

**Trade Liberalization and Export Variety:
A Comparison of Mexico and China**

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1. INTRODUCTION

The hallmark of the endogenous growth models (Romer 1990, Grossman and Helpman, 1991) is their focus on the creation of new or higher quality products, and the effects of such innovations on productivity and economic growth. Opening a country to trade opportunities due to tariff reductions will typically increase the product variety of imports available, and may also increase the variety of exports, both of which contribute to growth. Despite the microeconomic focus of these models, the link between trade and growth is usually assessed at a more aggregate level, in which case the causality between the two is unclear (Frankel and Romer, 1999, Dollar and Kraay, 2001, Rodriguez and Rodrik, 2000). To move beyond these aggregate statistics, we need more detailed information on the *product variety* of traded goods, and on the link between tariff reductions and product variety.

The issue of measuring product variety has received relatively little attention due to its inherent difficulty. In the language of index numbers, an expansion in the range of inputs or outputs is a “new goods” problem: a good that is newly available will have an observed price and quantity, but no corresponding price or quantity the year before. The availability of this new good will yield a welfare gain to consumers, as well as a productivity gain to firms buying the new input. In this paper we show how product variety can be measured in the case of a CES aggregator function. We apply these results to the measurement of export variety from China and Mexico to the US.

The application to China and Mexico is motivated by the changes in trade policy facing those countries in recent years. Mexico joined the North America Free Trade Area (NAFTA) in 1994, which substantially lowered its tariffs to the US and Canadian markets. What has happened to Mexico’s export variety since that time? Kehoe and Ruhl (2002) argue that goods from Mexico

that were the least traded before tariff liberalization account for a disproportionate growth in trade following the reduction of trade barriers. We will also document the expansion in export varieties from Mexico due to NAFTA. Similarly, while China was accepted into the WTO in 2000, it was implementing unilateral tariffs reductions of its own before that time and benefiting from low tariffs abroad. We will investigate the growth in export variety from China over 1990-2001, and compare those findings to Mexico. In addition, we will argue that the expansion of China's export variety due to the fall of US tariffs has caused an adverse market competition effect on the export variety from Mexico.

This paper is organized as follows. After reviewing the literature on the "new goods" problem in section 2, we discuss how to measure export variety in the CES case in section 3. In sections 4 and 5 we discuss the empirical applications to export variety growth in Mexico and China. Regression results relating trade liberalization to industry export variety are presented in section 6, and conclusions are given in section 7.

2. LITERATURE REVIEW

a. Theoretical Results

The problem of computing welfare gains for a consumer due to new goods is very similar to evaluating the productivity gains for a firm with new inputs. Hick's (1940) recommended one solution to this problem: a newly available good should be evaluated at its *reservation price* when it is not available, where demand is zero. When the new good becomes available then demand is positive and so its price is lower than the reservation price. Thus, the fall in prices can be computed as the difference between the reservation and observed prices, and integrating the demand curve between these prices is a measure of the consumer welfare gain, or firm productivity gain, due to the new good. Examples of this approach applied empirically include

Griliches and Cockburn (1994) and Berndt et al. (2002) for generic drugs, and Hausman (1997, 1999) for breakfast cereals and cellular telephones.

The productivity gain from a new input for a firm is illustrated in Figure 1. Given output $y_t = \bar{y}_t$, the inputs would lie along an isoquant ACD like that illustrated. If only input 1 is available, then the costs of producing \bar{y}_t would be minimized at point A, with the budget line AB. But if input 2 is also available, then the costs are instead minimized at point C, with a *fall* in costs. This illustrates the benefits of input variety.

The difficulty with applying this solution in practice is that reservation prices are not that easy to estimate, especially when there are many new goods appearing. A simpler solution is proposed by Feenstra (1994) for that case where new goods appear within a CES aggregator function (i.e. a production function for firms, expenditure function for consumers, or production possibility frontier for an economy). Suppose that the elasticity of substitution between the goods is $\sigma > 1$. In that case, the reservation price for any good is infinite: the isoquants of the firm hit the axis in Figure 1 with slope zero (at point A) and infinity (at point D). But the total reduction in costs due to the new input can still be computed. Suppose that the set of inputs available to the firm each period is I_t , $t = 0, 1$, with the common set $I \equiv (I_0 \cap I_1) \neq \emptyset$. Feenstra (1994) shows that costs fall due to the appearance of new inputs by the amount:

$$\left(\frac{\lambda_1(I)}{\lambda_0(I)} \right)^{1/(\sigma-1)}, \quad (1)$$

where the values $\lambda_t(I)$ are constructed as:

$$\lambda_t(I) \equiv \left(\frac{\sum_{i \in I} p_{it} x_{it}}{\sum_{i \in I_t} p_{it} x_{it}} \right) = 1 - \left(\frac{\sum_{i \in I_t, i \notin I} p_{it} x_{it}}{\sum_{i \in I_t} p_{it} x_{it}} \right), \quad t = 0, 1. \quad (2)$$

In these expressions, I_t denotes the set of inputs available in periods $t = 0, 1$, at the prices p_{it} and with cost-minimizing quantities x_{it} . New goods will be in the set I_1 but not I_0 , whereas disappearing goods are in the set I_0 but not I_1 . From (2), each of the terms $\lambda_t(I) \leq 1$ can be interpreted as the *period t expenditure on the goods in the set I relative to total expenditure in that period*. Alternatively, this can be interpreted as *one minus the share of period t expenditure on “new” goods (not in the set I)*. When there is a greater number of new goods in period t , this will lower the value of $\lambda_t(I)$. Notice that the ratio $[\lambda_1(I)/\lambda_0(I)]$ in (1) is raised to the power $1/(\sigma - 1)$, so with $\sigma > 1$ a lower value of $\lambda_1(I)$ due to new inputs will *reduce* the ratio in (1), by an amount depending on the elasticity of substitution.

While (1) measures the reduction in costs due to the appearance of new inputs, the term $[\lambda_1(I)/\lambda_0(I)]$ itself is an *inverse* measure of product variety: when $[\lambda_1(I)/\lambda_0(I)] < 1$ then there are more “new” than “disappearing” goods, and product variety is expanding. By simply inverting this term, we obtain a direct measure of product variety that can be implemented using data on observed expenditures on goods. There are several applications of this method to measuring the variety of traded goods, as discussed in the next section.

Before turning to these applications, note that the formulas in (1) and (2) cannot be applied when $0 \leq \sigma \leq 1$, because in that case inputs are *essential* to the production process, and having zero of any input results in zero output. So we cannot even consider “new goods” in that case. However, these formulas are still relevant when $\sigma < 0$. That case applies to measuring the benefits from *output variety* for an economy. This is illustrated in Figure 2, where we show the production possibility frontier (PPF) between two output varieties x_{1t} and x_{2t} . For a given PPF, and given prices, an increase in the number of output varieties will raise revenue. For example, if only

output variety 1 is available, then the economy would be producing at the corner A, with revenue shown by the line AB. Then if variety 2 becomes available, the new equilibrium will be at point C, with an *increase* in revenue. When $\sigma < 0$, then (1) measures the increase in revenue due to the appearance of new outputs, and the ratio $[\lambda_1(I)/\lambda_0(I)]$ is an inverse measure of output variety.

b. Empirical Applications

There are several studies that measure the benefits of input or output variety in raising productivity. Feenstra et al. (1999) provide an application of this method to industry productivity growth in South Korea and Taiwan. The data used to measure variety are the disaggregate *exports* from these countries to the United States. Those authors analyze the relationship between changes in export variety and the growth in TFP across South Korea and Taiwan, for sixteen sectors over 1975-1991. They find that changes in relative export variety (entered as either a lag or a lead) have a positive and significant effect on TFP in nine of the sixteen sectors. Seven of these sectors are classified as secondary industries, in that they rely on as well as produce differentiated manufactures, and therefore seem to fit the idea of endogenous growth. Among the primary industries, which rely more heavily on natural resources, the authors find mixed evidence: the correlation between export variety and productivity can be positive, negative, or insignificant. In addition, the authors also find evidence of a positive and significant correlation between *upstream* export variety and productivity in six downstream sectors, five of which are secondary industries.

Funke and Ruhwedel (2001) have applied the same measure of product variety to analyze economic growth across the OECD countries. Using a panel dataset of 19 countries over 1989-1996, they find that a country's export variety relative to the US is a significant determinant of its GDP per-capita. Notice that these measures of product variety, which are constructed from highly disaggregate trade data, are unlikely to suffer from the endogeneity problem that plagues

aggregate trade flows (as discussed by Frankel and Romer, 1999). Therefore, the construction of product variety indexes and their correlation with TFP offers an alternative way to assess the importance of trade in economic growth.

More recently, Hummels and Klenow (2005) decompose the growth of world trade into that part due to countries exporting new products – what they call the “extensive margin” – and that part due to countries exporting more of the same products – the “intensive margin.” They find that extensive margin accounts for two-thirds of the greater exports of larger economies, and one-third of their imports. In another application, Broda and Weinstein (2005) measure the impact on welfare for the importer. For the United States, they find that the upward bias in the conventional import price index (due to ignoring product variety) is approximately 1.2 per cent per year, implying that the welfare gains from cumulative variety growth in imports are 2.8 per cent of GDP in 2001. Finally, Feenstra and Kee (2006) estimate the impact of export variety on productivity growth for a group of countries, and Broda, Greenfield and Weinstein (2006) show how import variety is related to country productivity.

3. MEASURING EXPORT VARIETY

Our results above have been stated in terms of changes in product variety over time. But the same results apply to a comparison of two countries at a point in time. Suppose that the set of exports from countries a and c differ, but have some product varieties in common. Denote this common set by $I \equiv (I_t^a \cap I_t^c) \neq \emptyset$. Rewriting (2), an inverse a measure of export variety from country c relative to country a is:

$$\frac{\lambda_t^c(I)}{\lambda_t^a(I)} \quad \text{where,} \quad \lambda_t^c(I) \equiv \frac{\sum_{i \in I} p_{it}^c q_{it}^c}{\sum_{i \in I_t^c} p_{it}^c q_{it}^c} . \quad (3)$$

Notice that $\lambda_t^c(I) \leq 1$ in (3) due to the differing summations in the numerator and denominator.

This term will be strictly less than one if there are goods in the set I_t^c that are *not found* in the common set I . In other words, if country c is selling some goods in period t that are not sold by country a , this will make $\lambda_t^c(I) < 1$, so it is an inverse measure of country c export variety.

The ratio $[\lambda_t^c(I) / \lambda_t^a(I)]$ is an inverse measure of export variety from country c relative to country a . Taking the reciprocal, we shall measure $[\lambda_t^a(I) / \lambda_t^c(I)]$ using exports of Mexico and China to the United States. While it would be preferable to use their worldwide exports, our data for the US are more disaggregate and allows for a finer measurement of “unique” products sold by one country and not another. Specifically, for 1989-2001 we shall use the 10-digit Harmonized System classification of imports.

To measure the ratio $[\lambda_t^a(I) / \lambda_t^c(I)]$, we need a consistent comparison country. For this purpose, we shall use the *worldwide exports* from all countries to the US as the comparison, which are also *averaged over years*. Denote this comparison country by a , so that the set $I^a \equiv \bigcup_{c,t} I_t^c$ is the *total set of varieties* imported by the US in over all years, and $p_i^a q_i^a$ is the *average value of imports* for product i (summed over all source countries and averaged across years). By aggregating across countries and over time, we obtain a consistent comparison set of good I^a that does not itself vary over time.¹

When comparing country c to the “aggregate” country a , it is immediate that the common

¹ In contrast, Feenstra and Kee (2004) measure export variety each year relative to the set of products imported into the US that year, which can lead to inconsistent cross-year comparisons.

set of goods exported is $I \equiv I_t^c \cap I^a = I_t^c$, or simply the set of goods exported by country c .

Therefore, from (3) we have that $\lambda_t^c(I_t^c) = 1$, and:

$$\text{Variety}_t^c \equiv \frac{\lambda_t^a(I_t^c)}{\lambda_t^c(I_t^c)} = \frac{\sum_{i \in I_t^c} p_{it}^a q_{it}^a}{\sum_{i \in I^a} p_{it}^a q_{it}^a}. \quad (4)$$

Notice that the denominator on the right of (4) is total US imports, summed over all products and countries, but using *average* import values over time. The numerator equals the value of imports in products that country c sells to the U.S., again summed over all source countries and averaged over time. This expression for the export variety of country c , Variety_t^c is therefore interpreted as the *share of total US imports from products that are exported by country c* . Note that this measure depends on the *set of exports* by country c , I_t^c , but not on its value of exports (except insofar as they affect the value of worldwide exports). In the following sections we document export variety from Mexico and China to the US, as measured by (4) over 1990-2001. We also discuss how tariffs have changed for those countries, and statistically relate the change in export variety to the change in tariffs.

4. MEXICO'S EXPORT VARIETY: 1990 VERSUS 2001

We break down the aggregate exports of Mexico to US into seven major groups and construct the export variety indexes of these seven industries according to (4). Table 1 presents the indexes of these industries in 1990 and 2001 to illustrate the variation across industries and years. In agriculture, for example, Table 1(a) shows that in 1990 Mexico exported 42 per cent of all the product varieties that the US imported (from any country). That share increased to 51 per cent in 2001, for an annual average growth rate of 1.8 per cent. During the same period, the

export variety from Mexico in the textiles and garments industry increased by 1.4 per cent annually, from covering 71 per cent of all varieties imported by the US in 1990 to 83 per cent in 2001.

The highest growth rate of variety is in the electronics industry, where in 1990 only 40 per cent of US imports were from products exported by Mexico, and in 2001 that share is 66 per cent. This represents an average annual growth rate of 4.6 per cent. On the other hand, the slowest growth of export variety is observed in the machinery and transport industry, with an annual growth rate of 1.3 per cent. That industry along with textiles and garments already had high export variety in 1990, which limited their future growth in variety. By contrast, export variety in the mining and basic metals industry is among the lowest among all non-agriculture industries in both years. Exports in that industry covered 47 per cent of the varieties in US imports in 1990, and increased to 56 per cent in 2001.

In summary, over the past decade Mexico has expanded its export variety across a range of different industries. Averaging over the industries, 67 per cent of US import varieties in 2001 are from products which Mexico exports, whereas that share was 52 per cent in 1990. Could trade liberalization explain the expansions in export variety of Mexico over this sample period? Given that Mexico joined the North America Free Trade Area (NAFTA) in 1994, we can compare the average variety within each industry before and after 1994 to identify the NAFTA effect on export variety. Figure 3 presents the average variety indexes pre and post-1994 in each of the seven industries. At the industry level, the increases range from 5.2 per cent in the agriculture industry to 21.4 per cent in the electronics industry. Overall, export variety of Mexico from increased by 11.4 per cent since 1994. That effect is statistically significant and robust to industry fixed effects, as we confirm in a later section.

Table 1(b) presents the tariff liberalizations in Mexico at the industry level in the pre and post-1994 eras with respect to products from the US. In 1990, the average tariff levied on US products entering Mexico was 12.1 per cent, and by 2001 that figure dropped to 1.1 per cent. The most dramatic reductions can be found in the textiles and garments industry, whose tariffs dropped from 17.7 per cent to 0.5 per cent. Large tariff decreases also occurred in machinery and transport and in electronics. The industry that has the smallest reduction is agriculture, which still achieved an reduction from 8.5 per cent to 2.1 per cent over the 11 year period. Thus, Mexico went through some very dramatic declines in tariffs with respect to goods from the US.

Table 1(c) further presents the tariff liberalizations in the US at the industry level in the pre and post-1994 eras with respect to Mexico's exports. In 1990, the average tariff imposed by the US on Mexico's product was 4.1 per cent, and in 2001, it was 0.3 per cent. In terms of absolute changes, the most largest fall in tariff is in the textiles and garments industry, where the average tariff dropped from 13 per cent to 0.4 per cent. In agriculture and electronics, the fall in tariffs is similar to the overall average, and in other industries the fall in tariffs is less. A challenge for our empirical work will be to explain the substantial increase in export variety over 1990-2001 using the relatively small (but permanent) drop in US tariffs under NAFTA. We return to this task after reviewing the export variety and tariffs for China.

5. CHINA'S EXPORT VARIETY: 1990 VERSUS 2001

Table 2(a) presents the export variety of China in 1990 and 2001. The product varieties imported by the US that are also exported by China range from 30 per cent in agricultural industry to 79 per cent in the textiles and garment industry in 1990, while in 2001, the range is between 34 per cent and 88 per cent. Over the same period, the fastest growth in export product variety is in the machinery and transport equipment industry, with average annual growth rate of 7.3 per cent.

Compared to Mexico, in 1990 China was leading in terms of export variety in the textiles and garments industry (with 8.2 per cent more export variety than Mexico), and wood and paper products (4.9 per cent more export variety). On the other hand, Mexico was ahead in the machinery and transport equipment industry (37.5 per cent more variety), petroleum and plastics (16.2 per cent more), mining and basic metals (15.5 per cent more), agricultural (12 per cent more), and electronics (4.3 per cent more).

By 2001, the advantage of China over Mexico in textiles and garments and wood and paper products were reduced to 5 per cent and 2 per cent, respectively. Thus to the extent that NAFTA caused an expansion in Mexico's export variety, the most dramatic effects are in these two industries. Despite the expansion in Mexican export variety across all industries, however, China caught up in those cases where Mexico led in 1990. In fact, for the electronics industry, China's export variety exceeded that of Mexico by 2.5 per cent in 2001, while the gaps in the petroleum and plastics, mining and basic metals, and machinery and transport equipment were reduced to 2.5 per cent, 1.3 per cent and 13.1 per cent, respectively.

Table 2(b) presents the import-weighted average tariffs at the industry level for China's exports to the US. It is evident that while Mexico was liberalizing its tariffs due to NAFTA, China was unilaterally reducing its tariffs, too. The average Chinese tariff on US products dropped from 22.9 per cent in 1992, the first year tariff data is available, to 18.1 per cent in 2001. The biggest reductions were in the most protected industries, which are textiles and garments and machinery and transport equipment. For the rest of the industries with the exception of agriculture, the tariff level is close to 10 per cent in 2001.

The agriculture industry in China was protected by non-tariff barriers (NTBs) such as import licensing and quotas, in addition to the high tariffs. Figure 4 shows the extent of non-tariff

barriers (i.e. quotas and any other import restrictions) maintained by China in 1996. For rice and what, for example, 100 per cent of the imports were subject to non-tariff barriers. Under its entry to the WTO, China made substantial progress in reducing the NTBs in agriculture, which resulted in increases in import volume of goods in those binding products. Such increases pushed up the import weighted average tariff in agriculture from 14 per cent to nearly 70 per cent, as shown in Table 2b. This does not reflect an increase in protection, however, since the *unweighted* average tariff in this industry has dropped from 48 per cent to 27 per cent (see Bhattachali et al, 2004, for a discussion).

Table 2(c) shows the import weighted average tariffs of the US on China's exports at the industry level. Given that US does not have any trade agreement with China, these tariffs reflect the Most Favorite Nations (MFN) tariffs. Overall, the average tariff on China's product was 5.8 per cent in 1990, and it dropped to 3.6 per cent by 2001. Industries that have the largest reductions are wood and paper products and the electronics industry. In most industries, however, the percentage point reduction in US tariffs on China is no greater than that for Mexico under NAFTA, and sometimes less. Average US tariffs on China in agriculture and in petroleum and plastic products have increased very slightly.²

6. REGRESSION RESULTS

To determine the effects of trade liberalization on export variety, we focus on the case of Mexico. Table 3 presents the regression results. We pool observations across industries and years, using the full sample from 1974-2001 for the initial regressions.³ There are seven

² The increase in average tariffs in those industries most likely reflects a shifting import bundle in the US towards products with slightly higher tariffs.

³ For 1974-1988 we construct export variety using the 7-digit Tariff Schedule of the United States, Annotated. Because that classification differs from the Harmonized System used after 1989, the export variety indexes are inconsistent between 1988 to 1989. So we re-scale the earlier indexes so that for each industry and each country,

industries and 28 years, which forms a balanced sample of 196 observations. In column (1), we regress the log of industry export variety of the industries on the NAFTA indicator variable, which is set to one for 1994 and later years, and zero otherwise. Controlling for industry fixed effects, the NAFTA indicator is statistically significant, which indicates an increase in export product variety. The estimated coefficient is 0.20, which implies a 20 per cent increase in export variety due to NAFTA.

We study the partial effects of the US tariff reduction on Mexico's export variety in column (2). The NAFTA indicator variable may be picking up other factors that change over time monotonically, which will bias our estimates. Thus, in addition to the NAFTA indicator, we introduce the log value of one plus the US tariffs. Controlling for industry fixed effects, the tariff term is negative and statistically significant. The coefficient on the US tariff in column (2) is interpreted as a semi-elasticity: each *one percentage point* reduction in US tariffs increases export variety from Mexico by *two per cent*.

This estimate of the semi-elasticity indicates that tariff cuts in the US are important in increasing export product variety of Mexico, but they cannot explain the observed increase in variety after NAFTA. Notice that the NAFTA indicator in column (2) is still estimated at 0.14, showing that the US tariff cuts only explain 6 percentage points of the expansion in export variety from Mexico, with the remaining 14 per cent attributed to some other NAFTA effect. Another way to arrive at this conclusion is to multiply the semi-elasticity of two by the average drop in US tariffs, which is $4.1 - 0.3 = 3.8$ per cent from Table 1(c), arriving at a predicted increase in average export variety of 7.6 per cent. This is only about one-half of the total increase in export variety reported in Table 1(a), of $66.7 - 52.4 = 14.3$ per cent.

export variety in 1988 equals that in 1989. In addition, we include an indicator variable for 1989 in the regressions, to further control for the change in classification systems.

The results in columns (1) and (2) may be biased if there are omitted variables that are correlated with the NAFTA liberalization and with the expansion of export variety. One such variable is the negative market competition effect due to the expansion of other countries export variety. To the extent that the reduction of the US MFN tariff causes an expansion in China's export variety, we expect Mexico's exports to be crowded out and its export variety to decrease. Given that the trade liberalization of China coincided with the Mexico's liberalization, omitting the competition from China may cause a downward bias on the estimated coefficient of the US tariffs on Mexico.

We control for the market competition effect from China by including the industry export variety of China as an explanatory variable. Column (3) includes the export variety of China within the NAFTA indicator specification, along with the US tariff reduction. It is clear that including China's export variety results in a substantial lowering of the NAFTA impact, to 4% in column (3), which is insignificantly different from zero. However, the results in column (3) could be biased itself due to the endogeneity of Chinese export variety. As mentioned before, including China's export variety may pick up the market competition effect, which leads to a negative effect on the export variety of Mexico. But the expansion of China's export variety may also be driven by industry-specific technological progress or US demand shocks that are common between the two countries within industry and year. This would have a positive effect on the export variety of Mexico. While industry-specific technological progress is unobservable, the expansion of Chinese export variety due to China's tariff reductions can be used to capture the market competition effect.

We study this hypothesis by using China's industry tariffs as an instrumental variable for Chinese export variety. When the specification in column (3) is run using this instrument, the

results (not reported in Table 3) are qualitatively similar: the coefficient on Chinese export variety is still positive, so that we are not picking up a market competition effect. This appears to be due to the long time span of the sample, for 1974 to 2001. In columns (5) and (6) we use a shorter time period, from 1990 to 2001, which is the focus of this study. We run a system of two equations, one for the export variety of Mexico and another for the export variety of China. In both equations, the set up is identical to that of column (4), which includes the US tariff, the export variety of the other country, and industry specific effects which are treated as common across the equations. Export variety of the other country is endogenous, and as an instrumental variable we use the US tariff on that country.

Column (5) shows the equation for Mexico's industry export variety, and (6) shows the equation for China's industry export variety. We now find that the market competition effect of Chinese products on Mexico exports are negative and statistically significant. Every *one per cent* increase in the export variety of China *reduces* the export variety of Mexico by *one-half of one per cent*, in column (5). On the other hand, an expansion of Mexico's variety does not have a significant impact on China's export variety, in column (6). Controlling for the expansion in Chinese products due to tariff reductions in China and the US, the marginal effect of the US tariff liberalization in column (5) is *larger* than it was before: each *one percentage point* reduction in tariffs now increases Mexican export variety by *4.5 per cent*. This demonstrates the substantial impact of tariff liberalization on product variety of the exporting country.

To see how much of Mexico's export variety increase we are now explaining, we go through a similar calculation as before. We multiply the semi-elasticity of 4.5 by the average drop in US tariffs, which is 3.8 per cent from Table 1(c), arriving at a predicted increase in average export variety of 17.2 per cent. This is slightly larger than the total increase in export variety

reported in Table 1(a), of 14.3 per cent, so that the US tariff cut *fully explains* the average increase in export variety from Mexico. However, regression (5) also predicts a fall in Mexico's export variety due to the competitive impact from China of $0.5 \times 21.2 = 10.6$ per cent.⁴ So in total, the regression under-predicts the average increase in Mexico's export variety. Performing the same calculation on specific industries, regression (5) over-predicts the increase in export variety in textiles and apparel from Mexico, and under-predicts most other industries. Evidently, textiles and apparel is an outlier with a very substantial drop in US tariffs on Mexico but a modest increase in export variety. The fact that this industry performs differently from the others also indicates that the regression should be run separately across industries. That is beyond the scope of the present paper due to a lack of observations, but would be possible in a panel dataset with more countries, which is an important direction for further research (Debaere and Mostashari, 2005).

7. CONCLUSIONS

The past decade has witnessed a significant increase in Mexico's export variety in all industries, especially since NAFTA went into effect. Overall, 67 per cent of US imports in 2001 are from products which Mexico exported, whereas this share was 52 per cent in 1990. Over the same period of time, China also experienced a rapid expansion in export variety, and in certain industries, China now exceeds Mexico in terms of exported varieties.

In this paper, we study the effects of US tariff reductions on export variety. Our empirical results indicate that tariff liberalization is important in expanding export variety. In particular, there is statistical evidence linking US tariff liberalization due to NAFTA to increased export variety from Mexico. That effect is robust to the market competition effect of Chinese exports, and

⁴ This amount is the elasticity of Mexico's export variety with respect to China's export variety, times the average increase in China's export variety, which is $63.3 - 42.1 = 21.2$, from Table 2(a).

in fact, the semi-elasticity between tariff cuts and export variety is *higher* when the competition from Chinese exports is taken into account.

While the static gains from trade have been widely studied and documented to be relatively small, the dynamic gains due to the expansion of export variety may well be more important. Broda and Weinstein (2004) document that the expansion of import varieties in the United States have had a significant impact on lowering the “true” import price index, and therefore on raising US welfare. Similarly, Feenstra and Kee (2006) argue that the growth of export varieties benefits aggregate productivity in the exporting country. This paper shows how the expansion in the variety of traded goods is linked to tariff reductions, thereby contributing to short term and long term gains.

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Table 1: Mexico's Trade with the U.S., 1990-2001**(a) Mexico's Export Variety to the U.S.**

	Average	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	52.4	41.5	71.2	47.3	55.4	46.6	65.6	39.5
2001	66.7	50.9	82.6	63.2	72.7	56.4	75.8	65.6
Growth rate	2.2	1.9	1.4	2.6	2.5	1.7	1.3	4.6

(b) Mexico's Tariffs on Imports from the U.S.

	Overall Industry	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	12.1	8.5	17.7	10.9	9.9	9.7	14.0	13.9
2001	1.1	2.1	0.5	0.6	1.5	1.3	1.1	0.6

(c) US Tariffs on Imports from Mexico

	Overall Industry	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	4.1	4.4	13.0	2.2	0.6	2.1	2.5	4.1
2001	0.3	0.8	0.4	0.0	0.1	0.7	0.1	0.1

Notes:

1. All figures are in per cent.
2. The growth rate in (a) is computed as $[\ln(\text{Variety}_{2001}) - \ln(\text{Variety}_{1990})] \times 100$.

Sources:

Export variety in (a) and US tariffs in (c) are computed from the US import data described in Feenstra, Romalis and Schott (2002). Tariffs in (b) are computed from the WITS database at the World Bank.

Table 2: China's Trade with the U.S., 1990-2001**(a) China's Export Variety to the U.S.**

	Average	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	42.1	29.6	79.4	52.2	39.2	31.1	28.1	35.2
2001	63.3	34	87.6	65.2	70.3	55.1	62.7	68.1
Growth rate	3.7	1.3	0.9	2.0	5.3	5.2	7.3	6.0

(b) China's Tariffs on Imports from the U.S.

	Average	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	22.9	14.0	52.6	15.8	17.8	17.0	33.7	18.3
2001	18.1	69.8	17.6	10.6	11.3	9.0	11.4	10.7

(c) US Tariffs on Imports from China

	Average	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
1990	5.8	1.4	13.0	6.6	2.7	6.4	5.1	5.1
2001	3.6	1.7	10.9	1.3	3.1	4.1	3.0	1.2

Notes:

1. All figures are in percent.
 2. Chinese tariffs listed in 1990 are for 1992.
- Other notes and sources from Table 1 also apply.

Table 3: Dependent Variable – Log of Industry Export Variety

	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) 3SLS	(6) 3SLS
NAFTA indicator	0.198** (0.036)	0.143** (0.044)	0.043 (0.033)	-0.006 (0.034)		
ln(1+Mexico tariff)		-2.049* (0.997)	-2.109** (0.540)	-2.139** (0.460)	-4.535** (0.932)	
China's export variety			0.316** (0.046)	0.474** (0.042)	-0.508** (0.108)	
ln(1+China tariff)						-2.974* (0.897)
Mexico's export variety						0.116 (0.142)
Constant	3.520** (0.044)	3.630** (0.069)	2.669** (0.137)	2.782** (0.148)	5.70** (0.391)	3.11** (0.566)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	196	196	196	196	84	84
R-squared	0.50	0.51	0.78	0.71		
Chi-square					131.2	241.4

Notes:

1. White-robust standard errors are in parentheses. * significant at 5%; ** significant at 1% level.
2. Dependent variables are the log of Mexico's export variety in columns (1)-(5), and the log of China's export variety in column (6). Columns (4), (5) and (6) are estimated with instruments for export variety, which consist of that country's tariffs. Columns (5) and (6) have common industry fixed effects.
3. Samples cover 1974 to 2001 in columns (1) to (4), and 1990 to 2001 in columns (5) and (6). There are seven industries included, as shown in Tables 1 and 2.

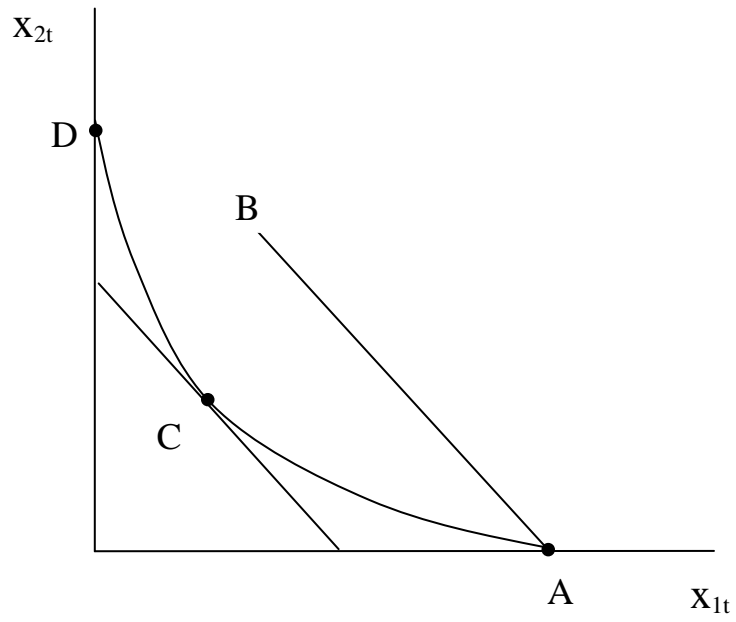


Figure 1: Input Varieties

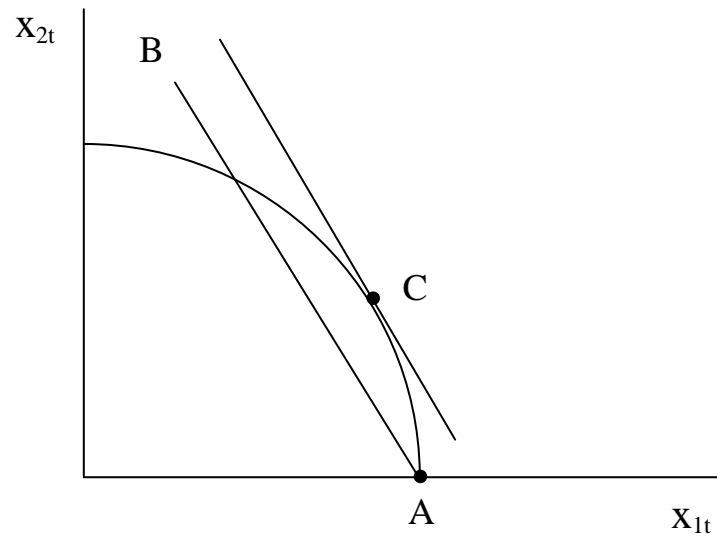


Figure 2: Output Varieties

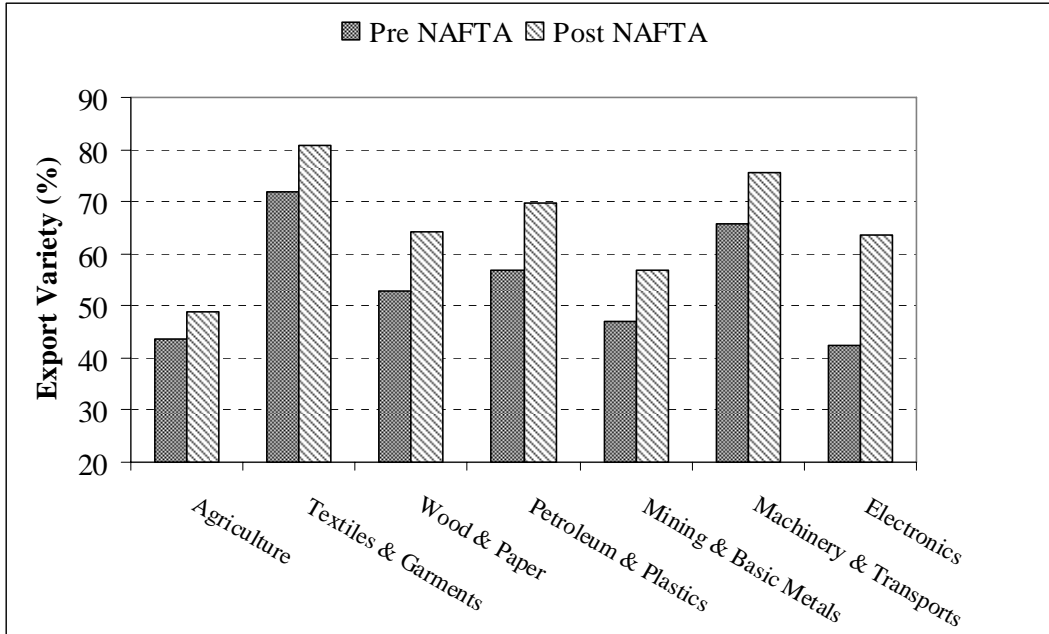


Figure 3: NAFTA and Export Variety
 Source: Author's calculations

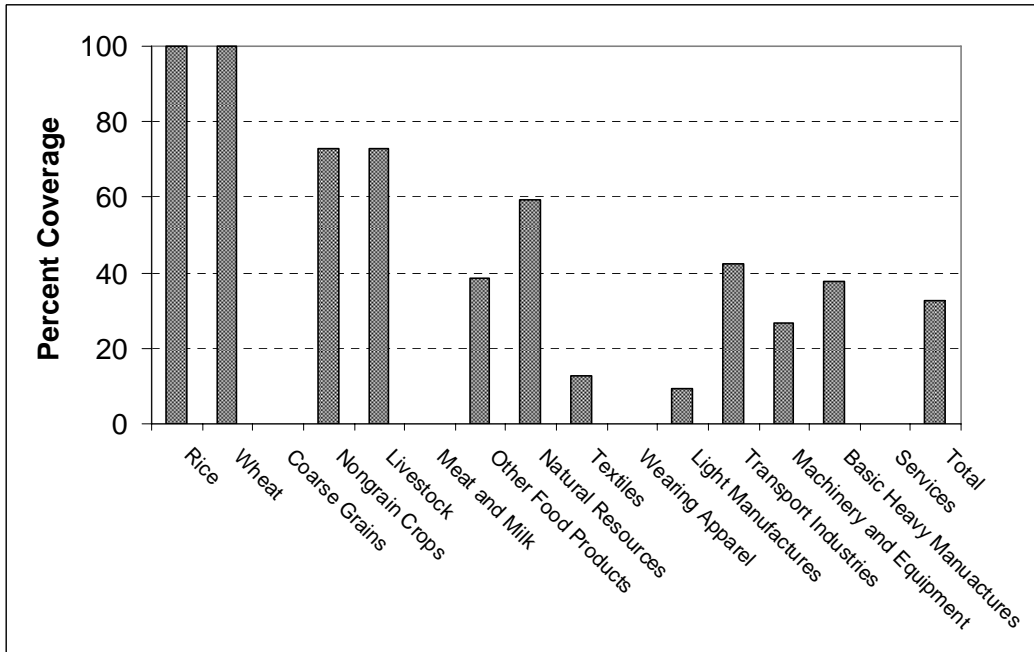


Figure 4: Non-tariff Measures Affecting China's Imports
 Source: World Bank, *China 2020: China Engaged*.