this hypothesis, the paper extends and

[51] Also, the Canada U.S. Free Trade Agreement (CUSFTA) began in 1989, such that bilateral rates with the United States were already less than Canada's tariffs for other countries.

[52] Exceptions are some former Eastern European States which acquired eligibility for the U.S. Generalized System of Preferences (GSP) tariff rates after losing their communist status. For these low income countries, one sees a larger decrease in U.S. tariff rates over the time period. See U.S. GSP Guidebook (1999) for the mandatory rules for eligibility. However, these outlier countries are not included in the sample.

modifies the Eaton and Kortum (2002) model to formulate an empirical model that relates bilateral trade flows to both importing and exporting country tariffs when production of goods involves intermediate use.

Employing a probabilistic model of technological heterogeneity, Eaton and Kortum (2002) derive simple structural equations linking bilateral trade to parameters related to absolute advantage, comparative advantage and geographic barriers in a multi-country setting. Furthermore, their model explicitly incorporates a role for intermediate trade in the determination of specialization patterns. The Eaton and Kortum (2002) set-up is at the country level, yet both tariffs and intermediate intensity vary at more disaggregate levels. Therefore, the analysis first proposes a methodology which maintains the main structure of their theory, but which invokes an estimation that is at the industry level, and that therefore allows one to exploit the variation in the data at this less aggregate level.[53, 54]

Several important results for the derived empirical model are highlighted. First, the structural model developed here suggests a specific way of measuring bilateral trade when one wants to relate trade to bilateral tariffs when there is trade in intermediate goods. Second, the particular measure of trade derived depends only on trade frictions between the two countries trading, and is independent of trade policies with other countries. Third, a simple manipulation of the trade flow term shows that the measure of

[53] Anderson and van Wincoop (2004) also argue in favor of disaggregate specifications since aggregate biases may in theory arise from many sources, yet little is known about the empirical magnitude of this bias.
[54] Several studies have sought to extend the Eaton and Kortum (2002) model to the sector level. For example, see Chor (2009) and Donaldson (2008); however, these papers do not also include intermediate trade. Yi (2010) extends the model to include three stages of production, but maintains the aggregate specification.

vertical specialization first formulated by Hummels, Rapoport, and Yi (1998) and Hummels, Ishii, and Yi (2001), the value of imported intermediates in exports, is nested within the trade flow term as an extreme case.

Technology and Preferences

There are $\overline{K}$ sectors. *J* and *K* will be used to denote sectors and any parameter or variable that is sector specific. Goods belonging to a particular sector are indicated with lower cases, such that a good belonging to sector *K* is denoted *k* and a good belonging to sector *J* is denoted *j,* where within each sector there are a continuum of goods $j,k \in [0,1]$. There are N countries, and *i*, *n*, and *s* will be used to indicate different countries.

Consistent with Ricardian models, countries have access to the same technology but vary in their efficiency levels. This is captured by a country-good specific total factor productivity term A_{ik}. The cost of a bundle of inputs, which consist of labor and intermediate goods, is assumed to be the same for all goods within a particular sector within a country, but varies across sectors within a country. This is because within countries inputs are mobile across sectors and goods within a sector employ factors with the same intensity; however, goods produced in different sectors vary in their intermediate and labor intensities. The cost of an input bundle of producing good *k* in country *i* as c_{iK}.[55]

[55] This is one of the departures from Eaton and Kortum (2002) who assume that intermediate shares are the same across all goods. In general, the main extension of Eaton and Kortum's model is the added dimensionality of sector specific parameters.

Geographic barriers take the convenient "iceberg" form, such that delivering a unit from country *i* to country *n*, requires producing d_{ni}>1 units for $n \neq i$, and d_{ii}=1. The triangle inequality is assumed to hold (such that for any three countries, *i,n*, and *s*, $d_{ni} \leq d_{ns} d_{si}$), as well as symmetry $d_{in} = d_{ni}$. In addition to these geographic barriers, an industry specific *ad valorem* tariff may be imposed by the importing country. Therefore, the total trade cost for country *n* to import a good *k* from country *i* is given by $(1+\tau_{niK})d_{ni}$.

Assuming that production of a particular variety is subject to perfect competition, the price a consumer in country *n* faces for a good *k* from country *i* is

$$(4.1) \quad p_{ni}(k) = \frac{c_{iK}(1+\tau_{niK})d_{ni}}{A_{ik}}.$$

Consumers have preferences for all varieties within each industry, but are indifferent about where they purchase the good. Therefore, they choose to buy the cheapest good available such that the price actually paid for good *k* by consumers in country *n* is

$$(4.2) \quad p_n(k) = \min\{p_{nik}; i = 1...N\}.$$

Facing these prices, buyers, who could be final consumers or firms buying intermediate inputs, purchase individual goods to maximize their respective objective functions. Specifically, consumers of final goods maximize

$$(4.3) \quad U = \prod_{J=1}^{\overline{K}} (X_J)^{B_J}$$

where B_J is the share of income spent on goods belonging to industry *J*, $\sum_{J=1}^{\overline{K}} B_J = 1$, and

where X_J is a composite industry specific good defined by the following CES function:

$$(4.4) \qquad X_J = \left[\int_0^1 x_j^{(\sigma-1)/\sigma} dx_j \right]^{\sigma/(\sigma-1)}$$

where $\sigma > 0$ is the elasticity of substitution among varieties of goods within a sector, and is assumed to be the same for all sectors.[56] Note that the industry specific composite goods are non-traded. Assembly takes place by the consumer after purchasing the individual varieties from their cheapest sources.

Producers, use the $\overline{K}$ composite intermediate goods as well as labor in order to produce a final good. Specifically, for a producer of good *k*, in country *i*, the production function takes the form

$$(4.5) \qquad x_{ik} = A_{ik} L^{\alpha_{KL}} \prod_{J=1}^{\overline{K}} (X_J)^{\alpha_{KJ}}$$

where $\alpha_{KL} + \sum_{J=1}^{\overline{K}} \alpha_{KJ} = 1$ and X_J is defined by equation (4.4). Here α_{KL} is the cost share of labor, α_{KJ} is the cost share of composite intermediate *J* in sector *K* goods' production, and *L* is the quantity of labor used. Given this specification, the cost of an input bundle used in the production of good *k* in country *i* can be expressed

$$(4.6) \qquad c_{iK} = \left(\frac{w_i}{\alpha_{KL}} \right)^{\alpha_{KL}} \prod_{J=1}^{\overline{K}} \left(\frac{p_{iJ}}{\alpha_{KJ}} \right)^{\alpha_{KJ}}$$

[56] One could also assume that the elasticity of substitution is sector specific. Since the term is canceled out of the empirical model, the results are not dependent on this assumption.

where p_{iJ} is the price index for composite good J for country i.

Productivity and Trade Flows

Following Eaton and Kortum (2002), a probabilistic representation of technological efficiency is modeled. Assume that country i's efficiency in producing good k is the realization of a random variable A_{ik} (drawn independently for each variety) from its country and industry specific probability distribution $F_{iK}(a) = \Pr[A_{ik} \leq a]$ which is Fréchet (Type II extreme value):

(4.7) $$F_{iK}(a) = e^{-T_{iK}a^{-\theta}}$$

where $T_{iK} > 0$ and $\theta > 1$.[57] As Eaton and Kortum (2002) point out, T_{iK} governs the location of the distribution, with higher values indicating that a high efficiency draw is more likely. The parameter θ reflects the amount of variation within the distribution, with higher values reflecting less variability. Moreover, small values of θ, indicating more heterogeneity, imply that comparative advantage exerts a stronger force for trade against the resistance imposed by trade barriers. In other words, for small values of θ, changes of trade costs result in relatively small changes in trade patterns, which are determined primarily by the state of technology T_{iK}.

[57]Essentially this formulation allows for within sector and across sector heterogeneity within a country which has been a common feature in the literature on trade with heterogeneous firms such as Melitz (2003). Also as Donaldson (2010) notes, it is common to assume that productivities are drawn independently across varieties, industries, and countries (e.g. Melitz and Ottaviano (2007), Chaney (2008), and Helpman, Melitz, and Rubinstein (2008).

Prices

The following derivations of price distributions follow those of Eaton and Kortum's (2002) with the only modification being to add the industry dimension to the analysis.

Given the assumptions on technology and preferences, it is possible to derive an expression for the distribution of prices that country *i* offers to country *n* in each industry. For example for industry *K* goods, the distribution of prices offered by *i* to country *n* is

$\Pr[p_{nik} \le p] = 1 - F(\frac{c_{iK}(1+\tau_{niK})d_{ni}}{p})$ or

(4.8) $$G_{niK}(p) = 1 - e^{-[T_{iK}(c_{iK}(1+\tau_{niK})d_{ni})^{-\theta}]p^{\theta}} .$$

The lowest price for a good *k* in country *n* will be less than *p* unless each source's price is greater than *p*. Hence the distribution of prices $G_{nK}(p) = \Pr[P_{nk} \le p]$ for what country *n* actually pays for industry *K* goods is given by

(4.9) $$G_{nK}(p) = 1 - \prod_{i=1}^{N}[1 - G_{niK}(p)] = 1 - e^{-\Phi_{nK}p^{\theta}}$$

where $\Phi_{nK} = \sum_{s} T_{sK}(c_{sK}(1+\tau_{nsK})d_{ns})^{-\theta}$.

Given these results, Eaton and Kortum (2002) derive three properties of the price distributions. The analogous properties taking into consideration the additional dimensionality are presented here. The first property is that the probability that country *i* provides a good in industry *K* at the lowest price to country *n*, is given by

(4.10) $\Pi_{niK} = \frac{T_{iK}(c_{iK}(1+\tau_{niK})d_{ni})^{-\theta}}{\Phi_{nK}}$.[58]

Second, the price of a good k belonging to industry K that country n actually buys from any country i also has the distribution $G_{nK}(p)$.[59] Third, the exact price index for the CES objective function used by both final consumers and firms aggregating varieties to make an industry specific composite good is given by

(4.11) $p_{nK} = \gamma\Phi_{nK}^{-1/\theta}$

where $\gamma = \left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{1/(1-\sigma)}$ is the gamma function.[60, 61]

Trade Flows and Empirical Model

One implication of the second property derived above is that n's average expenditure on an industry K good purchased does not vary by source, since for goods

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[58] Analogous to Eaton and Kortum (2002), this is true since $\Pi_{niK} = \Pr[p_{ni}(k) \le \min\{p_{ns}(k); s \neq i\}] = \int_0^\infty \prod_{s\neq i}[1-G_{nsK}(p)]dG_{niK}(p) = \frac{T_{iK}(c_{iK}(1+\tau_{niK})d_{ni})^{-\theta}}{\Phi_{nK}}$

[59] This is true since the distribution of prices of goods that n actually buys from i is given by $G_{nK}(p) = \frac{1}{\pi_{niK}}\int_0^p \prod_{s\neq i}(1-G_{nsK}(q))dG_{niK}(q)$.

[60] Note that consumers and firms in a country have different expenditure shares on goods from a particular industry, but since their demand for individual varieties are derived form the same CES objective, they will share the same price index for that industry.

[61] The price index for the CES objective function (4) in country n for industry K is derived from the result that $p_{nK} = \left[\int_0^1 p_{nk}^{1-\sigma}dk\right]^{1/(1-\sigma)} = \left[\int_0^\infty p^{1-\sigma}dG_{nK}(p)\right]^{1/(1-\sigma)} = \gamma\Phi_{nK}^{-1/\theta}$.

that are purchased conditioning on the source has no bearing in the good's price. Therefore, the fraction of n's industry K expenditures, spent on goods from country i takes the same form as the probability that i provides that good at least cost.

$$\frac{X_{niK}}{X_{nK}} = \frac{T_{iK}(c_{iK}(1+\tau_{niK})d_{ni})^{-\theta}}{\Phi_{nK}}. \tag{4.12}$$

where $\Phi_{nK} = \sum_s T_{sK}(c_{sK}(1+\tau_{nsK})d_{ns})^{-\theta}$. X_{nK} is n's total spending on industry K goods, and X_{niK} is n's total spending on K goods from country i. A similar expression can be derived for the share of K sector expenditures that are produced by n.

$$\frac{X_{nnK}}{X_{nK}} = \frac{T_{nK}(c_{nK})^{-\theta}}{\Phi_{nK}} \tag{4.13}$$

Dividing equation (4.12) by (4.13) gives an expression for the imports of sector K goods emanating from country $i,$ relative to n's expenditures on its own production.

$$\frac{X_{niK}}{X_{nnK}} = \frac{T_{iK}(c_{iK}(1+\tau_{niK})d_{ni})^{-\theta}}{T_{nK}(c_{nK})^{-\theta}} \tag{4.14}$$

Given this price index defined in (4.11), one can derive an expression for the relative price index of sector J composite goods for two countries:

$$\frac{p_{iJ}}{p_{nJ}} = \left(\frac{\Phi_{iJ}}{\Phi_{nJ}}\right)^{-1/\theta} \tag{4.15}$$

An important implication of equation (4.15) is that if country i systematically has higher trade barriers on k goods from other countries relative to n, it would have a higher price index. Consequently, this would yield a relative cost disadvantage to i in production of final goods that made intensive use of this industry. Moreover, the model shows that countries with systematically smaller trade barriers may become relatively more competitive in downstream goods.

By expression (4.12), one can write country *i*'s share of *n*'s goods in consumption relative to *n*'s share of its own goods in sector *J* as

$$(4.16)\quad \left(\frac{X_{inJ}}{X_{iJ}}\right)/\left(\frac{X_{nnJ}}{X_{nJ}}\right)=\left(d_{in}(1+\tau_{inJ})\right)^{-\theta}\left(\frac{\Phi_{nJ}}{\Phi_{iJ}}\right).$$

Using (4.16), to substitute out the Φ_{iJ}/Φ_{nJ} term from (4.16), the relative price index becomes a function of bilateral trade costs and *i*'s share of *n*'s goods in consumption relative to *n*'s share of its own goods in sector *J*:

$$(4.17)\quad \frac{p_{iJ}}{p_{nJ}}=\left(\frac{\Phi_{iJ}}{\Phi_{nJ}}\right)^{-1/\theta}=\left(d_{in}(1+\tau_{inJ})\right)\left[\left(\frac{X_{inJ}}{X_{iJ}}\right)/\left(\frac{X_{nnJ}}{X_{nJ}}\right)\right]^{1/\theta}.$$

By (4.6), the relative cost of input bundles to produce a good *k* is given by

$$(4.18)\quad \frac{c_{iK}}{c_{nK}}=\left(\frac{w_i}{w_n}\right)^{\alpha_{KL}}\prod_{J=1}^{\overline{K}}\left(\frac{p_{iJ}}{p_{nJ}}\right)^{\alpha_{KJ}}.$$

Finally, using equations (4.17) and (4.18), we can rewrite (4.14) as

$$(4.19)\quad \frac{X_{niK}}{X_{nnK}}=\left(\frac{T_{iK}}{T_{nK}}\right)\left(\frac{w_i}{w_n}\right)^{-\alpha_{KL}\theta}\left(\prod_{J=1}^{\overline{K}}\left\{\left(d_{in}(1+\tau_{inJ})\right)^{\theta}\left[\frac{X_{inJ}/X_{iJ}}{X_{nnJ}/X_{nJ}}\right]\right\}^{-\alpha_{KJ}}\right)((1+\tau_{niK})d_{ni})^{-\theta}$$

Rearranging such that all trade volumes are on the left hand side, the equation becomes

$$(4.20)\quad \frac{X_{niK}\prod_{J=1}^{\overline{K}}[X_{inJ}/X_{iJ}]^{\alpha_{KJ}}}{X_{nnK}\prod_{J=1}^{\overline{K}}[X_{nnJ}/X_{nJ}]^{\alpha_{KJ}}}=\left(\frac{T_{iK}}{T_{nK}}\right)\left(\frac{w_i}{w_n}\right)^{-\alpha_{KL}\theta}\left(\prod_{J=1}^{\overline{K}}\left\{\left(d_{in}(1+\tau_{inJ})\right)^{-\alpha_{KJ}\theta}\right\}\right)((1+\tau_{niK})d_{ni})^{-\theta}.$$

Before presenting the empirical methodology, it is worth taking a closer look as to what exactly the individual components of this equation represent. First, note that the denominator term on the left hand side serves to normalize trade flows from country *i* with a comparable measure of *n*'s use of its own goods. The numerator portion, $X_{niK}\prod_{J=1}^{\overline{K}}[X_{inJ}/X_{iJ}]^{\alpha_{KJ}}$, is *i*'s exports to country *n* multiplied by the weighted geometric mean of *n*'s share of *i*'s consumption, raised by the total intermediate share in production of industry *K*, where the weights are the cost shares of each composite intermediate. The left hand side term increases when *i* exports more to *n* and when *n*'s overall share of *i*'s consumption of intermediates increases. Trade flows are related to relative productivities, relative wages, and relative trade costs. Specifically, the term $\prod_{J=1}^{\overline{K}}\left\{\left(d_{in}(1+\tau_{inJ})\right)^{\alpha_{KJ}}\right\}$ captures the relative trade costs incurred by *i* in using intermediates from *n*. The term $(1+\tau_{niK})d_{ni}$ captures *n*'s additional trade costs of importing a good *k* from *i* relative to consuming the product from *n*.

First considered is how the trade flow measure on the left hand side relates specifically to measures of vertical specialization commonly used in the literature. To make this analogy, consider the simplified case without the added industry dimension.[62] In this case equation (4.20) simplifies to

[62] The essential requirements to go from the disaggregate to the aggregate specification are that all industries within a country have the same trade costs, intermediate shares, and productivity distributions.

(4.21) $$\frac{X_{ni}}{X_{nn}}\left(\frac{X_{in}/X_i}{X_{nn}/X_n}\right)^{1-\alpha_L} = \left(\frac{T_i}{T_n}\right)\left(\frac{w_i}{w_n}\right)^{-\alpha_L\theta}\left((d_{in}(1+\tau_{in}))^{-(1-\alpha_L)\theta}\right)((1+\tau_{ni})d_{ni})^{-\theta}$$

Notice that X_{in}/X_i represents the share of *i*'s consumption that comes from country *n*. Since consumers of final goods and firms demanding intermediate goods have the same preferences over varieties, the share of consumption by final consumers is also equal to the share of consumption of intermediates by firms. Therefore, the left hand side variable may also be written as

(4.22)

$$\frac{X_{ni}}{X_{nn}}\left(\frac{X_{in}/X_i}{X_{nn}/X_n}\right)^{1-\alpha_L} = \frac{X_{ni}}{X_{nn}}\left(\frac{INTER_{in}/(1-\alpha_L)OUTPUT_i}{INTER_{nn}/(1-\alpha_L)OUTPUT_n}\right)^{1-\alpha_L} = \frac{X_{ni}}{X_{nn}}\left(\frac{INTER_{in}/OUTPUT_i}{INTER_{nn}/OUTPUT_n}\right)^{1-\alpha_L}$$

where *INTER* refers to the value of intermediate goods and OUTPUT refers to the value of output. The numerator,

(4.23) $$X_{ni}\left(INTER_{in}/OUTPUT_i\right)^{1-\alpha}$$

, bears some resemblance to the bilateral counterpart measure of vertical specialization defined by Hummels, Rapoport, and Yi (1998) and Hummels, Ishii, and Yi (2001): $VS = EXPORTS_{in}\left(\frac{IMPORTED\ INTERMEDIATES_{ni}}{OUTPUT_i}\right)$. When labor's share is 0, equation (4.23) exactly equals VS. However, when labor's share is 1, the measure is simply equal to exports. Therefore, vertical specialization is nested within the trade flow term as an extreme case.

Another feature implied by the model is the magnified effect of bilateral trade liberalization when trade is vertically specialized. For example, assuming that tariffs and tariff changes are the same in both countries, i.e. $\tau_{nit} = \tau_{nit} = \tau_t$, then $d\ln(lhs) / d\ln(1+\tau) = -\theta(1+(1-\alpha_L))$. The intermediate share of production intensifies the effect of bilateral tariff liberalizations. Moreover, liberalizations in industries with greater intermediate intensity will see a larger effect on trade flows.

Finally, the model suggests an exact measure of bilateral trade flows that is appropriate when measuring the response of trade liberalizations in a multi-country world where countries have different rates of tariff liberalization and different preferential agreements. The measure of bilateral trade flows developed is one that is independent of trade policy with other countries and only depends on the tariffs imposed by the two relevant countries.[63] Moreover, the empirical equation does not require a multilateral trade resistance term as suggested by Anderson and van Wincoop (2003).

4.4 Data and Empirical Strategy

Taking the natural log of (4.20) produces the model to be estimated:

$$(4.24)\quad \ln\frac{\widetilde{X}_{niK}}{\widetilde{X}_{nnK}} = \ln\left(\frac{T_{iK}}{T_{nK}}\right) - \alpha_{KL}\theta\ln\left(\frac{w_i}{w_n}\right) - \theta\sum_{J=1}^{\overline{K}}\alpha_{KJ}\ln(1+\tau_{inJ}) - \theta\ln(1+\tau_{niK}) - \lambda\ln d_{in}$$

[63] The strategy employed in this paper was to come up with just such a measure. In Eaton and Kortum (2002), a similar strategy was employed to derive a bilateral trade flow measure that was independent of the exporting country's trade barriers.

where $\ln \widetilde{X}_{niK} = \ln X_{niK} + \sum_{J=1}^{\overline{K}} \alpha_{KJ} \ln(X_{inJ} / X_{iJ})$, and $\lambda = \theta(2 - \alpha_{KL})$. As can be seen from the above equation, bilateral trade flows depend on both the importing country and exporting country tariffs and geographic barriers, with the exporting country barriers becoming relatively more important in deterring bilateral vertically specialized trade the greater the intermediate share in production. This specification then allows one to estimate the main parameters of the model, as well as to quantify exactly how important the greater liberalizations experienced by the least developed countries has contributed to their greater growth rates in U.S. trade. In order to accomplish this, the model looks specifically at how tariffs on intermediate goods imposed by countries exporting to the U.S. as well as U.S. tariff preferences impact the degree of bilateral trade as measured by the left hand side variable. Therefore in estimating the specification suggested by equation (4.24), *n* will represent the United States. Countries denoted by *i* are all other trading partners with the United States for which all necessary data are available. The analysis includes data over the period 1989-2001 such that variables are also time specific.

The left hand side variables are calculated using data from the World Bank's *Trade and Production Database, 1976-2004*.[64] This database contains measures of output, and bilateral imports and exports for 28 manufacturing industries defined at the three digit International Standard Industrial Classification (ISIC) Revision 2 level for an

[64] The econometric analysis is limited to 2001, as this is the last year U.S. production data are reported in the database.

unbalanced panel of countries.[65] Output and trade volumes are summed into ten separate industries: (1) food/beverages/tobacco, (2) textiles/apparel/leather, (3) wood/paper, (4) chemicals/plastics/rubber, (5) petroleum/coal, (6) pottery/glass/non-metallic mineral products, (7) iron/steel/metal products, (8) machinery/scientific equipment, and (9) transport equipment, (10) Other. Therefore, an industry *K* corresponds to one of these 10 industries.

U.S. consumption of own production in year t, X_{nnKt}, is measured as output less manufacturing exports. Total industry expenditures for a country *i* in year t, X_{iKt}, is measured as output plus net imports in that industry. Bilateral trade with the United States are measured by U.S. reported trade, where X_{inKt} represents U.S. exports to *i*, and X_{niKt} represents U.S. imports from *i* in industry *K*. Country *i*'s consumption in an industry, X_{iKt}, is measured as output plus net imports in that industry.

The measure for worker compensation in a particular year is nominal GDP per worker, translated from local currency units to dollars using average annual exchange rates. GDP data are taken from the World Development Indicators, and the number of workers in a particular year is estimated using data from the Penn World Tables 6.3 obtained by dividing the variable Real GDP purchasing power parity (Chain Index) by the real GDP per worker. Following Eaton and Kortum (2002) Annual compensation is

[65] The production data from this database were collected by UNIDO and OECD through their joint annual collection program of general industrial statistics. However, the production data from UNIDO are subject to differences in national classifications and assumptions are applied in order to convert from the national (country specific) industrial classification into the ISIC classification. These problems, which undermine the international comparability of the data, are generally more pronounced at the more disaggregate level. See Nicita and Olarreaga (2006), and Yamada (2005).

adjusted for education to measure wages in efficiency units. Specifically, wages are given by $w_{it} = comp_{it} * e^{-.06H_{it}}$ where .06 is an estimate of the return to education, H_{it} is the average years of schooling of the adult population for country *i* and $comp_{it}$ is nominal GDP per worker in year *t* for country *i*.[66,67] The natural log of the relative state of technology, $\ln\left(T_{iK}/T_{nK}\right)$, is estimated with a country and industry fixed effect and is assumed to be constant across time.[68] This fixed effect also subsumes the distance term capturing relative transportation costs, also assumed not to be constant across time.

U.S. tariff data are taken from the United States Trade Commission's Tariff Database. The database includes the ad valorem, specific, and estimated *ad valorem* equivalent tariffs based on the Most Favored Nation (MFN) status. In addition, the file indicates commodities that are eligible for tariff preference programs and the applicable tariffs under these programs. The estimated *ad valorem* equivalent tariff for a particular country applicable under the relevant preference program is used as a measure for U.S. tariffs. If a country/good qualifies for more than one preference program, the minimum tariff of all qualifying programs is used. These data are available for commodity

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[66] Eaton and Kortum (2002) use annual compensation per worker in manufacturing for their OECD sample, and adjust this measure for worker quality in the same manner. They reference Bils and Klenow (2000) as sources for this particular measure of the return to education. Avoiding the attrition of the less developed countries precludes limiting the sample to OECD countries; therefore, the study uses GDP per worker to keep the widest range of countries and years in the sample.

[67] Data on educational attainment is taken from Barro and Lee (2001). The measure used is the average years of education for the population age 15 and up. Because the data are only available at five year intervals, the measure for a given year is used for that year as well as the for the immediate two prior and subsequent years.

[68] An alternative strategy would be to transform the equation to a first difference; however, because for many observations data in consecutive years are not available in the panel, there is quite a bit of attrition under this specification resulting in nearly half of the sampled observations being dropped.

descriptions at the HTS 8-digit level which are then concorded with the ISIC Revision 2 classifications and then aggregated to the industry level noted above.

Ideally, the tariff data for each country would be measured as the average tariff imposed specifically on the United States. However, these data are not available. Instead tariff data for each country i is taken from the World Bank's *Trade and Production Database, 1976-2004*, which reports several measures of *ad valorem* tariff rates: the import weighted applied tariff rate, the import weighted average Most Favored Nation (MFN) tariff, simple average applied tariff rate, and the simple average MFN tariff. The applied tariffs differ from the MFN counterparts in that they are calculated taking into consideration preferential trade agreements, when available.

The final specification is given by

$$(4.25)\quad \ln\frac{\tilde{X}_{niKt}}{\tilde{X}_{nnKt}} = \beta_0 + \beta_1 relwage_{iKt} + \beta_2 owntariff_{iKt} + \beta_3 ustariff_{iKt} + \eta_{iK} + \varepsilon_{iKt}$$

where η_{iK} captures time constant industry-country specific factors, $relwage_{iKt} = \alpha_{KL} * \ln\left(\frac{w_{it}}{w_{nt}}\right)$, $owntariff_{iKt} = \sum_{J=1}^{\bar{K}} \alpha_{KJ} \ln(1+\tau_{inJt})$, $ustariff_{iKt} = \ln(1+\tau_{niKt})$, and ε_{iKt} is the random error term.[69] In the empirical estimation, production function parameters are measured using the U.S. production data as a benchmark. Labor's share in a particular industry is calculated as the average share of wages in output for the U.S. sample, in a

[69] This specification bears some resemblance to recent empirical models of Romalis (2004) and Nunn (2007), among others, who have sought to measure the importance of interactions between country and industry specific factors as sources of comparative advantage. Romalis (2004) tests the importance of factor abundance interacted with factor intensity measures and Nunn (2007) extends the model to consider the importance of contract enforcement for contract intensive industries.

particular industry. These measures are reported in Table 4.5.[70] Individual intermediate industry cost shares, α_{KJ}, are estimated using the U.S. Input-Output data also provided by World Bank's *Trade and Production Database, 1976-2004*.[71]

4.5 Results

The final data set for which all data for specification (4.25) are available consists of an unbalanced panel of 57 trading partners with the United States. Results are reported in Table 4.6. In all regressions robust standard errors are clustered by country and industry. The four columns correspond to the four different measures of country *i* tariffs. As can be seen, the coefficient estimates for both tariff terms have the expected sign and are statistically significant. Because the different measures of exporting country tariffs do not produce statistically different results, in the remaining regressions only the simple average MFN tariff is used when constructing intermediate tariffs.[72] However, the Eaton and Kortum structure suggests that the coefficients on relative wages and both tariff terms should be the same. While the relative wage term consistently has the correct sign, it is only marginally significant, and smaller in absolute value then the coefficient on both U.S. tariff terms. Included at the bottom of Table 4.6 are the p-values for the linear restrictions suggested by the theory of having all three coefficients equal and the

[70] In the original specification, the model follows Eaton and Kortum (2002) and ignores capital as an input, allowing for intermediates to play a similar role in the production function. Under this specification, the total intermediate share is one minus labor's share. Additional controls for relative capital costs and financial development are included later when checking the robustness of the results.
[71] A detailed description of this calculation is provided in Appendix B.
[72] Since the objective is to approach the tariff imposed on the United States, using applied tariffs which consider all preferential arrangements may underestimate tariffs that would be applied to the United States. However, for Canada and Mexico the tariff measure will overstate the tariff imposed on the US. However, omitting NAFTA countries does not fundamentally change the results.

coefficients on the two tariff terms equal. The results clearly reject equality in all specifications at the 1 percent level.

In Table 4.7, the analysis includes several additional variables that are typically expected to influence trade patterns. One source of concern with respect to estimating the influence of tariffs arises from the endogenous trade protection literature, which suggests that higher levels of import penetration may lead to greater protection if competing domestic firms are able to successfully lobby for greater protection.[73] The consequence of not considering this effect is a possible downward bias, in absolute value, on protection variables.[74] The inclusion of country and industry fixed effects, however, alleviates concern for an omitted variable bias at this level of aggregation. However, for U.S. policy in particular a problem may still arise from the Generalized System of Preferences (GSP) program, which allows for duty-free treatment for a broad range of products to qualifying less-developed countries.[75] Since these preferences are given to countries precisely

[73] See Brock and Magee (1978), Findlay and Wellisz (1982), Hillman (1982, 1989), Mayer (1984), Magee, Brock, and Young (1989), and Trefler (1993).

[74] Trefler (1993) models trade penetration and non-tariff barriers simultaneously and finds that by doing so the restrictive impact of non-tariff barriers is significantly larger. In his primary results modeling US trade, he does not include tariffs on the grounds that U.S. tariffs were too low to have had a large impact on imports. In addition, he argues that tariffs may be treated as predetermined regressors since applied tariffs did not diverge much from the General Agreement on Tariffs and Trade (GATT) rates set during the Tokyo Round. While this argument may be applied to other GATTmember countries, tariff rates of other trading partners who joined the GATT or World Trade Organization (WTO) may not necessarily be treated as predetermined over this sample period.

[75] Recently, there has been some fairly critical literature on the perverse effects that GSP eligibility may have on export performance. For example, Ozden and Reinhardt (2005) argue that developing countries would better be served if fully integrated into the reciprocity-based world trade regime rather than depend on continued GSP preferences. They show that GSP benefits result in less-liberal trade polices of eligible countries, which can influence the ease at which countries may acquire intermediate products, as well as technology from abroad, both of which would dampen export performance. In addition, while a good may potentially qualify for duty-free treatment under the GSP program, the United States imposes competitive needs limits, which threaten to withdraw preferences for certain goods if exports reach certain levels. Furthermore, even when the competitive needs limits are not problematic, the stringent rules of origin requirements may inhibit the use of the preference program altogether.

because they are not competitive, there is concern that not controlling for GSP status at the country level, may result in underestimating the negative effect of tariffs on trade volumes. Therefore, in the first column of Table 4.7, included is an additional control for weather or not country *i* was a GSP beneficiary in that year. As can be seen, the coefficient on GSP status does have the expected negative sign and is highly significant. The magnitudes of both tariff terms are raised, as expected, but not significantly.

Another concern is whether or not the relative state of technology can reasonably be assumed to stay constant across time.[76] Relative wages and relative levels of productivity are expected to be correlated so incorrect measurement of the relative state of technology could induce a bias especially on the relative wage term. Therefore, it is assumed that relative productivity growth is the same for all industries within a country and the state of technology is proxied by estimating a country and year specific Total Factor Productivity (TFP) term. This measure is calculated as the residual from the regression of the natural log of real GDP on the natural log real capital stock and the available labor force which is also measured in efficiency units.[77, 78] Regression 2 of Table 4.7 contains the results for the specification that includes the natural log of the relative TFP term. As can be seen, this term has the expected positive sign and is

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[76] Changes in technology may be especially important as suggested by recent research by Keane and Feinberg (2007) who argue that the advent of improved logistics management practices, including the 'just-in-time' (JIT) production system, can explain much of the growth of intra-firm trade. Lileeva and Trefler (2007) argue that tariff cuts can be effective especially in conjunction with new technologies such as just-in-time delivery.

[77] Specifically, the available labor force in country *i* in year *t* is given by $L_{it} = pop_{it} * e^{.06H_{it}}$.

[78] Data and documentation used to construct TFP measures were obtained from a database provided by Adalmir Marquetti at http://homepage.newschool.edu/~foleyd/epwt/. These data are based on the extensions of the Penn World Tables 6.2. Because the Penn World Tables do not currently have capital stock data, the standardized capital stock measure is obtained by applying the Perpetual Inventory Method to the investment series computed form the variable Real Investment Share of GDP.

statistically significant. The inclusion also marginally raises the magnitude and significance level of the relative wage interaction.

In the rest of the table, capital intensity and capital costs are allowed to play role in the production function. Therefore in measuring the input shares, labor's share is still calculated as the share of wages in output, capital's share is calculated as the value added share of output minus labor's share, and the total intermediate share is calculated as 1 minus the value added share of output. Table 4.8 summarizes the factor cost shares. Two controls for comparative advantage in capital intense industries are added separately: first the capital share in industry *K* interacted with the natural log of relative capital stock, and second the capital share interacted with the natural log of the relative private bank credit to GDP ratio, an indicator of the relative level of financial development.[79] Regressions 3, 4 and 5 of Table 4.7 include these results. While the interaction of the capital share and capital stock is insignificant, the measure for capital share interacted with the relative private bank credit to GDP is positive as expected and significant. The magnitude of the relative wage interaction is lowered and becomes insignificant; however, the relative tariff terms are no longer statistically different from each other, as the theory suggests. Finally, added to the regression is a dummy for the Canadian U.S. Free Trade Agreement (CUSFTA) and the North American Free Trade Agreement (NAFTA) to control for other trade barrier liberalizations specific to Free Trade Agreements that go beyond the scope of tariff decreases but which are likely correlated. Regression 6 of Table 4.7 shows that

[79] Relative bank credit to GDP data are taken from the Financial Structure Dataset. See Beck, Demirgüç-Kunt and Levine (2009).

this coefficient is positive and significant but only marginally lowers the magnitudes of the tariff coefficients.

One possible explanation for the lower, in absolute value, coefficient on relative wages is that wages are inherently endogenous and likely to be larger for countries with higher overall levels of technology. The analysis has attempted to control for country and industry specific differences in technology with fixed effects, and with an estimate of TFP that is year and country specific for changes in technology across time. To control for any additional omitted variable bias, an Instrumental Variable (IV) procedure is employed. To be consistent with Eaton and Kortum (2002), two primary instruments for relative wages are used: the natural logs of the relative supply of workers, measured in efficiency units, and the relative population density.[80] In the IV estimation, the primary instruments are used as well as the corresponding interaction with labor's share to instrument for the interaction of the natural log of relative wages with labor's share. The IV results are presented in Regression 2 of Table 4.9. As can be seen, the result is a significant and larger in absolute value negative coefficient on the relwage term, as expected. In addition, the Hausman test of exogeneity rejects the null of exogeneity at the 1 percent level. The exclusion restrictions appear to be met at the 1 percent level. However, the magnitudes of the tariff terms decrease in absolute value and the owntariff term becomes insignificant.

To check the robustness of the results, outcomes from three alternative regressions are reported in Table 4.10. To insure that the NAFTA countries do not drive

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[80] Labor supply for country *i* measured in efficiency units is measured as $L_{it} = pop_{it} * e^{.06H_{it}}$. Population density is measured as the population divided by land area.

the results, Canada and Mexico are dropped as well as the FTA dummy. In the second regression, all observations pertaining to the textile industry are dropped. This is because the textile industry was subjected to substantial non-tariff barriers, and consequently tariffs may not accurately measure trade restrictions in this industry. In the third specification, the relwage term is replaced by the relative labor supply interacted with labor intensity. No significant changes are made by these specifications except that the U.S. tariff coefficient and the intermediate tariff coefficient are no longer statistically different from each other.

In all specifications the coefficient on U.S. tariffs is marginally larger than that of exporting country tariffs; however, as was noted in the descriptive statistics, U.S. liberalizations have been relatively moderate with the exception of NAFTA tariffs. On the other hand, there have been substantial liberalizations especially by the least developed countries. In order to study the implied effects of actual trade liberalization for the sample, the implied change in trade suggested by the model is calculated for the sampled countries over the widest time frame for which exporting country tariff data are available. The specification used is that of Regression 4 of Table 4.5. These results are given in Table 4.11. The impact of China's trade liberalization was over 4.5 times the effect of U.S. tariff liberalization. Taking the average effect of tariff liberalizations across countries, Table 4.12 shows that on average exporting country liberalizations have been an important source of comparative advantage and quantitatively more important than U.S. liberalizations. For the least developed countries, their own liberalizations have been on average 3 times more important than U.S. liberalizations and for lower middle income countries their own liberalizations have been twice as large. For upper middle and high income countries, U.S. tariff decreases have had a larger effect, on average.

4.6 Conclusion

Throughout the 1960's and 1970's, many developing countries erected highly protected trade regimes in the hopes of expanding the industrial sectors of their economies. The standard rationale behind protectionist measures falls under the infant industry argument which theorizes that protectionism will allow an infant industry to grow and develop to the point at which it can compete on international markets without protectionist measures. Other proponents of trade protection argue that domestic firms should be more able to invest in new infrastructure and modern production techniques if guaranteed protection from foreign competition. While developing countries have for some time adhered to the more conventional wisdom that greater openness to foreign competition induces both productivity and welfare gains, developing countries have only recently begun to abandon development through protection policies. For some countries recent trade liberalizations have been substantial and have also coincided with large export growth rates which have far outpaced those of high income countries.

This paper was motivated by the observation that U.S. imports from less developed countries are becoming increasingly important in U.S. trade, and consequently imply that when analyzing trade growth limiting one's sample to a balanced panel of the most developed countries at the time, may result in neglecting important sources and causes of trade growth. This paper investigates whether or not the more pronounced export growth of less developed countries is related to recent trade liberalizations by promoting the development of vertical production networks. There are several reasons to expect trade liberalization to stimulate export growth, which do not necessarily involve vertical specialization. For instance, technology diffusion and productivity growth resulting from increased access to foreign capital goods, or investment liberalizations which typically coincide with more open trade policies, should both contribute to a country's ability to compete in export markets. The analysis does not assess the contribution of trade policy to productivity growth, but instead quantifies the direct impact of trade liberalizations on export growth, through lower cost access to foreign intermediates and lower trade costs imposed by destination countries.

As Yi (2003) argues, vertical specialization can generate magnified effects on trade and consequently resolve the quantitative puzzle of why trade, especially from less developed countries, has responded so strongly to moderate tariff reductions. To explicitly investigate this hypothesis, the paper builds and estimates an empirical model that is guided by extensions of the Eaton and Kortum (2002) model. The objective is to relate an appropriate measure of bilateral trade, which correctly controls for trade policies with other countries, to both importing and exporting country tariff policy. The results suggest that both intermediate tariffs imposed by countries exporting to the United States as well as U.S. tariffs matter for trade. Higher U.S. tariffs are associated with less trade, and countries with low intermediate tariffs tend to export relatively more in industries that are intermediate intense. Empirical studies estimating trade elasticities have tended to focus on importer barriers and not to directly measure the importance of exporter country policies. My results indicate that especially for less developed countries who have historically had much more protected trade regimes, their own liberalizations have been relatively more important than U.S. tariffs, which in turn have been quite moderate. While attempts have been made to control for productivity and other cost factors, the analysis could be improved upon by better measurements of productivity across industries and time, as well as bilateral tariffs and the inclusion of non-tariff barriers.

Chapter 5: Conclusion

Sustained growth in international trade has characterized the post WWII world economy, but tariff reductions of developed countries, which account for most of world trade, have been moderate. Recent researchers have rationalized the amplified effect of tariffs on trade volumes with two explanations: first, growth in the extensive margin, or the range of goods that countries export, and second growth in internationally fragmented production networks. This dissertation investigates the likelihood of tariff liberalizations driving the growth in world trade through the extensive margin and when production of goods is modeled to be internationally fragmented.

The first essay casts doubt on the contention that the extensive margin has amplified the impact of tariffs on trade flows to such an extent that the relatively moderate tariff reductions since WW II can explain the strong growth of world trade. First, while growth in the range of goods that countries export may be quite important for source countries, especially smaller and less developed countries, the contribution of net extensive margin change to real US import growth appears relatively moderate, only 9.3 percent for the period 1989-1999. Second, the contribution of US tariff policy liberalization to extensive margin growth suggested by the model is small as well, at most 5 percent of the increasing extensive margin for the period 1989-1999. The analysis then leaves open the question of what exactly does drive changes in the range of goods that countries export as well as trade growth.

The second essay in this dissertation looks more closely at the country and industry specific variables that matter for the range of goods that countries export. The analysis finds that the traditional determinants of comparative advantage, for example factor abundance of a country for sectors intense in those factors, play a role for the range of goods that countries exports. However, the study considers the possibility that trade frictions affect more fragmented industries differently. The results show that closer countries and countries with lower tariffs imposed on them export a wider range of goods in sectors that have large intermediate cost shares. Alternatively, tariffs and distance tend to have a larger negative effect on the range of goods that countries export in more intermediate intense industries. These findings are consistent with theories of fragmentation, which suggest that effective trade frictions increase with the intermediate share when there exists substantial back and forth trade between countries.

The third essay studies the impact of trade liberalizations of exporting countries, which should be important when exports are made with imported intermediates. While developing countries have for some time adhered to the more conventional wisdom that greater openness to foreign competition induces both productivity and welfare gains, developing countries have only recently begun to abandon development through protection policies. For some countries recent trade liberalizations have been substantial and have also coincided with large export growth rates which have far outpaced those of high income countries. The paper builds a model that relates bilateral trade flows to bilateral tariffs and other cost factors. The empirical estimates of this study suggest that especially for less developed countries their own liberalizations have been quantitatively much more important in explaining bilateral trade growth than the impact of decreases in the tariffs imposed on their exports. The results are likewise consistent with hypotheses suggesting internationally fragmented production amplifies the impact of tariffs.

Changing trade patterns and the contribution of tariff policy are important for accurately assessing welfare gains or losses from policy changes. The papers in this dissertation make a first step in considering the contribution of tariff policies to trade growth along the extensive margin and when trade may be vertically specialized. For developing countries, whose tariffs have been low and whose liberalizations moderate, tariffs imposed on imports do not appear to be a major factor in extensive margin growth; however, trade frictions do appear to have amplified effects on intermediate intense industries. For developing nations whose liberalizations have been substantial, increased access to specialized intermediates may be an important factor in gaining comparative advantage and increasing exports. While the papers in this dissertation measure the contribution of these liberalizations to US trade, exactly uncovering the welfare implications for the United States and other countries is a challenge for future research.

Table 2.1
Extensive Margin Change
Manufacturing exports to the US at the HTS 6 digit level: 3,328 goods

Panel A: 1989-1999

Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continuously traded goods[4]	Disappearing goods' share of 1989 trade volume	Newly traded goods' share of 1999 trade volume
Canada	3100	0.08	0.08	0.84	3.6%	4.4%
Mexico	2572	0.26	0.10	0.63	6.7%	9.6%
China	2504	0.34	0.06	0.60	2.3%	5.1%
Rest of the World	74480	0.30	0.19	0.51	6.8%	9.9%

Panel B: 1996-2006

Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continuously traded goods[4]	Disappearing goods' share of 1996 trade volume	Newly traded goods' share of 2006 trade volume
Canada	3045	0.07	0.07	0.86	1.4%	3.7%
Mexico	2641	0.14	0.13	0.73	1.5%	4.8%
China	2958	0.29	0.02	0.69	0.6%	3.5%
Rest of the World	81545	0.30	0.16	0.54	3.6%	12.1%

Notes:
1. Number of goods exported either at the beginning or end of the time frame.
2. Number of goods exported at the end of the time frame but not the beginning.
3. Number of goods exported at the beginning but not the end of the time frame.
4. Number of goods exported both in the beginning and end of the time frame.

Table 2.2
Probit estimates for the effect of Δln(1+tariff) on export status, 1989-1999

	Export Status: A good is traded if there are positive exports to the US in 1999						Alternative Definition[1]
	Full Sample		Selected samples: Not traded in 1989[2]	Traded in 1989[3]	Upper Income[4]	Low Income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	-2.27***	-0.56***	-0.32***	-0.37	-1.28***	-0.16	-0.43
Text/App/Other	-2.04*	-0.67*	-0.32*	-0.16	-0.84**	-0.69	-1.57***
Wood/Paper	-5.87	-1.49	-0.53	-1.99	-2.12	0.01	-3.08*
Minerals	-2.32	-0.33	-0.48	1.77	-0.12	-0.65	-1.57*
Chemicals	-3.08*	-0.49*	-0.30**	-0.58	-0.87	-0.08	-0.89**
Plastics/Rubber	-4.07	-1.33	-0.64	-0.35	-1.05	-0.27	-2.26**
Pottery/China	-4.85**	-1.50**	-0.49	-2.29***	-2.40*	-0.02	-2.02**
Iron/Steel	-7.75***	-1.56***	-0.79***	-0.29	-3.21**	-0.15**	-1.17
Nonferrous metal	-6.65***	-1.97**	-0.83***	-1.07	-2.94***	0.25	-3.01***
Machinery	-7.29**	-2.21**	-0.77*	-2.44***	-3.00**	0.01	-3.94***
Transportation	-9.23***	-1.34***	-0.64***	-0.93	-3.59***	0.05	-2.58***
Other	-3.82*	-1.32*	-0.44	-1.18*	-1.30	-0.13	-1.78**
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				7724			
disappearing goods if Δln(1+tariff)=0				8244			
disappearing goods due to tariffs				-520			
new goods	13800		13786		10520	3286	13931
new goods if Δln(1+tariff)=0	13110		13068		9882	3230	13184
new goods due to tairffs	690		718		638	56	747
tariff contribution	0.05		0.05	-0.07	0.06	0.02	0.05

Notes:
1 A good is considered traded if there were positive exports in 1997, 1998, or 1999.
2 Country/good pairs that were exported in 1989 are omitted.
3. Country/good pairs that were not exported in 1989 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table 2.3
Probit estimates for the effect of Δln(1+tariff) on export staus, 1996-2006

	Export Status						
	A good is traded if there are positive exports to the US in 2006						Alternative Definition[1]
	Full Sample		Selected samples				
			Not traded in 1996 [2]	Traded in 1996[3]	Upper income[4]	Low income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	1.01	0.28	0.20	-0.22	0.37	0.63	0.51
Text/App/Other	-0.50	-0.18	-0.28	0.28	-0.30	0.19	-0.37
Wood/Paper	-0.54	-0.16	-0.23	0.15	2.78	2.16*	-1.00
Minerals	-11.69*	-1.59*	-1.10*	-6.47*	-1.16	-0.93	-0.75
Chemicals	-6.51***	-1.29***	-0.72***	-0.72	-0.13	-0.16	-1.83***
Plastics/Rubber	-7.65**	-2.76**	-1.23**	-1.46**	-1.03	-0.01	-2.87**
Pottery/China	-3.52*	-1.24*	-0.85**	-0.24	0.84	-0.54	-0.78
Iron/Steel	-8.33**	-1.99**	-1.11***	0.00	-0.26	0.10	-2.44**
Nonferrous metal	-6.79***	-2.21***	-1.17***	-0.71	-0.21	-0.16	-2.23***
Machinery	-9.97**	-3.47**	-1.69**	-1.30	-0.01	-0.55	-4.86***
Transportation	-2.99	-0.62	-0.29	-2.82**	0.82	0.04	-0.86
Other	-5.11**	-1.97**	-0.83	-1.47**	-0.74	1.03	-2.21**
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				7484.463			
disappearing goods if Δln(1+tariff)=0				7775.726			
disappearing goods due to tariffs				-291			
new goods	13844		13859		10236	3667	12641
new goods if Δln(1+tariff)=0	12632		12187		10077	3759	11425
new goods due to tairffs	1212		1672		159	-92	1216
tariff contribution	0.09		0.12	-0.04	0.02	-0.03	0.10

Notes:
1 A good is considered traded if there were positive exports in 2004, 2005, or 2006.
2 Country/good pairs that were exported in 1996 are omitted.
3. Country/good pairs that were not exported in 1996 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table 2.4
Alternative Models
Estimates for the effect of Δln(1+tariff) on export status, 1989-1999 and 1996-2006

	Export Status A good is traded if there are positive exports to the US in 1999			Export Status A good is traded if there are positive exports to the US in 2006		
Industry	conditional logit (1) marginal effect	random effects probit (2) marginal effect	linear probability (4) marginal effect	conditional logit (1) marginal effect	random effects probit (2) marginal effect	linear probability (4) marginal effect
Food/Bev/Tobacco	-.98*	-0.37**	-0.36**	0.36	0.08	0.03
Textiles	-1.35**	-0.56***	-1.19***	-0.17	-0.46***	-0.09
Apparel	-0.78	0.72***	0.01	-1.08***	-0.36***	-0.64*
Other Articles	-0.53	-0.26	0.03	-0.16	-0.34	-0.12
Wood/Paper	-2.41**	-1.70***	-2.01**	-0.84	-1.32**	-1.86*
Minerals	-1.18	0.38	0.17	-5.29**	-0.82	-1.63**
Chemicals	-1.16***	-0.29***	-0.43**	-3.31***	-0.72***	-0.91***
Plastics/Rubber	-1.81**	-1.03***	-0.79	-4.09***	-2.86***	-1.90***
Pottery/China	-2.12***	-1.20***	-0.76*	-2.19***	-1.16***	-1.08***
Iron/Steel	-2.97***	-0.66**	-1.35***	-5.38***	-0.65*	-1.27***
Nonferrous metal	-3.04***	-1.28***	-1.11***	-3.49***	-1.74***	-1.35***
Machinery	-3.38***	-1.32***	-0.98	-5.41***	-2.05***	-1.64*
Transportation	-3.61***	-1.09***	-0.89***	-2.08	-0.27	-0.04
Other	-1.53***	-1.02***	-0.73	-2.67***	-1.76***	-1.25**
Model Predictions:						
new goods	33733	12924	14670	29334	13194	14973
new goods if Δln(1+tariff)=0	32437	12438	13948	25623	11882	13302
new goods due to tairffs	1296	487	722	3711	1312	1670
tariff contribution	0.04	0.04	0.05	0.13	0.10	0.11

Notes:
Robust standard errors clustered by country for the linear probability models.
Robust standard errors for the conditional logits and random effects probit.
Marginal effects for the conditional logit and random effects probit are calculated assuming the goods effects are zero.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table 3.1
Countries Included in the Analysis

Argentina	Madagascar
Australia	Malawi
Austria	Malaysia
Bangladesh	Malta
Belgium	Mauritius
Bolivia	Mexico
Brazil	Morocco
Cameroon	Netherlands
Canada	New Zealand
Chile	Nigeria
Colombia	Norway
Costa Rica	Pakistan
Denmark	Panama
Ecuador	Papua New Guinea
Egypt	Peru
El Salvador	Philippines
Fiji	Portugal
Finland	Singapore
France	South Africa
Germany	Spain
Ghana	Sri Lanka
Greece	Suriname
Guatemala	Sweden
Honduras	Syrian Arab Republic
Hong Kong	United Republic of Tanzania
Iceland	Thailand
India	Tunisia
Indonesia	Turkey
Ireland	United Kingdom
Italy	Uruguay
Jamaica	Venezuela
Japan	Zambia
South Korea	Zimbabwe

Table 3.2
Twenty Industries with the Lowest and Highest Intermediate Cost Shares

20 Lowest Intermediate Shares			
Industry Description	intshare	1-H	GL
Indus. mold man.	0.48	0.94	0.75
Newpaper publishers	0.52	0.92	0.42
Search, detection, & navigation instruments	0.55	0.93	0.75
Vitreous china & earthenware articles man.	0.56	0.93	0.61
Cutting tool & mach. tool accessory man.	0.57	0.94	0.98
Turned product & screw, nut, & bolt man.	0.58	0.95	0.87
Small arms man.	0.60	0.95	0.28
Porcelain electrical supply man.	0.60	0.95	0.65
Bread & bakery product, except frozen, man.	0.60	0.95	0.80
Fluid power cylinder & actuator man.	0.60	0.94	0.92
Cut stone & stone product man.	0.61	0.92	0.08
Hand & edge tool man.	0.61	0.94	0.78
Ophthalmic goods man.	0.61	0.94	0.39
Packaging mach. man.	0.61	0.95	0.86
Power boiler & heat exchanger man.	0.62	0.94	0.30
Ferrous metal foundaries	0.62	0.96	0.93
Speed changers & mechanical power transmission	0.62	0.94	0.76
Optical instrument & lens man.	0.63	0.95	0.97
Musical instrument man.	0.63	0.90	0.67
Narrow fabric mills & schiffli embroidery	0.63	0.89	0.98
20 Highest Intermediate Shares			
Industry	intshare	1-H	GL
Soybean processing	0.98	0.48	0.07
Petroleum refineries	0.97	0.57	0.69
Fats & oils refining & blending	0.94	0.85	0.79
Oth. oilseed processing	0.94	0.76	0.72
Prim. smelting & refining of copper	0.94	0.59	0.26
Oth. animal food man.	0.94	0.89	0.30
Cheese man.	0.93	0.73	0.40
Coffee & tea man.	0.93	0.76	0.22
Rice milling	0.93	0.67	0.38
Flour milling	0.92	0.65	0.50
Wet corn milling	0.92	0.73	0.94
Animal, except poultry, slaughtering	0.92	0.65	0.67
Distilleries	0.92	0.86	0.33
Breakfast cereal man.	0.91	0.86	0.77
Automobile & light truck man.	0.91	0.68	0.38
Phosphatic fertilizer man.	0.91	0.91	0.37
Plastics material & resin man.	0.90	0.87	0.64
Nitrogenous fertilizer man.	0.89	0.87	0.00
Soft drink & ice man.	0.89	0.89	0.73
Cigarette man.	0.89	0.88	0.05

Table 3.3
Correlations among Measures of Fragmentation

	intshare	1-H	GL
intshare	1		
1-H	-.56*	1	
GL	-.22*	.20*	1

Correlation Coefficients are reported. * indicates significance at the 1 percent level

Table 3.4
Correlations among Factor Intensity and Fragmentation

	intshare	1-H	GL
unskilled intensity	-.85*	.43*	.16*
skilled intensity	-.78*	.50*	.19*
capital intensity	.30*	-.26*	.03*
value added /shipments	-.67*	.56*	.07*

Correlation Coefficients are reported. * indicates significance at the 1 percent level

Table 3.5
Regression Results

	(1)	(2)	(3)	(4)
lnustar	-0.088***	-0.081***	-0.080***	-0.080***
Unksill interaction	0.080***	0.113***	0.110***	0.109***
Skill interaction	0.107***	0.083***	0.081***	0.076***
Capital interaction	-0.098***	-0.092***	-0.085***	-0.113***
Intshare interaction	-0.976***	-0.557***	-0.558***	-0.551***
Intshare_Judicial Quality		-0.539***	-0.440***	-0.431***
(1-Herfindahl)_Judicial Quality			0.231***	
GL_Judicial Quality				0.204***
Country Fixed Effects	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes
R2	0.71	0.71	0.705	0.714
Number of observations	11880	11880	11880	11880

Notes:
Standardized beta coefficients are reported.
All regressions conducted with robust standard errors.
*** indicates signficance at the 1 level
** indicates signficance at the 5 level
* indicates signficance at the 1 level

Table 3.6
Regression Results with Distance Interactions

	(1)	(2)	(3)	(4)
lnustar	-0.080***	-0.075***	-0.075***	-0.076***
Unksill interaction	0.110***	0.094***	0.094***	0.094***
Skill interaction	0.081***	0.094***	0.094***	0.093***
Capital interaction	-0.085***	-0.084***	-0.085***	-0.085***
Intshare interaction	-0.558***	-0.688***	-0.688***	-0.688***
Intshare_Judicial Quality	-0.440***	-0.328***	-0.327***	-0.328***
(1-Herfindahl)_Judicial Quality	0.231***	0.232***	0.234***	0.232***
Intshare*ln(distance)		-0.449***	-0.394***	-0.465***
(1-Herfindahl)*ln(dististance)			0.103	
GL*ln(distance)				-0.071
Country Fixed Effects	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes
R2	0.71	0.71	0.705	0.714
Observations	11880	11880	11880	11880

Notes:
Standardized beta coefficients are reported.
All regressions conducted with robust standard errors.
*** indicates signficance at the 1 level
** indicates signficance at the 5 level
* indicates signficance at the 1 level

Table 3.7
Regression Results with Tariff Interactions

	(1)	(2)	(3)	(4)
lnustar	-0.075***	0.080	0.455*	0.034
Unksill interaction	0.094***	0.096***	0.096***	0.097***
Skill interaction	0.094***	0.094***	0.095***	0.094***
Capital interaction	-0.085***	-0.085***	-0.085***	-0.086***
Intshare interaction	-0.688***	-0.650***	-0.644***	-0.645***
Intshare_Judicial Quality	-0.327***	-0.318***	-0.296***	-0.322***
(1-Herfindahl)_Judicial Quality	0.234***	0.233***	0.287***	0.220***
Intshare*ln(distance)	-0.394***	-0.347***	-0.322***	-0.347***
(1-Herfindahl)*ln(dististance)	0.103	0.096	0.146	0.082
Intshare*lnustariff		-0.156	-0.281**	-0.169
(1-Herfindahl)*lnustariff			-0.254*	
GL*lnustariff				0.059**
Country Fixed Effects	yes	yes	yes	yes
Industry Fixed Effects	yes	yes	yes	yes
R2	0.71	0.71	0.705	0.714
Observations	11880	11880	11880	11880

Notes:
Standardized beta coefficients are reported.
All regressions conducted with robust standard errors.
*** indicates signficance at the 1 level
** indicates signficance at the 5 level
* indicates signficance at the 1 level

Table 3.8
Regression Results with Judicial Quality Interaction

	(1)
lnustar	0.410*
Unksill interaction	0.060***
Skill interaction	0.070***
Capital interaction	-0.009
Intshare interaction	-0.637***
Intshare_Judicial Quality	-0.183***
(1-Herfindahl)_Judicial Quality	0.158**
Intshare*ln(distance)	-0.336***
(1-Herfindahl)*ln(dististance)	0.129
Intshare*lnustariff	-0.254*
(1-Herfindahl)*lnustariff	-0.21
Judicial Quality Interaction	0.250***
Country Fixed Effects	yes
Industry Fixed Effects	yes
R2	0.71
Observations	11880

Notes:
Standardized beta coefficients are reported.
All regressions conducted with robust standard errors.
*** indicates signficance at the 1 level
** indicates signficance at the 5 level
* indicates signficance at the 1 level

Table 4.1
US Trading Partners Represented in the the Descriptive Statisitcs

Tanzania	Ecuador	Ireland
Uganda	Turkey	Israel
Malawi	Panama	Greece
Benin	Tunisia	New Zealand
Ghana	Algeria	Spain
Mozambique	Jordan	Oman
Nigeria	Botswana	Singapore
Nepal	Colombia	Macao
Bangladesh	Costa Rica	United Kingdom
China	Malaysia	Italy
Senegal	South Africa	France
India	Brazil	Finland
Kenya	Mexico	Sweden
Pakistan	Poland	Denmark
Bolivia	Chile	Germany
Sri Lanka	Uruguay	Belgium
Cameroon	Trinidad and Tobago	Australia
Indonesia	Venezuela	Netherlands
Ivory Coast	Mauritius	Hong Kong
Honduras	Argentina	Austria
Philippines	Gabon	Japan
Egypt	South Korea	Iceland
El Salvador	Hungary	Canada
Peru	Taiwan	Norway
Morocco	Malta	Kuwait
Guatemala	Portugal	Switzerland
Thailand	Cyprus	Qatar

Ordered by 1989 per capita GDP (Constant 2005 dollars)

Table 4.2
Growth of US Imports/Output and US Tafiff Liberalization 1989-2001

Year	US imports/US output	Average US tariff	
1989	0.149	0.052	
1990	0.149	0.049	
1991	0.154	0.048	
1992	0.159	0.046	
1993	0.167	0.046	
1994	0.180	0.043	
1995	0.188	0.043	
1996	0.182	0.041	
1997	0.195	0.039	
1998	0.206	0.038	
1999	0.222	0.035	
2000	0.245	0.035	
2001	0.265	0.034	
1989-2001	Δln(US imports/US output)	Δln(1+tariff)	Trade to Tariff Elasticity
	0.58	-0.02	-33.57

Table 4.3
Distribution of US Manufacturing Imports by Country/Country Group

Country/Country Group	Share of US Imports 1989	2001	%Δ Share of US Imports
Least Developed[1]	0.009	0.015	0.55
Low Middle Income[2]	0.083	0.109	0.31
Upper Middle Income[3]	0.123	0.108	-0.12
High Income[4]	0.519	0.367	-0.29
Mexico	0.049	0.116	1.38
Canada	0.193	0.176	-0.08
China	0.023	0.108	3.67

Notes:

Data Sources: *World Bank Trade and Production Database and Penn World Tables 6.3.*

Countries included are listed in Table 1.

1 All countries with 1989 per capita GDP (Constant 2005 dollars) <$3000

2 All countries with 1989 per capita GDP (Constant 2005 dollars) between $3000 and $10,000

3 All countries with 1989 per capita GDP (Constant 2005 dollars) between $10000 and $18,000

4 All countries with 1989 per capita GDP (Constant 2005 dollars) greater than $18,000

Table 4.4
Trends in World Tariffs by Country/Country Group

Country/Country Group	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Δln(1+tariff)
World	0.19	0.19	0.13	0.16	0.16	0.17	0.16	0.11	0.14	0.14	0.12	0.12	0.12	-0.07
	0.30	*0.24*	*0.15*	*0.18*	*0.18*	*0.22*	*0.48*	*0.15*	*0.20*	*0.30*	*0.13*	*0.13*	*0.13*	
Canada	0.10	.	.	.	0.10	.	0.10	0.09	0.07	0.06	0.06	0.05	0.05	-0.05
	0.05	.	.	.	*0.05*	.	*0.06*	*0.06*	*0.05*	*0.06*	*0.05*	*0.04*	*0.04*	
Mexico	.	.	0.15	.	.	.	0.14	.	0.18	0.17	0.21	0.21	0.21	0.05
	.	.	*0.03*	.	.	.	*0.03*	.	*0.10*	*0.10*	*0.10*	*0.10*	*0.10*	
China	.	.	.	0.51	0.48	0.44	.	0.29	0.20	0.20	0.20	0.20	0.19	-0.24
	.	.	.	*0.30*	*0.29*	*0.29*	.	*0.16*	*0.13*	*0.13*	*0.13*	*0.13*	*0.11*	
Least Developed[1]	0.80	0.64	.	0.51	0.17	0.33	0.31	0.23	0.24	0.27	0.24	0.19	0.19	-0.41
	0.57	*0.33*	.	*0.26*	*0.10*	*0.32*	*0.22*	*0.15*	*0.15*	*0.17*	*0.15*	*0.11*	*0.12*	
Lower Middle Income[2]	0.37	0.28	0.21	0.18	0.24	0.19	0.21	0.16	0.18	0.19	0.14	0.15	0.15	-0.18
	0.19	*0.21*	*0.17*	*0.10*	*0.22*	*0.18*	*0.66*	*0.19*	*0.27*	*0.45*	*0.15*	*0.15*	*0.14*	
Upper Middle Income[3]	0.11	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.06	0.07	0.06	0.06	-0.05
	0.11	*0.12*	*0.13*	*0.10*	*0.11*	*0.12*	*0.13*	*0.12*	*0.10*	*0.08*	*0.08*	*0.06*	*0.07*	
High Income[4]	0.07	0.09	0.09	0.09	0.08	0.09	0.08	0.06	0.07	0.05	0.06	0.05	0.04	-0.03
	0.11	*0.11*	*0.12*	*0.13*	*0.10*	*0.12*	*0.13*	*0.09*	*0.10*	*0.08*	*0.08*	*0.07*	*0.06*	

Notes:
Tariff measured is simple average MFN tariff for manufacturing industries with standard deviations in italics.
1 All countries with 1989 per capita GDP (Constant 2005 dollars) <$3000 (excluding China)
2 All countries with 1989 per capita GDP (Constant 2005 dollars) between $3000 and $10,000 (excluding Mexico)
3 All countries with 1989 per capita GDP (Constant 2005 dollars) between $10000 and $18,000
4 All countries with 1989 per capita GDP (Constant 2005 dollars) greater than $18,000 (excluding Canada)

Table 4.5
Average labor share of output by manufacturing sector, US production

Industry	Labor Share[1]
Food, Beverages and Tobacco	0.07
Textile, Wearing Apparel and Leather Industries	0.19
Wood Products, Paper Products, Printing and Publishing	0.19
Products of Petroleum and Coal	0.05
Chemical, Plastic, and Rubber Products	0.15
Pottery, Glass, and other Non-metallic Mineral Products	0.23
Basic Iron, Steel, and Metal Products	0.15
Fabricated Metal Products and Professional and Scientific Equipment	0.21
Transport equipment	0.15
Other	0.21
Mean	0.16

1 Labor share is the average share of wages in output.

Table 4.6
OLS Regression Results

	(1) coef	st error	(2) coef	st error	(3) coef	st error	(4) coef	st error
relwage	-1.09*	0.66	-0.94	0.66	-1.13*	0.67	-1.17*	0.67
ustar	-10.18***	2.15	-10.49***	2.13	-10.98***	2.16	-10.30***	2.17
owntariff[1]	-3.47***	0.94	-4.05***	0.85	-3.83***	1.05	-3.52***	1.15
country/industry fixed effects	yes							
R2 (within)	0.04		0.05		0.05		0.04	
no obs	2394		2394		2414		2421	
Linear Restrictions:								
HO: relwage=ustar=owntar (p-value)	0.0005		0.0002		0.0002		0.0006	
Accept or Reject at 1% level	Reject		Reject		Reject		Reject	
HO: ustar=owntar (p-value)	0.0039		0.0030		0.0016		0.0049	
Accept or Reject at 1% level	Reject		Reject		Reject		Reject	

Notes:
1 The measure for owntariff used for Regression 1 is the import weighted applied, for Regression 2 is the import weighted MFN, for Regression 3 is the simple average applied, and for Regression 4 is the simple average MFN,
Robust standard errors are clustered by country and industry.
***Significant at the 1% level
**Significant at the 5% level
*Significant at the 10% level

Table 4.7
OLS Regressions with Additional Variables.

	OLS without capital inputs				OLS with capital inputs							
	(1)		(2)		(3)		(4)		(5)		(6)	
	coef	st error	coef	st error	coef	st error	coef	st error	coef	st error	coef	st error
relwage	-1.03	0.67	-1.28*	0.68	-0.51	0.71	-1.09	0.67	-0.43	0.71	-1.06	0.67
ustar	-10.73***	2.04	-11.25***	2.03	-9.62***	1.82	-9.50***	1.78	-9.52***	1.74	-9.18***	1.76
owntariff	-3.67***	1.07	-3.30***	1.08	-5.49***	2.07	-4.37**	2.16	-4.52**	2.16	-4.47**	2.18
gsp status	-0.83***	0.20	-0.86***	0.20	-0.75***	0.18	-0.67***	0.17	-0.71***	0.17	-0.52**	0.20
ln relative TFP			1.25**	0.58	0.94*	0.55	1.32**	0.56	1.05*	0.53	1.32**	0.56
capital share*ln relative capital stock					-0.4	0.67			-0.97	0.68		
capital share*ln relative credit to GDP							1.01***	0.25	1.08***	0.26	1.01***	0.25
CUSFTA/NAFTA											0.56**	0.27
country/industry fixed effects	yes		yes		yes		yes		yes		yes	
R2 (within)	0.05		0.06		0.05		0.06		0.06		0.06	
no obs	2421		2421		2421		2341		2341		2341	
Linear Restrictions:												
HO: relwage=ustar=owntar (p-value)	0.0001		0		0		0.0001		0		0.0001	
Accept or Reject at 1% level	Reject		Reject		Reject		Reject		Reject		Reject	
HO: ustar=owntar (p-value)	0.0023		0.0007		0.1629		0.0907		0.0949		0.1197	
Accept or Reject at 1% level	Reject		Reject		Accept		Accept		Accept		Accept	

Notes:
Measure for own tariff based on the simple average MFN.
Robust standard errors are clustered by country and industry.
***Significant at the 1% level
**Significant at the 5% level
*Significant at the 10% level

Table 4.8
Average input shares of output by manufacturing sector, US production

Industry	Labor Share[1]	Capital Share[2]	Intermediate Share[3]
Food, Beverages and Tobacco	0.07	0.47	0.45
Textile, Wearing Apparel and Leather Industries	0.19	0.29	0.53
Wood Products, Paper Products, Printing and Publishing	0.19	0.30	0.51
Products of Petroleum and Coal	0.05	0.19	0.76
Chemical, Plastic, and Rubber Products	0.15	0.38	0.47
Pottery, Glass, and other Non-metallic Mineral Products	0.23	0.38	0.39
Basic Iron, Steel, and Metal Products	0.15	0.24	0.61
Fabricated Metal Products and Professional and Scientific Equipment	0.21	0.35	0.44
Transport equipment	0.15	0.24	0.61
Other	0.21	0.34	0.45
Mean	*0.16*	*0.32*	*0.52*

Notes:

1 Labor share is caluclated as labor payments/output.

2 Captial Share is calculated as value added/output - labor share.

3 Intermediate share is 1-capital share-labor share.

Table 4.9
IV Regressions

	OLS (1)		IV (2)	
OLS and second stage IV estimates	coef	st error	coef	st error
relwage	-1.06	0.67	-5.60**	2.54
ustar	-9.18***	1.76	-7.61***	1.86
owntariff	-4.47**	2.18	-3.24	2.33
gsp status	-0.52**	0.20	-0.48**	0.19
ln relative TFP	1.32**	0.56	1.58**	0.65
capital share*ln relative credit to GDP	1.01***	0.25	1.17***	0.26
CUSFTA/NAFTA	0.56**	0.27	0.48*	0.28
country/industry dummies	yes		yes	
First stage IV estimates:				
ln relative labor supply			0.00	0.09
ln relative labor supply*labor share			-1.71***	0.63
ln relative population density			0.02	0.10
ln relative population density*labor share			2.65***	0.71
no obs	2341		2270	
Hausman Test (p-value)			0.0001	
Over-id test (p-value)			0.0121	
Linear Restrictions:				
HO: relwage=ustar=owntar (p-value)	0.0001		0.3157	
Accept or Reject at 1% level	Reject		Accept	
HO: ustar=owntar (p-value)	0.1197		0.1344	
Accept or Reject at 1% level	Accept		Accept	

Notes:
Measure for own tariff based on the simple average MFN.
Robust standard errors are clustered by country and industry.
***Significant at the 1% level
**Significant at the 5% level
*Significant at the 10% level

Table 4.10
Sensitivity analysis.

	No Nafta Countries (1)		Dropping Textiles (2)		Relative labor supply instead of relative wages (3)	
	coef	st error	coef	st error	coef	st error
relwage	-1.1	0.69	-0.56	0.76		
ustar	-7.16***	1.75	-7.95***	1.74	-9.96***	1.8
owntariff	-4.60**	2.23	-4.62*	2.38	-4.48**	2.12
gsp status	-0.49**	0.2	-0.62***	0.22	-0.49**	0.21
ln relative TFP	1.20**	0.58	1.19*	0.63	1.32**	0.54
capital share*ln relative credit to GDP	1.05***	0.26	0.88***	0.27	0.96***	0.24
CUSFTA/NAFTA			0.33	0.25	0.56**	0.26
ln relative labor supply					6.77*	3.99
country/industry fixed effects						
R2 (within)	0.04		0.05		0.06	
no obs	2202		2078		2341	
Linear Restrictions:						
HO: relwage=ustar=owntar (p-value)	0.0033		0.0004			
Accept or Reject at 1% level	Reject		Reject			
HO: ustar=owntar (p-value)	0.4027		0.3001		0.075	
Accept or Reject at 1% level	Accept		Accept		Accept	

Notes:
Measure for own tariff based on the simple average MFN.
Robust standard errors are clustered by country and industry.
***Significant at the 1% level
**Significant at the 5% level
*Significant at the 10% level

Table 4.11

Average predicted effect of tariff liberalization, by country

Country Name	Time Frame	$\hat{\beta}_2 \Delta ustariff$	$\hat{\beta}_3 \Delta owntariff$	Income[1]
Bangladesh	1989-2000	0.092	1.114	1
Bolivia	1993-2001	-0.041	0.008	1
China	1992-2001	0.100	0.460	1
Ghana	1993-2000	0.100	-0.018	1
India	1990-2001	0.094	0.711	1
Kenya	1994-2001	0.102	0.272	1
Malawi	1994-2001	0.102	0.295	1
Nepal	1993-2000	0.100	0.066	1
Nigeria	1989-2001	0.272	0.123	1
Pakistan	1995-2001	0.112	0.536	1
Tanzania	1993-2000	0.100	-0.005	1
Uganda	1994-2001	0.102	0.163	1
Algeria	1993-2001	0.101	0.038	2
Argentina	1992-2001	0.074	-0.011	2
Brazil	1989-2001	0.095	0.512	2
Cameroon	1994-2001	0.102	0.026	2
Chile	1992-2001	0.074	0.063	2
Colombia	1991-2001	0.120	-0.110	2
Costa Rica	1995-2001	-0.008	0.091	2
Ecuador	1993-1999	-0.044	-0.082	2
Egypt	1995-1998	0.096	0.164	2
El Salvador	1995-2001	-0.008	0.068	2
Gabon	1995-2001	0.254	0.008	2
Guatemala	1995-2001	-0.008	0.064	2
Honduras	1995-2001	-0.008	0.057	2
Indonesia	1989-2001	0.095	0.250	2
Ivory Coast	1993-2001	0.103	0.246	2
Jordan	2000-2001	0.003	0.138	2
Malaysia	1991-2001	-0.091	0.100	2
Mauritius	1995-1998	0.096	0.115	2
Mexico	1991-2001	0.174	-0.087	2
Morocco	1993-2001	0.103	0.478	2
Panama	1997-2001	0.010	0.126	2
Peru	1993-2000	-0.044	0.102	2
Philippines	1989-2001	0.095	0.416	2
Poland	1991-2001	0.079	0.006	2
South Africa	1990-2001	0.269	0.080	2
Sri Lanka	1990-2001	0.094	0.330	2
Thailand	1989-2001	0.095	0.409	2
Trinidad and Tobago	1991-2001	-0.026	0.211	2
Tunisia	1990-1998	0.079	-0.025	2
Turkey	1993-1999	0.099	0.070	2
Uruguay	1992-2001	0.074	-0.124	2
Venezuela	1992-2000	0.071	0.115	2
Greece	1989-2001	0.102	0.054	3
Hungary	1991-1997	0.067	0.049	3
Ireland	1989-2001	0.102	0.054	3
South Korea	1989-1999	0.094	0.127	3
Malta	1997-2000	0.009	0.001	3
New Zealand	1992-2000	0.092	0.136	3
Portugal	1989-2001	0.102	0.054	3
Taiwan	1989-2001	0.102	0.101	3
Australia	1991-2001	0.102	0.160	4
Austria	1990-2001	0.098	0.085	4
Belgium	1989-2001	0.102	0.054	4
Canada	1989-2001	0.336	0.124	4
Denmark	1989-2001	0.102	0.054	4
Germany	1989-2001	0.102	0.054	4
Finland	1992-2001	0.100	0.051	4
France	1989-2001	0.102	0.054	4
Iceland	1993-2001	0.101	0.019	4
Italy	1989-2001	0.102	0.054	4
Japan	1989-2001	0.102	0.046	4
Netherlands	1989-2001	0.102	0.054	4
Norway	1993-2001	0.101	0.069	4
Oman	1992-1997	0.062	0.038	4
Singapore	1989-2001	0.102	0.012	4
Spain	1989-2001	0.102	0.054	4
Sweden	1989-2001	0.102	-0.011	4
United Kingdom	1989-2001	0.102	0.054	4

Notes:

Sampled over observations with data for own country tariffs. Observations are average across industries.

1 All countries with 1989 per capita GDP (Constant 2005 dollars) <$3000

2 All countries with 1989 per capita GDP (Constant 2005 dollars) between $3000 and $10,000

3 All countries with 1989 per capita GDP (Constant 2005 dollars) between $10000 and $18,000

4 All countries with 1989 per capita GDP (Constant 2005 dollars) greater than $18,000

Table 4.12

Average predicted effect of tariff liberalization, by income group

Income Group	Δustariff	Δowntariff	$\hat{\beta}_2 \Delta ustariff$	$\hat{\beta}_3 \Delta owntariff$
Least Developed[1]	-0.01	-0.07	0.103	0.310
Lower Middle Income[2]	-0.008	-0.027	0.069	0.120
Upper Middle Income[3]	-0.009	-0.016	0.084	0.072
High Income[4]	-0.012	-0.013	0.112	0.057
Sample Average	-0.010	-0.029	0.088	0.131

Notes:

1 All countries with 1989 per capita GDP (Constant 2005 dollars) <$3000

2 All countries with 1989 per capita GDP (Constant 2005 dollars) between $3000 and $10,000

3 All countries with 1989 per capita GDP (Constant 2005 dollars) between $10000 and $18,000

4 All countries with 1989 per capita GDP (Constant 2005 dollars) greater than $18,000

Table A.1
Extenstive Margin Change at the HTS10 Level
Concorded according to Pierce and Schott (2009) mehodology: 11,778 manufacturing goods

Panel A: 1989-1999				
Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continulously traded goods[4]
Canada	9372	0.17	0.12	0.71
Mexico	7203	0.35	0.12	0.53
China	7791	0.40	0.07	0.53
Rest of the World	197095	0.34	0.21	0.45

Panel B: 1996-2006				
Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continulously traded goods[4]
Canada	9188	0.11	0.12	0.77
Mexico	7499	0.18	0.17	0.65
China	9608	0.35	0.03	0.62
Rest of the World	215452	0.32	0.19	0.48

Notes:
1. Number of goods exported either at the beginning or end of the time frame.
2. Number of goods exported at the end of the time frame but not the beginning.
3. Number of goods exported at the beginning but not the end of the time frame.
4. Number of goods exported both in the beginning and end of the time frame.

Table A.2
Extenstive Margin Change at the HTS10 Level, Consistently Defined Goods
Concorded according to Pierce and Schott (2009) mehodology and dropping redefined goods: 8,401 goods

Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continulously traded goods[4]
Panel A: 1989-1999				
Canada	6601	0.17	0.12	0.70
Mexico	5041	0.36	0.12	0.52
China	5443	0.40	0.07	0.53
Rest of the World	135218	0.33	0.22	0.45

Exporting Country/Group	All exported goods[1]	Newly traded goods[2]	Disappearing goods[3]	Continulously traded goods[4]
Panel B: 1996-2006				
Canada	6434	0.12	0.12	0.76
Mexico	5236	0.19	0.17	0.64
China	6753	0.36	0.03	0.61
Rest of the World	147037	0.33	0.19	0.48

Notes:
1. Number of goods exported either at the beginning or end of the time frame.
2. Number of goods exported at the end of the time frame but not the beginning.
3. Number of goods exported at the beginning but not the end of the time frame.
4. Number of goods exported both in the beginning and end of the time frame.

Table A.3
Probit estimates for the effect of Δln(1+tariff) on export status, 1989-1999
HTS 10 digit level, concorded according to Pierce and Schott (2009) mehodology

	Export Status A good is traded if there are positive exports to the US in 1999						Alternative Definition[1]
	Full Sample		Selected samples				
			Not traded in 1989[2]	Traded in 1989[3]	Upper Income[4]	Low Income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INDUSTRY	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	-0.38	-0.05	-0.07	0.04	-0.16	-0.03	-0.15**
Textiles	-0.89	-0.09	-0.03	0.16	-0.22	-0.15	-0.22*
Apparel	-3.52**	-0.92**	-0.43*	-1.05****	-1.75***	0.24	-1.08***
Other Articles	0.40	0.09	0.00	0.63***	0.28	-0.20*	-0.20
Wood/Paper	-1.95	-0.36	-0.14	-1.43	-70.00	0.33	-0.63
Minerals	-0.43	0.061	-0.24	0.07	-0.42	1.11*	-0.88
Chemicals	-2.92*	-0.3*	-0.17*	-1.27**	-0.64	0.00	-0.55**
Plastics/Rubber	-3.92	-1.16	-0.48	-1.13*	-1.40	-0.01	-1.83*
Pottery/China	-1.72	-0.39	-0.16	-0.30	-0.76	0.02	-0.72**
Iron/Steel	-3.44	-0.55	-0.33	0.45	-1.20	-0.01	-0.55
Nonferrous metal	-3.98*	-0.86*	-0.45**	-0.06	-1.63**	0.04	-1.55**
Machinery	-7.51**	-1.83**	-0.75**	-1.72**	-2.77**	0.01	-3.07***
Transportation	-7.14***	-0.82***	-0.45***	0.33	-2.23***	0.00	-1.91***
Other	-2.63	-0.61	-0.29	-0.51	-1.00	0.08***	-1.08*
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				23612			
disappearing goods if Δln(1+tariff)=0				24437			
disappearing goods due to tarrifs				-824			
new goods	40798		40781		32402	8406	44254
new goods if Δln(1+tariff)=0	39157		39054		30806	8457	42482
new goods due to tairffs	1641		1727		1596	-51	1772
tariff contribution	0.04		0.04	-0.03	0.05	-0.006	0.04

Notes:
1 A good is considered traded if there were positive exports in 1997, 1998, or 1999.
2 Country/good pairs that were exported in 1989 are omitted.
3. Country/good pairs that were not exported in 1989 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table A.4
Probit estimates for the effect of Δln(1+tariff) on export status, 1996-2006
HTS 10 digit level, concorded according to Pierce and Schott (2009) mehodology

	Export Status A good is traded if there are positive exports to the US in 2006						Alternative Defintion[1]
	Full Sample		Selected samples				
			Not traded in 1996[2]	Traded in 1996[3]	Upper income[4]	Low income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INDUSTRY	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	-0.24	-0.04	0.02	-0.37***	-0.14	0.19	-0.06
Textiles	0.04	0.01	-0.01	-0.03	-0.15	-0.03**	0.01
Apparel	-1.08	-0.33	-0.32	0.16	-0.02	-0.06	-0.46
Other Articles	0.28	0.08	0.02	0.16	-0.03	0.24**	0.04
Wood/Paper	-1.79	-0.40	-0.20	-1.01	1.46*	-0.11	-0.52
Minerals	-3.38	-0.45	-0.64*	3.53*	-0.41	-0.32*	0.14
Chemicals	-5.93***	-0.79***	-0.48***	-1.25**	-0.02	-0.03*	-1.14***
Plastics/Rubber	-7.11**	-2.30**	-1.02*	-1.29**	-0.14	-0.31	-2.82**
Pottery/China	-1.87	-0.52	-0.25	-0.56	-0.15	-0.03	-0.62
Iron/Steel	-7.65**	-1.44**	-0.74***	-0.42	-0.12	0.01	-1.81**
Nonferrous metal	-4.81***	-1.20***	-0.66***	-0.43	0.12	0.00	-1.52***
Machinery	-10.06***	-2.91***	-1.43***	-1.43**	-0.54	-0.26*	-3.42***
Transportation	-4.25*	-0.70*	-0.50*	-0.23	0.54	0.02	-1.27**
Other	-5.87***	-1.87***	-1.12**	-0.53	-0.97	0.03	-1.74**
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				23910			
disappearing goods if Δln(1+tariff)=0				24794			
disappearing goods due to tarrifs				-884			
new goods	40279		40339		31128	9312	41308
new goods if Δln(1+tariff)=0	36532		35544		30705	8837	37731
new goods due to tairffs	3747		4795		423	475.004	3577
tariff contribution	0.09		0.12	-0.04	0.01	0.05	0.09

Notes:
1 A good is considered traded if there were positive exports in 2004, 2005, or 2006.
2 Country/good pairs that were exported in 1996 are omitted.
3. Country/good pairs that were not exported in 1996 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table A.5
Probit estimates for the effect of Δln(1+tariff) on export status, 1989-1999
HTS 10 digit level, consistently defined goods

	Export Status: A good is traded if there are positive exports to the US in 1999						Alternative Definition[1]
	Full Sample		Selected samples				
			Not traded in 1989[2]	Traded in 1989[3]	Upper Income[4]	Low Income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INDUSTRY	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	-1.02*	-0.13*	-0.12**	0.09	-0.27**	-0.10	-0.23*
Textiles	-0.94	-0.09	-0.05	0.53	-0.22*	-0.17	-0.26*
Apparel	-2.62**	-0.71**	-0.26*	-1.13***	-1.35***	0.39	-0.89***
Other Articles	0.15	0.03	0.00	0.57**	0.24	-0.21**	-0.17
Wood/Paper	-3.50	-0.61	-0.15	-3.12***	-1.11	-0.18	-1.50*
Minerals	1.32	0.15	0.05	2.77	0.45	0.41	-0.93
Chemicals	-2.78*	-0.29*	-0.16*	-1.35*	-0.63	0.00	-0.56**
Plastics/Rubber	-3.24	-0.86	-0.40	-0.71	-1.27	0.03	-1.43
Pottery/China	-2.25*	-0.52*	-0.23*	-0.32	-0.83	0.02*	-0.94**
Iron/Steel	-5.47**	-0.79**	-0.50**	1.06	-1.70*	-0.01	-0.82
Nonferrous metal	-4.13**	-0.88**	-0.51**	0.28	-1.71**	0.11***	-1.65***
Machinery	-6.89**	-1.53**	-0.65**	-1.65**	-2.39**	0.02	-2.71***
Transportation	-7.73***	-0.67***	-0.42***	1.14	-1.86***	0.01	-1.55***
Other	-2.49	-.55	-0.25	-0.63	-0.92	0.06	-1.02
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				16539			
disappearing goods if Δln(1+tariff)=0				17034			
disappearing goods due to tarrifs				-495			
new goods	28319		28314		22607	5723	30875
new goods if Δln(1+tariff)=0	27219		27117		21553	5756	29605
new goods due to tairffs	1100		1197		1055	-32.83456	1270.908
tariff contribution	0.04		0.04	-0.03	0.05	-0.01	0.04

Notes:
1 A good is considered traded if there were positive exports in 1997, 1998, or 1999.
2 Country/good pairs that were exported in 1989 are omitted.
3. Country/good pairs that were not exported in 1989 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Table A.6
Probit estimates for the effect of Δln(1+tariff) on export status, 1996-2006
HTS 10 digit level, consistently defined goods

	Export Status: A good is traded if there are positive exports to the US in 2006						Export Status: Alternative Defintion[1]
	Full Sample		Selected samples: Not traded in 1996 [2]	Traded in 1996[3]	Upper income[4]	Low income[5]	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INDUSTRY	coefficient	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect	marginal effect
Food/Bev/Tobacco	0.68	0.11	0.09	0.10	0.24	0.12	-0.25**
Textiles	1.04	0.14	0.07	0.47	0.06	-0.01	-0.22**
Apparel	-1.08	-0.35	-0.33**	0.13	-0.04	-0.11	-0.87***
Other Articles	0.18	0.05	0.01	0.19	0.04	0.22	-0.17
Wood/Paper	-0.99	-0.22	-0.29	0.13	1.74*	0.49	-1.45*
Minerals	-10.47	-1.20	-1.08*	-2.65	-0.78	-0.92*	-0.91
Chemicals	-6.03***	-0.83***	-0.54***	-1.25**	-0.17	-0.05*	-0.51**
Plastics/Rubber	-5.24*	-1.55*	-0.75	-1.07	0.33	-0.01	-1.37
Pottery/China	-1.24	-0.36	-0.21	-0.16	0.18	-0.06	-1.01***
Iron/Steel	-6.98**	-1.26**	-0.68**	-0.04	0.02	0.04	-0.75
Nonferrous metal	-4.61***	-1.12***	-0.65***	-0.74	0.17	0.07	-1.52**
Machinery	10.10***	-2.71***	-1.40***	-1.47*	-0.54	-0.17	-2.58***
Transportation	-1.63	-0.22	-0.17	-1.18	0.38	0.18**	-1.37***
Other	-5.50***	-1.72***	-1.11**	-0.71	-1.13	0.09	-1.11*
Goods Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Model Predictions:							
disappearing goods				16890			
disappearing goods if Δln(1+tariff)=0				17181			
disappearing goods due to tarrifs				-291			
new goods	29914		29957		22522	7491	32637
new goods if Δln(1+tariff)=0	28046		27312		22534	7354	31331
new goods due to tairffs	1868		2645		-12	136.4386	1306.293
tariff contribution	0.06		0.09	-0.02	0.00	0.02	0.04

Notes:
1 A good is considered traded if there were positive exports in 2004, 2005, or 2006.
2 Country/good pairs that were exported in 1996 are omitted.
3. Country/good pairs that were not exported in 1996 are omitted.
4 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars greater than $7,600.
5 Sample inlcudes only countries with 1989 Real GDP in 2005 dollars less than $7,600.
Robust standard errors clustered by country.
* Indicates significance at the 10% level.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.

Figure 2.1: Share of Newly Traded Goods in 1999 Exports: Quantity Share

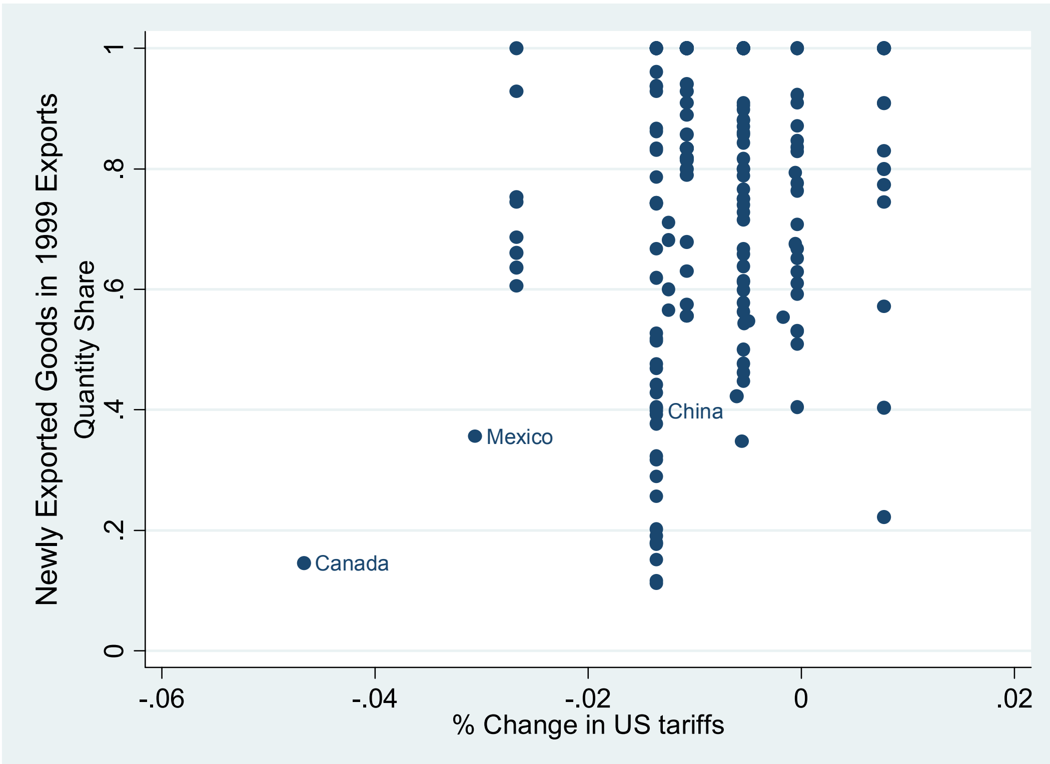


Figure 3.1: Average Share of Exported Goods vs. per capita GDP

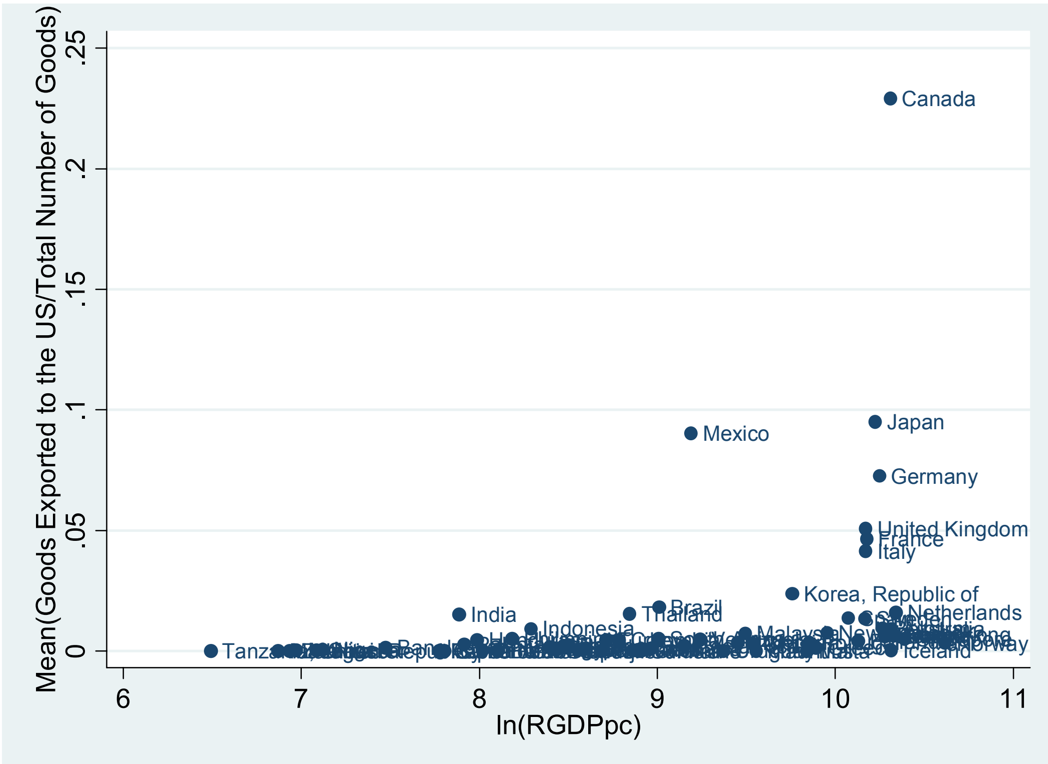


Figure 3.2 Average Share of Exported Goods vs. GDP

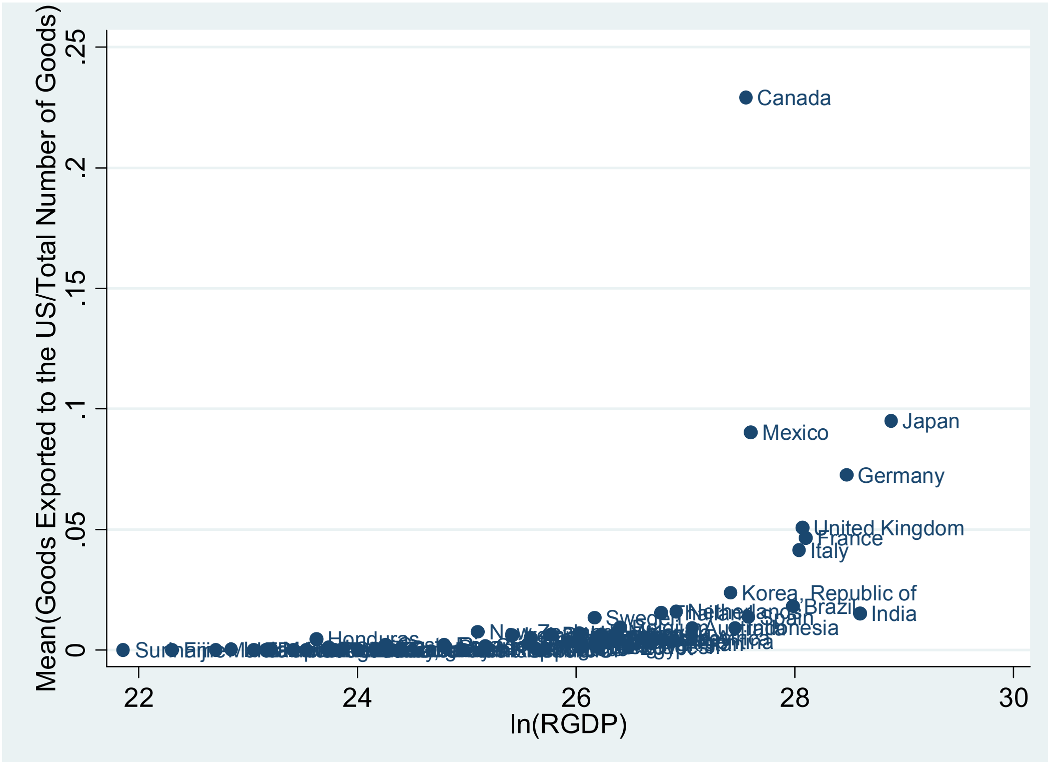


Figure 3.3 Average Share of Exported Goods vs. U.S. Import Tariff

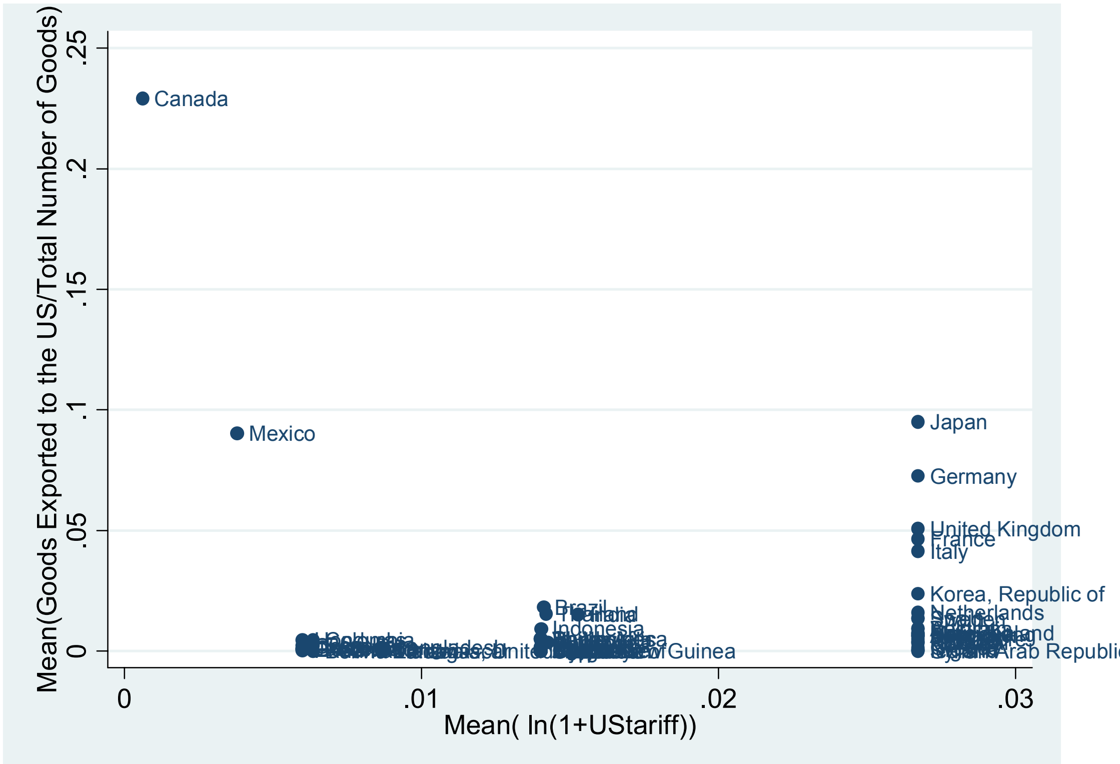


Figure 3.4 Distribution of Intermediate Cost Share

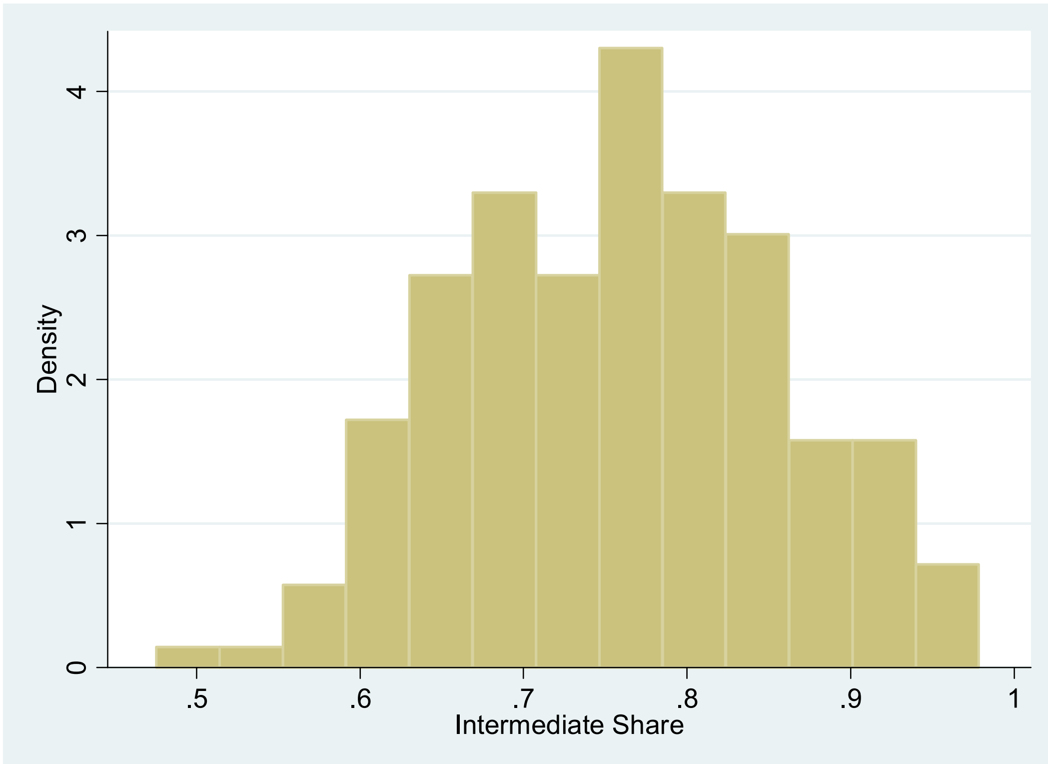


Figure 3.5 Distribution of 1 minus Herfindahl Index

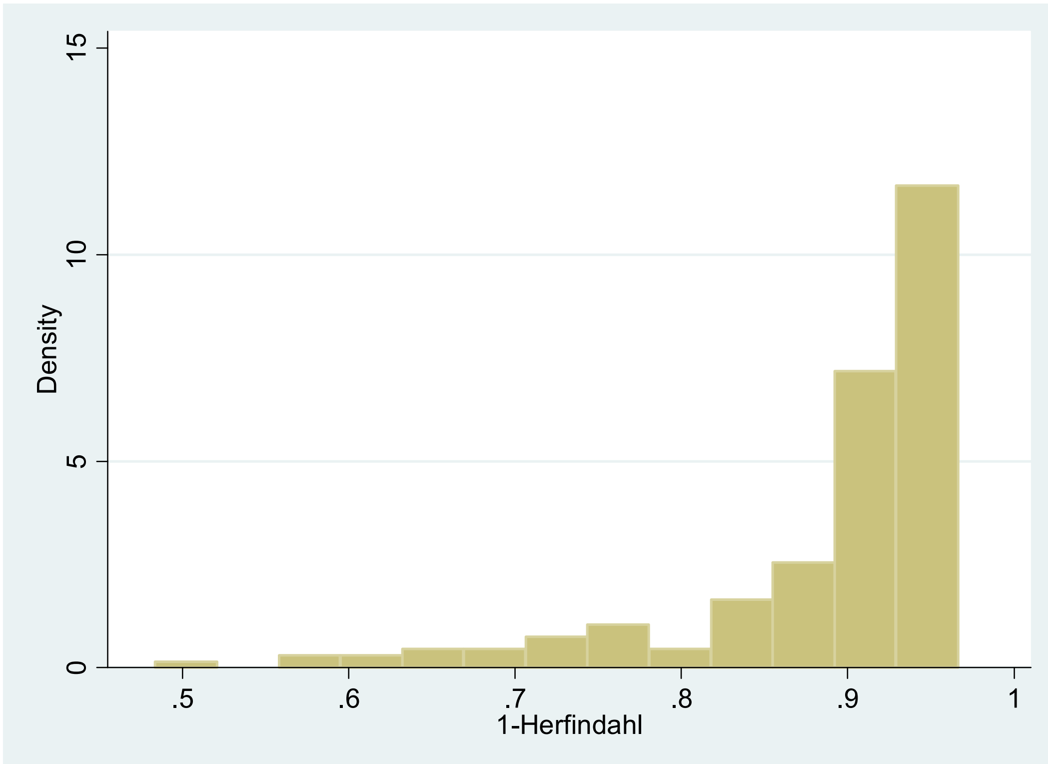


Figure 3.6 Distribution of Grubel-Lloyd Index

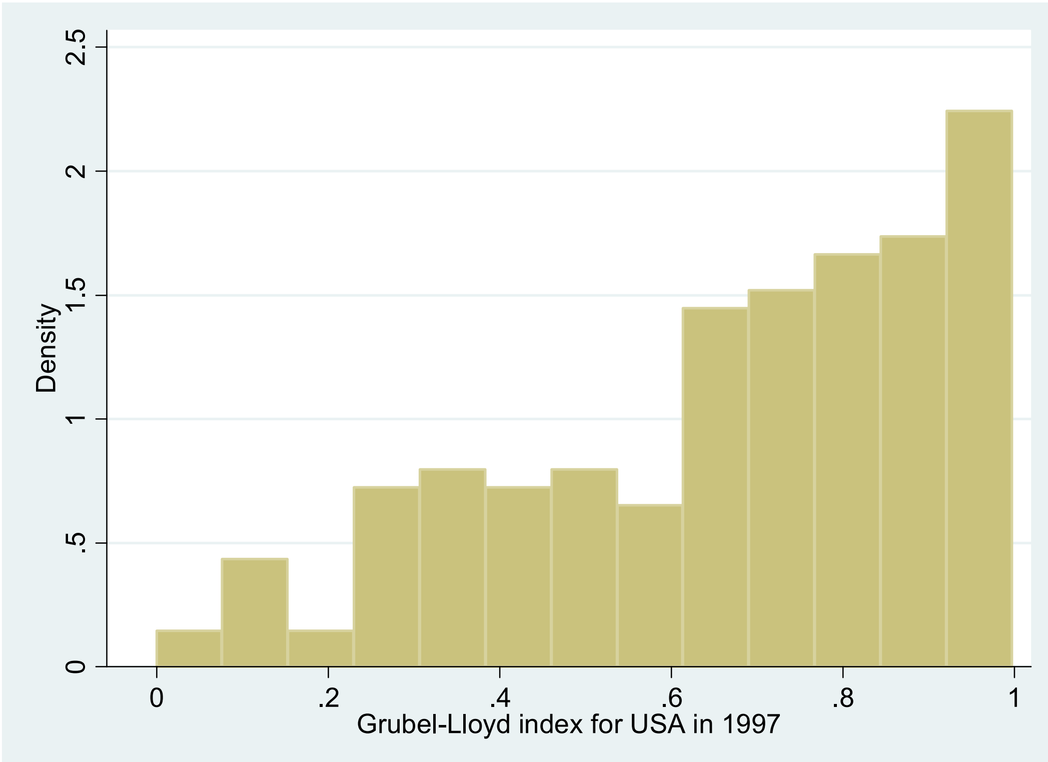
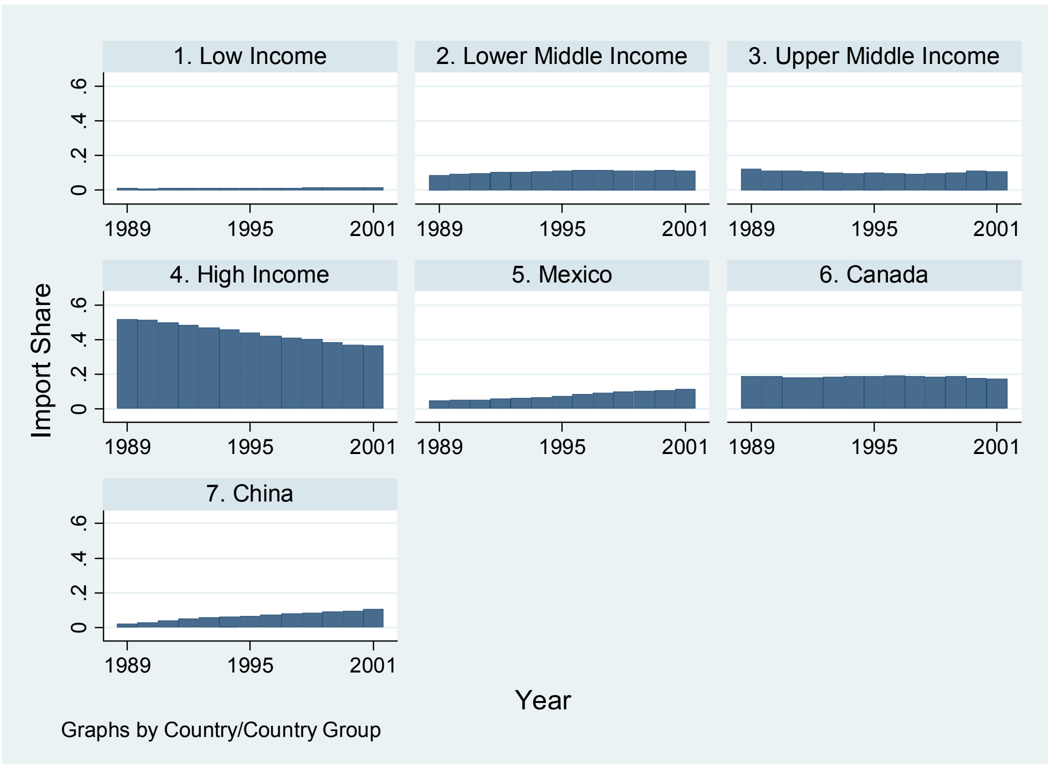


Figure 4.1: Distribution of U.S. Import Shares 1989-2001



Appendix A

A.1. Data Concordance

The analysis performed in Chapter 2 documents the importance of new goods being exported, the so-called extensive margin, and quantifies the importance of tariff liberalizations in stimulating this type of trade. Data are first collected at a disaggregate level: disaggregate trade data (defined at the ten-digit Harmonized System level) and tariff data (defined at the eight-digit Harmonized System level) to define distinct goods. As Pierce and Schott (2009) note, frequent changes have been made to the U.S. import codes at the ten-digit level. The strategy for dealing with this inconsistency in the coding system is to only consider goods that were consistently coded over the sample period. Furthermore the analysis is conducted at the 6 digit level. In this appendix, it is shown that this aggregate focus on non-reclassified goods is without loss of generality. In particular, similar results are obtained by performing the analysis at the more disaggregate level, both with and without goods that underwent a reclassification.

Based on annual Census publications documenting goods' classifications that become obsolete and the new codes that take their place, Pierce and Schott (2009) formulate a methodology for concording goods over time. This methodology assigns a common synthetic code to all ten-digit Harmonized System codes that either emanated from a single code (a growing family tree) or that were consolidated into a single code (a shrinking family tree) over time. The same methodology for concording goods categories over time is employed in this analysis to get a single set of Harmonized System level codes that are consistent from 1989 to 2007. Note that because of how goods' codes are renumbered a 6-digit analysis that would include reclassified goods is not feasible. Many of the goods categories that were redefined over the sample period were put into categories that belonged to different 6-digit codes. Therefore, attempting to keep redefined goods and to aggregate to the 6 digit level would result in a much more aggregate specification than the 6 digit level.[81]

In the next section it is show how all descriptive statistics and regressions at this more disaggregate level are consistent with the 6-digit analysis employed in the paper.

A.2 Descriptive Statistics and Probit Analysis 10-Digit Level

When including all goods and focusing on the more disaggregate data, one still finds significant extensive margin change. In Table A.1, Panel A reports the importance of new trade for all 10-digit goods properly concorded, a total of 11,778 goods, between 1989 and 1999. In Panel B the same analysis is performed for the time period 1996-2006. Finally Table A.2 includes the same analysis at the 10-digit level, but focuses only on goods that were consistently defined leaving a total of 8,401 goods. As can be seen, the importance of new trade is consistent across the different samples and similar in magnitudes to those presented in the paper at the 6-digit level.

The fixed effect-probit model estimates are also consistent for the 10-digit samples with and without reclassified goods for both periods: 1989-1999 and 1996-2006.

[81] For a simple example, consider the 10-digit goods: 0101100010, 0101110010, and 0101201000 which all belong to the same synthetic code. Each one has a separate 6-digit code: 010110, 010111, and 010120. Furthermore, to be consistent all goods with these same 6-digit codes would have to be aggregated, and consequently so would any goods within these 6-digit codes that were associated with other synthetic codes.

Tables A.3 and A.4 include the results for the full sample, and Tables A.5 and A.6 include the results for the samples including only the consistently defined goods.[82] As one can see, the results are quantitatively and qualitatively similar for both10-digit datasets, indicating that dropping reclassified goods does not introduce a bias. In addition, the results are broadly consistent with the findings at the 6-digit level goods reported in Chapter 2, but marginally less statistically significant.

A.3 Sample of countries

Countries included in both the descriptive statistics and the regression analysis, ordered approximately by GDP per capita in 1999, are Norway, Switzerland, Singapore, the Netherlands, Australia, Canada, Denmark, Ireland, Belgium, Germany, Japan, France, Italy, the United Kingdom, Spain, Macao, New Zealand, Taiwan, Greece, Cyprus, Portugal, Saudi Arabia, South Korea, Mauritius, Chile, Malaysia, Trinidad and Tobago, Argentina, Poland, Mexico, Brazil, Jamaica, Colombia, El Salvador, Ecuador, Jordan, China, Indonesia, the Philippines, Bolivia, Ivory Coast, Pakistan, Guyana, Kenya, Senegal, Benin, Nigeria, Malawi, Tanzania, and the Democratic Republic of the Congo.

Additional Countries included in the descriptive statistics but not the regression analysis are Qatar, Luxembourg, Brunei, Bermuda, the United Arab Emirates, Kuwait, Liechtenstein, Austria, Hong Kong, Iceland, Christmas Island, Cocos Island, Norfolk

[82] For the 10-digit specification, the data are divided into 14 industries because of the large number of goods in the Textile/Apparel/ Other category.

Island, Greenland, Andorra, San Marino, Vatican City, Sweden, Finland, the Bahamas, Gibraltar, Aruba, the Netherlands Antilles, Barbados, Oman, French Polynesia, Israel, the Cook Islands, Niue, Tokelau, Bahrain, Malta, the British Indian Ocean Territory, Seychelles, New Caledonia, Antigua and Barbuda, Grenada, Palau, the Falkland Islands, Hungary, Uruguay, St. Lucia, Anguilla, the British Virgin Islands, Guadeloupe, Martinique, Montserrat, St. Kitts and Nevis, Venezuela, Costa Rica, Gabon, South Africa, the Cayman Islands, the Turks and Caicos Islands, Lebanon, Belize, Tunisia, the Dominican Republic, St. Pierre and Miquelon, French Guiana, Suriname, Panama, Thailand, Botswana, the Marshall Islands, Swaziland, Tonga, Turkey, Fiji, Nauru, Guatemala, Vanuatu, Cape Verde, Namibia, Algeria, Dominica, Djibouti, Peru, Paraguay, Morocco, Egypt, Western Samoa, Sri Lanka, St. Vincent and the Grenadines, Sao Tome and Principe, the Republic of the Congo, Guinea, Angola, the Maldives, Zimbabwe, Honduras, the Federated States of Micronesia, Bhutan, India, Syria, Cameroon, Papua New Guinea, Kiribati, Pitcairn Island, Mauritania, Comoros, Reunion, Bangladesh, Nepal , Lesotho, Haiti, the Solomon Islands, Chad, Sudan, the Gambia, Mozambique, Ghana, St. Helena, Sierra Leone, Mali, Burkina, Uganda, Zambia, Togo, Madagascar, Rwanda, the Central African Republic, Niger, Burundi, Guinea-Bissau, Somalia, and Liberia.

A.4 Predicted Net Contribution of U.S. Tariff Changes

The predicted net contribution of U.S. tariff changes to extensive margin growth is calculated as $\frac{\sum_i \sum_{z \in Z'} (\Phi(X_{iz}^{'}\hat{B}) - \Phi(X_{iz}^{'}\hat{B} \mid \Delta \ln ustar = 0))}{\sum_i \sum_{z \in Z'} \Phi(X_{iz}^{'}\hat{B})}$ where Z' comprises all goods not exported in 1989.

A.5 Expected Share of Disappearing Goods

The expected share of disappearing goods that can be explained by tariffs is calculated $\frac{\sum_i \sum_{z \in Z''} ((1 - \Phi(X_{iz}^{'}\hat{B}) - (1 - \Phi(X_{iz}^{'}\hat{B} \mid \Delta \ln ustar = 0)))}{\sum_i \sum_{z \in Z''} (1 - \Phi(X_{iz}^{'}\hat{B}))}$, where Z'' comprises all goods exported in 1989.

Appendix B

B.1 Measuring Intermediate Cost Shares

The World Bank's *Trade and Production Database*, provides country and industry specific input-output (IO) tables. For the analysis in Chapter 4 intermediate cost shares in each industry are constructed from the U.S. IO tables. Given data on the intermediate shares α_{KJ} the measurement of the intermediate tariff would be straightforward; however, what is observed in the World Bank data is the value of a sector needed to produce one unit of another sector. In other words, we observe λ_{KJ} such that product $\lambda_{KJ} X_K$ is the value needed of *J* to produce *X* units of *K*. This implies that the value share given by $\alpha_{KJ} = P_J X_J / P_K X_K = \lambda_{KJ} X_K / P_K X_K$ or rearranging,

(C.1) $\lambda_{KJ} = \alpha_{KJ} P_K$

Dividing through by the summation of λ across all intermediates *J*,

(C.2) $\lambda_{KJ} / \sum_J \lambda_{KJ} = \alpha_{KJ} P_K / \sum_J \lambda_{KJ} = \alpha_{KJ} P_K / (P_K \sum_J \alpha_{KJ}) = \alpha_{KJ} / (1 - \alpha_{KL})$

Therefore,

(C.3) $\alpha_{KJ} = (1 - \alpha_{KL}) \frac{\lambda_{KJ}}{\sum_J \lambda_{KJ}}$

Therefore, given labor's share, we have

(C.4) $\alpha_{KJ} = (1 - \alpha_{KL}) \frac{\lambda_{KJ}}{\sum_J \lambda_{KJ}}$

Therefore, in (4.25),

(C.5) $\sum_J \alpha_{KJ} \ln(1 + \tau_{iK}) = \alpha_{KJ} = \frac{(1 - \alpha_{KL})}{\sum_J \lambda_{KJ}} \sum_J \lambda_{KJ} \ln(1 + \tau_{iK})$

is the estimate of the intermediate tariff country *i* pays in sector *K*. Essentially this is a weighted average of tariffs imposed on all sectors where the weights are the intermediate costs shares of each sector in *K*'s production.

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Vita

Shalah Mostashari attended St. Andrew's-Sewanee High School, Sewanee, Tennessee. In 1988 she entered Hollins University in Roanoke, Virginia, where in 1992 she received a Bachelor of Arts in English and Economics. In August 2000, she entered the Graduate School of The University of Texas at Austin, where she earned a Master of Science in 2002. While at The University of Texas at Austin, she worked as a Teaching Assistant and as an Assistant Instructor. She also worked as an Assistant Instructor at Texas A&M University in College Station, Texas during her last three years as a graduate student.

Permanent Address: 1510 Payne Ave, Austin, Texas 78757

This manuscript was typed by the author.