

Globalization, Competition, and the U.S. Price Level

by

Robert C. Feenstra

David E. Weinstein

Revised, July 2009

Preliminary and Incomplete
(Please do not cite or quote without permission)

Abstract

This paper is the first attempt to derive and estimate the impact of globalization on markups and welfare in a monopolistic competition model. To achieve this, we work with a class of preferences that allow for endogenous markups and are especially convenient for empirical work – the translog preferences, with symmetry imposed across products. Although the magnitude of the consumer gains assuming translog preferences is similar to that assuming CES preferences (a drop in overall consumer prices of 0.6 percentage points between 1992 and 2005), the sources of these gains is quite different. We estimate that only between one-third and one-half of the gains arise from new varieties, and the remainder arise from competition effects driving down markups of existing producers. Moreover, we estimate that these markup effects would have been substantially larger had there not been substantial exit from U.S. manufacturing.

1. Introduction

A promise of the monopolistic competition model in trade was that it offered additional sources of the gains from trade, beyond that from comparative advantage. These additional sources include: consumer gains due to the expansion of import varieties; efficiency gains due to increasing returns to scale; and welfare gains due to reduced markups. While the first two sources of gains have received recent empirical attention,¹ the promise of the third source – reduced markups – has not yet been realized. To be sure, there are estimates of reduced markups due to trade for several countries: Levinsohn (1993) for Turkey; Harrison (1994) for the Ivory Coast; and Badinger (2007a) for European countries. But these cases rely on dramatic liberalizations to identify the change in markups and are not tied in theory to the monopolistic competition model. The reason that this model is not used to estimate the change in markups is because of the prominence of the constant elasticity of demand (CES) system, with its implied constant markups. To avoid that case, the above authors did not specify the functional form for demand and instead relied on a natural experiment to identify the change in markups.

For these reasons, we do not have evidence beyond these case studies about how the broad process of globalization affects markups, and particularly no evidence on the impact of such markup reductions on U.S. welfare. This paper is the first attempt to derive and estimate the impact of globalization on markups and welfare in a monopolistic competition model. To achieve that, we work with a class of preferences that are new to that literature – the translog preferences, with symmetry imposed across products. These preferences are known to have good properties for empirical work (Diewert, 1976): they are homothetic; can give a second-order

¹ The consumer gains due import variety have been estimated for the U.S. by Broda and Weinstein (2006). Gains due to increasing returns to scale, or more specifically due to the self-selection of efficient firms (as in Melitz, 2003) have been demonstrated for Canada by Trefler (2004) and for a broader sample of countries by Badinger (2007b, 2008). See also Head and Ries (1999, 2001) for Canada, and Tybout *et al* (1991, 1995) for Chile and Mexico.

approximation to an arbitrary expenditure function; and correspond to the Törnqvist price index, which is very close to price index formulas that are used in practice. Furthermore, these preferences prove to be highly tractable even as the range of import varieties change, so they can join the quadratic preferences used by Melitz and Ottaviano (2008) as being alternatives to the CES case that allow for endogenous markups.²

In the translog case, the elasticity of demand is inversely related to a product's market share, markups fall as more firms enter, which we call the *pro-competitive effect*. On the other hand, domestic firms may exit as foreign competition intensifies offsetting some of this gain to consumers. This we will refer to as the *domestic exit effect*. Incorporating these two effects into the analysis allows us to estimate the impact of globalization on markups. Furthermore, this class of preferences also allows us to address a potential criticism of Broda and Weinstein (2006): that by assuming CES preferences, it may overstate the gains from import variety.³ The translog system allows for an alternative estimate of the variety gains, which we find are much smaller than in the CES case and also smaller than the pro-competitive effect. But our *combined* consumer gains for the U.S. due to import variety and the pro-competitive effect are of the same magnitude as Broda and Weinstein's estimate for the CES case

Since markups depend on products market shares in the translog system, we begin in section 2 by summarizing the trends in U.S. market shares since 1990s. The market shares of U.S. producers have fallen dramatically due to import competition, while the number of firms in

² The quadratic preferences used by Melitz and Ottaviano (2008) lead to linear demand curves with zero income elasticity, though country population can act as a demand shift parameter. Demand curves of this type and the associated markups are estimated in the industrial organization literature: see Bresnahan (1982, 1987) and the recent trade application by Blonigen *et al* (2007). For other preferences that are non-homothetic and allow for variable markups see Behrens *et al* (2008) and Simonovska (2008).

³ The gains from a new product variety can be thought of as the area under the demand curve and above the price when the product first appears. While the CES system has an infinite reservation price, this area under the demand curve is still bounded above (provided the elasticity of substitution is greater than unity). But it can be expected that the gains from new product varieties in this case might exceed the gain for other functional forms with *finite* reservation prices, as is the case of the translog system.

the U.S. market (as measured by the Herfindahl indexes of market concentration) has increased only slightly. It follows that the *per-firm* market shares have also fallen, which provides us with *prima facie* evidence that there has been an increase in competition and reduced markups. In fact, for the translog system, the sum of the Herfindahl indexes for U.S. producers and for exporters to the U.S., weighted by their squared market shares, is precisely the right way to measure competition, and we show that these “market-level” Herfindahl indexes have fallen in many sectors.

Our results suggest that globalization has been exerting important economic impacts on the U.S. economy. Our point estimate for the gains to U.S. consumers from new varieties and decreased markups is 0.6 percentage points over the period 1992 to 2005. However, the impact on the merchandise sector (agriculture, manufacturing, and mining) was much larger. Increased foreign competition drove down prices by 1.7 percentage points and average markups by five percent over this time period.

In section 3, we introduce the translog expenditure function, and solve for the ratio of expenditure functions (or exact price index) in the presence of new and disappearing goods, which allow the gains from new products to be measured. The pro-competitive effect of imports is discussed in section 4. Our analysis allows for multiple products supplied by each country, and show how the Herfindahl indexes of export sales by each country enter into our equations. Significantly, we have been able to obtain these indexes for most countries selling to the U.S., by land or by sea. In section 5 we discuss the procedure for estimating the system of demand and pricing equations, and results are presented in section 6.

2. Data Preview

One of the dramatic changes that globalization has wrought on the U.S. economy is the declining importance of U.S. supply of U.S. demand. To see this, we define U.S. domestic supply as aggregate U.S. sales less exports of agricultural, mining, and manufacturing goods (see the data Appendix for detailed definitions of all of our variables). We define U.S. apparent consumption as domestic supply plus imports. Similarly, we define the U.S. suppliers' share of the U.S. market, i.e. what share of U.S. consumption was met by U.S. suppliers, as U.S. domestic supply divided by apparent consumption. Finally, we define each country's import share as the exports from that country to the U.S. divided by apparent consumption. As one can see from Table 1, while U.S. suppliers produced 86 percent of all goods demanded by U.S. consumers in 1992, this number fell to only 67 percent by 2005. The flip side of this decline was an almost doubling of the import share in these sectors. Over a third of this increase was due to increases in import shares from China and Mexico.

One possible explanation for what we see in Table 1 is that the rise in import penetration was confined to a few important sectors. We can examine whether this was the case by looking at more disaggregated data. In Figure 1, we plot the U.S. suppliers' share in 2005 against its level in 1992 for each HS 4-digit category. We also place a 45-degree line in the plot so that one can easily see which sectors experienced gains in U.S. shares and which experienced declines. As one can see from the figure, the vast majority of sectors lie below the 45-degree line, meaning that these sectors had greater import penetration in 2005 than they had in 1992. This establishes that the rise in import penetration, though quite pronounced in some sectors, was a general phenomenon that was common across virtually all merchandise sectors.

Along with the declining U.S. market share in many sectors, there has also been an exit of manufacturing firms. The Department of Census data reveals that in 1992, there were 337,409 firms in manufacturing. By 2002 this number had fallen to 309,696: an 8.2 percent decline. However, we will argue that this decline in the number of firms has been less than the decline in the U.S. market share, so that the *per-firm* shares of U.S. firms have also fallen. That will be the key feature leading to a decline in their markups.

To make this argument, it is convenient to work with Herfindahl indexes of market concentration, defined for each country selling to the U.S. We let i denote countries, j denote firms (each selling one product), k denote sectors and t denote time. Let s_{jt}^{ik} denote firm j 's exports to the U.S. in sector k , as a share of country i 's total exports to the U.S. in that sector. Then the Herfindahl for country i is

$$H_{it}^k = \sum_j (s_{jt}^{ik})^2 .$$

The inverse of a Herfindahl can be thought of as the “effective number” of exporters, or U.S. firms, in an industry. Thus, a Herfindahl of one implies that there is one firm in the industry and an index of 0.5 would arise if there were two equally sized firms in the sector. Similarly, if we multiply the Herfindahl by the share of the country's suppliers in the market, one obtains the market share of a synthetic typical firm in the market. This is a very useful statistic because in many models of competition, e.g. Cournot competition, the markup of the firm rises or falls with its market share, and this feature will also hold in our translog system.

In Table 1, we present average Herfindahls at the HS 4-digit level for the U.S. and the 30 major exporters to the U.S.⁴ As one can see from the table, the average U.S. Herfindahl rose

⁴ For the U.S., we have adjusted the NAICS 6-digit Herfindahls from the Bureau of Economic Analysis data so that they match the HTS 4-digit categories and detail that procedure in the data Appendix.

from 0.23 to 0.25 over this period indicating that increased foreign competition was likely associated with some exit of U.S. firms from the market. If we multiply this average Herfindahl by the share of U.S. suppliers, we can compute the typical market share of a U.S. firm. Table 1 reveals that the share in the U.S. market of our synthetic typical firm fell slightly from 19.7 percent in 1992 to 19.1 percent 2005. The fact that share of the U.S. market held by U.S. suppliers fell dramatically, but the typical market share of a U.S. firm did not fall by that much indicates that the rise in imports over this time period was accompanied by a large amount of exit by U.S. firms.

One can get a sense of what happened to concentration in other countries by plotting the average export Herfindahl in 2005 against the value in 1992 when we only include sectors for which we could compute a Herfindahl in both years. The Herfindahl index appears to have risen for most countries in the world indicating that the export market has become more concentrated over time. That said, the opposite trend seems to be true for many of the most important exporters to the U.S.. In Figure 2, we label the points for the top ten exporters to the U.S. market. With the exception of Japan, Mexico, and the United Kingdom, all of the remaining top ten exporters to the U.S. saw their export Herfindahls decline over this time period.

In Figure 3 we plot changes in a country's Herfindahl of sales to the U.S. against changes in the market share of the country. Although there is a lot of noise in the data, there is a slight negative relationship indicating that increases in market share are associated with increases in firm entry (i.e. a fall in the Herfindahl) and decreases in share are associated with exit. This suggests that analyses that define new varieties based on country-industry data are likely to understate variety growth and destruction.

Our data preview suggests that prior work on the impact of new varieties is likely to suffer from a number of biases. First, as foreign firms have entered the U.S. market, there has been exit by U.S. firms which serves to offset some of the gains of new varieties. Second, while U.S. Herfindahls rose, the Herfindahls of many of our largest suppliers fell. This suggests that there may have been substantial variety growth that is not captured in industry level analyses. Finally, because the market shares of foreign entrants are much smaller than those of domestic firms, the rise in foreign entry is likely to have depressed markups overall and therefore lowered prices. Thus, estimates of the gains from new varieties estimated from industry-level data using CES aggregators could either be too large if domestic exit is an important source of variety loss, or too small if foreign firm entry and market power losses are important unmeasured variety gains. We turn to quantifying these gains and losses in the next section.

3. Translog Function

To introduce the translog function, we will initially simplifying our notation that distinguished countries, firms, and sectors, and instead just let the index i denote products (we will re-introduce countries and firms below). We consider a translog function defined over the universe of products, whose maximum number is denoted by the fixed number \tilde{N} . The translog unit-expenditure function is defined by:⁵

$$\ln e = \alpha_0 + \sum_{i=1}^{\tilde{N}} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{\tilde{N}} \sum_{j=1}^{\tilde{N}} \gamma_{ij} \ln p_i \ln p_j, \text{ with } \gamma_{ij} = \gamma_{ji}. \quad (1)$$

Note that the restriction that $\gamma_{ij} = \gamma_{ji}$ is made without loss of generality. To ensure that the expenditure function to be homogenous of degree one, we add the restrictions that:

⁵ The translog direct and indirect utility functions were introduced by Christensen, Jorgenson and Lau (1975), and the expenditure function was proposed by Diewert (1976, p. 122).

$$\sum_{i=1}^{\tilde{N}} \alpha_i = 1, \quad \text{and} \quad \sum_{i=1}^{\tilde{N}} \gamma_{ij} = 0. \quad (2)$$

In order to further require that all goods enter “symmetrically” in the γ_{ij} coefficients, we can impose the additional restrictions that:

$$\gamma_{ii} = -\gamma \left(\frac{\tilde{N}-1}{\tilde{N}} \right) < 0, \quad \text{and} \quad \gamma_{ij} = \frac{\gamma}{\tilde{N}} > 0 \text{ for } i \neq j, \text{ with } i, j = 1, \dots, \tilde{N}. \quad (3)$$

It is readily confirmed that the restriction in (3) satisfies the homogeneity conditions (2).

The share of each good in expenditure can be computed by differentiating (1) with respect to $\ln p_i$, obtaining:

$$s_i = \alpha_i + \sum_{j=1}^{\tilde{N}} \gamma_{ij} \ln p_j. \quad (4)$$

These shares must be non-negative, of course, but we will allow for a subset of goods to have zero shares, because they are not available for purchase. To be precise, suppose that $s_i > 0$ for $i=1, \dots, N$, while $s_j = 0$ for $j=N+1, \dots, \tilde{N}$. Then for the latter goods, we set $s_j = 0$ within the share equations (4), and use these $(\tilde{N} - N)$ equations to solve for the reservation prices \tilde{p}_j , $j=N+1, \dots, \tilde{N}$, in terms of the observed prices p_i , $i=1, \dots, N$. Then these reservation prices \tilde{p}_j should appear in the expenditure function (1) for the unavailable goods $j=N+1, \dots, \tilde{N}$.

In the presence of unavailable goods, then, the expenditure function becomes rather complex, involving their reservation prices. However, if we consider the symmetric case defined by (3), then it turns out that the expenditure function can be simplified considerably, so that the reservation prices no longer appear explicitly. Specifically, Bergin and Feenstra (2009) show that the expenditure function is simplified as:

$$\ln e = a_0 + \sum_{i=1}^N a_i \ln p_i + \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^N b_{ij} \ln p_i \ln p_j, \quad (5)$$

where:
$$b_{ii} = -\gamma \frac{(N-1)}{N} < 0, \quad \text{and} \quad b_{ij} = \frac{\gamma}{N} > 0 \text{ for } i \neq j \text{ with } i, j = 1, \dots, N, \quad (6)$$

$$a_i = \alpha_i + \frac{1}{N} \left(1 - \sum_{i=1}^N \alpha_i \right), \quad \text{for } i = 1, \dots, N, \quad (7)$$

$$a_0 = \alpha_0 + \left(\frac{1}{2\gamma} \right) \left\{ \sum_{i=N+1}^{\tilde{N}} \alpha_i^2 + \left(\frac{1}{N} \right) \left(\sum_{i=N+1}^{\tilde{N}} \alpha_i \right)^2 \right\}. \quad (8)$$

Notice that the expenditure function in (5) looks like a conventional translog function defined over the goods $i=1, \dots, N$, while the symmetry restrictions in (6) continue to hold. To interpret (7), it implies each of the coefficient α_i is increased by the same amount to ensure that the coefficients a_i sum to unity over $i=1, \dots, N$. The final term a_0 , appearing in (8), incorporates the coefficients α_i of the unavailable products. If the number of available products N rise, then a_0 falls, indicating a welfare gain from increasing the number of available products. As it is stated, however, (8) does not allow for the direct measurement of welfare gain because it depends on the unknown parameters α_i . We now develop an alternative formula for the welfare gain that depends on the observable expenditures shares on goods, and can therefore be measured.

Let us distinguish two periods $t-1$ and t , and re-introduce our notation that i denotes countries, while j denotes firms (each selling one good), so the pair (i, j) denotes a unique product variety. We assume that the countries $i=M+1, \dots, \tilde{M}$ do not supply in either period, while the countries $\{1, \dots, M\}$ are divided into two (overlapping) sets: the M_τ countries $i \in I_\tau$ sell in period $\tau = t-1, t$; with union $I_{t-1} \cup I_t = \{1, \dots, M\}$ and non-empty intersection $I_{t-1} \cap I_t \neq \emptyset$.

We shall let $\bar{I} \subseteq I_{t-1} \cap I_t$ denote any non-empty subset of their intersection.

Firms in each country provide the set of varieties $j \in J_{it}$, with the number $N_{it} > 0$, so the total number of varieties available each period is $N_t \equiv \sum_{i \in I_t} N_{it}$. If a country supplies in period t but not $t-1$, then there is obviously an expansion in its set of varieties. But we can also measure an expansion in varieties by examining the Herfindahl indexes of exporting firms for countries supplying *both* periods: a reduction in the Herfindahl indicates greater varieties. For our next result, we will need to specify a set of countries $i \in \bar{I}$ for which variety *does not* expand; in practice, we identify these countries by their (relatively) constant Herfindahl indexes. For these countries we assume that there is unchanging sets of variety, $J_{it} \equiv \bar{J}_i$ for $i \in \bar{I}$, with the number $\bar{N}_i > 0$ in each country, so the total number of *unchanging* product varieties is $\bar{N} \equiv \sum_{i \in \bar{I}} \bar{N}_i$.

With this notation, the shares s_{ijt} are used in place of s_{it} in all our earlier formulas. We can decompose these product shares as $s_{ijt} = s_{jt}^i s_{it}$, where $s_{it} = \sum_{j \in J_{it}} s_{ijt}$ denotes the share of expenditure on all varieties from country i , and $s_{jt}^i \equiv s_{ijt} / s_{it}$ denote the expenditure share on variety j *within* the spending on country i , so that $\sum_{j \in J_{it}} s_{jt}^i = 1$. In practice we only observe the U.S. import shares s_{it} by country, while we will make inferences about the firm shares s_{jt}^i using the Herfindahl indexes of concentration for each product.

Returning to the expenditure function, the Törnqvist price index is exact for the translog function (Diewert, 1976), which means that the ratio of the unit-expenditure functions is measured by:

$$\ln \left(\frac{e_t}{e_{t-1}} \right) = \sum_{i=1}^M \sum_{j \in J_i} \frac{1}{2} (s_{ijt} + s_{ij,t-1}) (\ln p_{ijt} - \ln p_{ij,t-1}), \quad (9)$$

where $J_i \equiv J_{it} \cup J_{i,t-1}$ is the set of product varieties sold by country i over both periods. Of course, some of those products may be available in only one period, and likewise, some of the

countries $i = 1, \dots, M$ are selling in only one period. In such cases we again solve for the reservation prices for goods not available, using their respective shares equal to zero.

Substituting these reservation prices back into (12) and simplifying, we obtain the following expression for the exact price index:

Theorem 1

Then the ratio of translog unit-expenditure functions can be written as:

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = \sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} \frac{1}{2} (\bar{s}_{ijt} + \bar{s}_{ijt-1}) (\ln p_{ijt} - \ln p_{ijt-1}) + V, \quad (10)$$

where, the shares \bar{s}_{ijt-1} and \bar{s}_{ijt} are defined as:

$$\bar{s}_{ij\tau} \equiv s_{ij\tau} + \frac{1}{\bar{N}} \left(1 - \sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} s_{ij\tau} \right), \text{ for } i \in \bar{I} \text{ and } \tau = t-1, t, \quad (11)$$

and,

$$V \equiv -\left(\frac{1}{2\gamma}\right) \left\{ \sum_{i \in \bar{I}} (H_{it} s_{it}^2 - H_{it-1} s_{it-1}^2) + \frac{1}{\bar{N}} \left[\left(\sum_{i \in \bar{I}} s_{it} \right)^2 - \left(\sum_{i \in \bar{I}} s_{it-1} \right)^2 \right] \right\}, \quad (12)$$

where $H_{it} \equiv \sum_{j \in \bar{J}_i} (s_{jt}^i)^2$ denotes the Herfindahl index for firm exports by country i .

To interpret this result, notice that the constructed shares $\bar{s}_{ij\tau}$ apply to the \bar{N} products that are available in both periods. The constructed shares simply take the observed shares $s_{ij\tau}$ and additively increase each of them by an amount that $\bar{s}_{ij\tau}$ now sum to unity across \bar{N} products. This transformation of shares means that the term $\sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} \frac{1}{2} (\bar{s}_{ijt} + \bar{s}_{ijt-1}) (\ln p_{ijt} - \ln p_{ijt-1})$ appearing in (10) is the Törnqvist price index defined over products available in both periods.⁶ The term V defined in (12) is therefore the *extra* impact on the exact price index from having the

⁶ Actually, the \bar{N} products are a subset of those available both periods, since \bar{I} can be a proper subset of the countries i supplying both periods.

new and disappearing varieties, and depends on their squared shares, as indicated by the Herfindahl indexes.

To interpret this formula for V , we consider a simple example with U.S. consumers purchasing Budweiser and Heineken in period 1, and then having a new domestic variety called American Ale available in period 2.⁷ For simplicity, the varieties available each period sell in equal shares. The U.S. products have market share rising from $s_{us1} = 1/2$ in period 1 to $s_{us2} = 2/3$ in period 2, with Herfindahl indexes $H_{us1} = 1$ in period 1 and $H_{us2} = 1/2$ in period 2 (since then there are two equally sized firms). The change in the U.S. Herfindahl indicates a potential change in variety, so the U.S. is country $i \notin \bar{I}$. In contrast, the Netherlands has unchanged variety (i.e. Heineken), so it is country $i \in \bar{I}$, and $\bar{N} = 1$. Using this information in (15) we obtain,

$$\begin{aligned} V &= -\left(\frac{1}{2\gamma}\right) \left\{ \left[\frac{1}{2} \left(\frac{2}{3}\right)^2 - \left(\frac{1}{2}\right)^2 \right] + \frac{1}{\bar{N}} \left[\left(\frac{2}{3}\right)^2 - \left(\frac{1}{2}\right)^2 \right] \right\} \\ &= -\left(\frac{1}{2\gamma}\right) \left\{ \left[-\frac{1}{36} \right] + \frac{1}{\bar{N}} \left[\frac{7}{36} \right] \right\} = -\left(\frac{1}{2\gamma}\right) \frac{1}{6} < 0. \end{aligned}$$

The negative value for V lowers the exact price index in (13) and indicates the gain from product variety. Notice that to obtain this negative value, however, we need to incorporate the second term in curly brackets, which is positive; the first bracketed term is negative, reflecting the fall in the U.S. Herfindahl, and on its own would give the wrong sign for the variety gain. So to evaluate V we need to have an accurate value for \bar{N} , which in practice we will measure by the sum of the inverse Herfindahls indexes for countries $i \in \bar{I}$, i.e. countries whose Herfindahl indexes do not change by more than some specified tolerance over time.⁸

⁷ American Ale is being introduced by the Budweiser company in 2009, but we will suppose in our example that this product is being sold by another U.S. firm.

⁸ In our robustness checks we will change the tolerance used to include countries in the “common” set \bar{I} or not.

We conclude with two final observations on V . First, we should not interpret this as the “total” welfare effect of new goods, independently of the Törnqvist index appearing in equation (10). Rather, new goods will also contribute to lower prices for existing goods: this is the pro-competitive effect that we described in the Introduction. Accordingly, we will refer to V as a “partial” welfare effect of new goods; the “total” impact will also have to take into account the pro-competitive effect.

Second, in order to measure V in (12) we need an estimate of γ . This parameter plays a similar role as the elasticity of substitution in the CES case, in that the welfare gains are reduced as either parameter rises. Obviously, we cannot compare the CES and translog cases without knowledge of these parameters.⁹ In both cases, the parameters are estimated from the demand equations. For the translog case, the share equation is obtained by differentiating (5), using (6) and (7), and also using our notation for countries i and firms j , as:

$$s_{ijt} = (a_{ij} + a_t) - \gamma(\ln p_{ijt} - \overline{\ln p_t}),$$

where $a_t = (1 - \sum_{i \in I_t} \sum_{j \in J_{it}} \alpha_{ij})$ is a time-effect which ensures that $\sum_{i \in I_t} \sum_{j \in J_{it}} (\alpha_{ij} + a_t) = 1$, and $\overline{\ln p_t} = \frac{1}{N_t} \sum_{i \in I_t} \sum_{j \in J_{it}} \ln p_{ijt}$ is the average log-price of all available goods in period t . We have included a time subscript on the parameter a_t because it depend on the set of varieties available, which is changing over time.

Using $s_{ijt} = s_{jt}^i s_{it}$ and multiplying the share equation by s_{jt}^i , it becomes:

$$(s_{jt}^i)^2 s_{it} = s_{jt}^i (a_{ij} + a_t) - \gamma(s_{jt}^i \ln p_{ijt} - s_{jt}^i \overline{\ln p_t}).$$

⁹ Feenstra and Shiells (1997, p. 258) compare the gains from a single new good in the CES and translog cases, by assuming that the new good has the same elasticity of demand in both cases. They show that the “partial” welfare gain from the new good in the translog case is about one-half of the welfare gain in the CES case.

Summing this equation over $j \in J_{it}$, and noting that $\sum_{j \in J_{it}} s_{jt}^i = 1$, we obtain:

$$H_{it} s_{it} = a_{it} + a_t - \gamma (\ln p_{it} - \overline{\ln p_t}), \quad (13)$$

where $\ln p_{it} \equiv \sum_{j \in J_{it}} s_{jt}^i \ln p_{ijt}$ is the (weighted) geometric mean of prices, and $a_{it} \equiv \sum_{j \in J_{it}} s_{jt}^i a_{ij}$ is a geometric mean of the taste parameters. This average taste parameter will change as the set of selling firms shifts towards those with higher demand. We therefore model the movement in these tastes parameters as:

$$a_{it} = a_i + \varepsilon_{it}, \quad (14)$$

where ε_{it} is an error term. Substituting (14) into (13), we obtain the share equations,

$$H_{it} s_{it} = a_i + a_t - \gamma (\ln p_{it} - \overline{\ln p_t}) + \varepsilon_{it}. \quad (15)$$

The parameter γ is obtained by estimating (15), recognizing that the intercept term differs across i and also over time, reflecting changes in the number of available goods. The important properties of these share equation is that the parameter γ *does not* depend on the set of goods available. However, we can expect that the price appearing in (15) are endogenous, as in a conventional supply and demand system. For the CES case, Feenstra (1994) showed how this endogeneity could be overcome even without the use of conventional instrument variables, but by exploiting heteroskedasticity in second-moments of the data. We will follow the same procedure in the translog case, as described in section 5. But first, we need to solve for the optimal prices charged by imperfectly competitive firms, in the next section.

4. Optimal Prices and the Pro-Competitive Effect

We will suppose that the available products are produced by single-product firms, acting as Bertrand competitors. The profit maximization problem for firm j in country i is,

$$\max_{p_{ijt}} p_{ijt} x_{ij}(p_t, E_t) - C_{ij}[x_{ij}(p_t, E_t)] ,$$

where $x_{ij}(p_t, E_t)$ denotes the demand arising from the translog system, with the price vector p_t and expenditure E_t , and $C_{ijt} = C_{ij}[x_{ij}(p_t, E_t)]$ denotes the costs of production. We denote the elasticity of demand by $\eta_{ij}(p_t, E_t) \equiv -\partial \ln x_{ij}(p_t, E_t) / \partial \ln p_{ijt}$. Then the optimal price can be written as the familiar markup over marginal costs:

$$p_{ijt} = C'_{ij}[x_{ij}(p_t, E_t)] \left[\frac{\eta_{ij}(p_t, E_t)}{\eta_{ij}(p_t, E_t) - 1} \right]. \quad (16)$$

The elasticity of demand from the translog system is:

$$\eta_{ijt} = 1 - \left(\frac{\partial \ln s_{ijt}}{\partial \ln p_{ijt}} \right) = 1 + \frac{\gamma(N_t - 1)}{s_{ijt} N_t} .$$

It follows that the log-markup appearing in (16) is:

$$\ln \left[\frac{\eta_{ij}(p_t, E_t)}{\eta_{ij}(p_t, E_t) - 1} \right] = \ln \left\{ 1 + \frac{s_{ijt} N_t}{\gamma(N_t - 1)} \right\} .$$

Substituting these equations into (16), we obtain:

$$\ln p_{ijt} = \ln C'_{ijt} + \ln \left[1 + \frac{s_{ijt} N_t}{\gamma(N_t - 1)} \right], \quad (17)$$

where $C'_{ijt} \equiv C'_{ij}[x_{ij}(p_t, E_t)]$ denotes the time-dependent marginal costs.

We aggregate this equation across firms in each country by multiplying by s_{jt}^i and summing over j :

$$\ln p_{it} = \ln C'_{it} + \sum_{j \in J_{it}} s_{jt}^i \ln \left[1 + \frac{(s_{jt}^i s_{it}) N_t}{\gamma(N_t - 1)} \right], \quad (18)$$

where $\ln p_{it}$ is again the geometric mean of prices, and $\ln C'_{it} \equiv \sum_{j \in J_{it}} s_{jt}^i \ln C'_{ijt}$ is the geometric mean of marginal costs in country i . In order to evaluate this expression, we need to bring the summation (like an expectation) within the log expression, which means that we are ignoring Jensen's inequality; we argue below that this is a second-order approximation. In that case, we obtain the final form of our pricing equation:

$$\ln p_{it} \approx \ln C'_{it} + \ln \left[1 + \frac{H_{it} s_{it} N_t}{\gamma(N_t - 1)} \right]. \quad (19)$$

The pro-competitive effect is obtained by substituting the pricing equation (19) into (10). The resulting expression involves both share-weighted and unweighted geometric means of the firm prices, because the shares $\bar{s}_{ij\tau}$ in (11) are an additive transformation of the shares $s_{ij\tau}$. In practice we will not be able to distinguish weighted and unweighted firm prices, and simply use import unit-values for either. So to eliminate this distinction in the theory, we strengthen our earlier assumption that countries supplying in both periods have unchanging sets of variety, $J_{it} \equiv \bar{J}_i$ for $i \in \bar{I}$. Specifically, we now assume that if there is no entry or exit of firms in a country, the firm shares are *equal and unchanging* within each such country:

$$s_{j\tau}^i = \frac{1}{\bar{N}_i}, \text{ for } i \in \bar{I}, \tau = t-1, t. \quad (20)$$

Notice that the *country shares* s_{it} still change for countries selling in both periods, so that (20) specifies that firms within these countries $i \in \bar{I}$ do not change size relative to their country sales. In that case, the pro-competitive effect is written as follows:

Theorem 2

The pricing equation (19) is obtained as a second-order approximation to (18) around the point where $s_{it} N_t / \gamma(N_t - 1) = 0$ and (20) holds. Then using (19) and (20), the pro-competitive effect P is:

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = \sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) (\ln C'_{it} - \ln C'_{it-1}) + V + P,$$

with the shares $\bar{s}_{it} \equiv s_{it} + \frac{\bar{N}_i}{N} \left(1 - \sum_{i \in \bar{I}} s_{it}\right)$, for $i \in \bar{I}$ and $\tau = t-1, t$, and,

$$P \equiv \sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) \left\{ \ln \left[1 + \frac{H_{it} s_{it} N_t}{\gamma(N_t - 1)} \right] - \ln \left[1 + \frac{H_{it-1} s_{it-1} N_{t-1}}{\gamma(N_{t-1} - 1)} \right] \right\}. \quad (21)$$

Using $\ln(1+x) \approx x$, the pro-competitive effect is approximated as:

$$P \approx V + \left(\frac{1}{2\gamma}\right) \sum_{i=1}^M (H_{it} s_{it}^2 - H_{it-1} s_{it-1}^2) + \frac{1}{2\gamma} \sum_{i \in \bar{I}} (\bar{s}_{it} + \bar{s}_{it-1}) \left[\frac{H_{it} s_{it}}{(N_t - 1)} - \frac{H_{it-1} s_{it-1}}{(N_{t-1} - 1)} \right]. \quad (22)$$

Equation (21) is the final form for the pro-competitive impact that we will evaluate, while (22) allows us to see that it lowers the exact price index by more than the partial variety effect, whenever the additional terms on the right of (22) are negative. Focusing on the second term on the right, then we can see that the pro-competitive effect lowers the price index by more than the partial variety effect provided that $\sum_{i=1}^N H_{it} s_{it}^2$ is falling over time. It is useful to give a more precise interpretation to the term $\sum_{i=1}^N H_{it} s_{it}^2$. Recalling that the Herfindahl indexes are

$H_{it} \equiv \sum_{j \in J_{it}} (s_{jt}^i)^2$, we see that:

$$\sum_{i=1}^M H_{it} s_{it}^2 = \sum_{i=1}^M \sum_{j \in J_{it}} (s_{jt}^i)^2 s_{it}^2 = \sum_{i=1}^M \sum_{j \in J_{it}} s_{ijt}^2 \equiv H_t^k. \quad (23)$$

In words, the sum of the Herfindahl firm indexes weighted by the squared country shares, on the left of (23), is exactly the right way to aggregate these indexes to obtain an *overall Herfindahl for the good k in question*, on the right of (23). We therefore see that a falling *overall Herfindahl* contributes to lowering the pro-competitive impact on prices even further.

5. Estimation and Results

We turn now to estimation of the translog parameter γ . We will specify that average costs from each exporting country take on the iso-elastic form:

$$\ln C'_{ijt} = \omega_{i0} + \omega \ln \left(\frac{s_{it} E_t}{p_{it}} \right) + \delta_{it},$$

where the term $(s_{it} E_t / p_{it})$ reflects the total quantity exported from country i , and δ_{it} is an error term. Substituting into (19), we obtain a modified pricing equation:

$$(1 + \omega) \ln p_{it} = \omega_{i0} + \omega \ln s_{it} + \omega \ln E_t + \ln \left[1 + \frac{H_{it} s_{it} N_t}{\gamma (N_t - 1)} \right] + \delta_{it}. \quad (24)$$

We see that the translog parameter γ appears in both the share equation (15) and the pricing equation (24): larger γ means that the goods are stronger substitutes and the markups are correspondingly smaller. It is also evident that the shares and prices are endogenously determined: shocks to either supply δ_{it} or demand ε_{it} will both be correlated with shares s_{it} and prices p_{it} . To control for this endogeneity will we estimate these equations simultaneously using a similar methodology to that proposed in the CES case by Feenstra (1994) and extended by Broda and Weinstein (2006).

The first step in our estimation is to difference (15) and (24) with respect to country k and with respect to time, thereby eliminating the terms $a_i + a_t$ and the overall average prices $\overline{\ln p_t}$ appearing in the share equations, and eliminating total expenditure $\ln E_t$. We also divide the share equation by γ and the pricing equation by $(1 + \omega)$, and then express each equation in terms of its error term:

$$\frac{(\Delta \varepsilon_{it} - \Delta \varepsilon_{kt})}{\gamma} = \frac{[\Delta(H_{it} s_{it}) - \Delta(H_{kt} s_{kt})]}{\gamma} + (\Delta \ln p_{it} - \Delta \ln p_{kt}),$$

$$\begin{aligned} \frac{(\Delta\delta_{it} - \Delta\delta_{kt})}{(1 + \omega)} &= (\Delta \ln p_{it} - \Delta \ln p_{kt}) - \frac{\omega(\Delta \ln s_{it} - \Delta \ln s_{kt})}{(1 + \omega)} \\ &\quad - \frac{1}{(1 + \omega)} \left\{ \Delta \ln \left[1 + \frac{H_{it}S_{it}N_t}{\gamma(N_t - 1)} \right] - \Delta \ln \left[1 + \frac{H_{kt}S_{kt}N_t}{\gamma(N_t - 1)} \right] \right\}. \end{aligned}$$

We multiply these two equations together, and average the resulting equation over time, to obtain the estimating equation:

$$\bar{Y}_i = \frac{\omega}{(1 + \omega)} \bar{X}_{1i} + \frac{\omega}{\gamma(1 + \omega)} \bar{X}_{2i} - \left(\frac{1}{\gamma} \right) \bar{X}_{3i} + \frac{1}{(1 + \omega)} \bar{Z}_{1i}(\gamma) + \frac{1}{\gamma(1 + \omega)} \bar{Z}_{2i}(\gamma) + \bar{u}_i, \quad (25)$$

where the over-bar indicates that we are averaging that variable over time, and:

$$Y_{it} \equiv (\Delta \ln p_{it} - \Delta \ln p_{kt})^2,$$

$$X_{1it} \equiv (\Delta \ln s_{it} - \Delta \ln s_{kt})(\Delta \ln p_{it} - \Delta \ln p_{kt}),$$

$$X_{2it} \equiv (\Delta \ln s_{it} - \Delta \ln s_{kt})[\Delta(H_{it}S_{it}) - \Delta(H_{kt}S_{kt})],$$

$$X_{3it} \equiv (\Delta \ln p_{it} - \Delta \ln p_{kt})[\Delta(H_{it}S_{it}) - \Delta(H_{kt}S_{kt})],$$

$$Z_{1it}(\gamma) \equiv \left\{ \Delta \ln \left[1 + \frac{H_{it}S_{it}N_t}{\gamma(N_t - 1)} \right] - \Delta \ln \left[1 + \frac{H_{kt}S_{kt}N_t}{\gamma(N_t - 1)} \right] \right\} (\Delta \ln p_{it} - \Delta \ln p_{kt}),$$

$$Z_{2it}(\gamma) \equiv \left\{ \Delta \ln \left[1 + \frac{H_{it}S_{it}N_t}{\gamma(N_t - 1)} \right] - \Delta \ln \left[1 + \frac{H_{kt}S_{kt}N_t}{\gamma(N_t - 1)} \right] \right\} (\Delta H_{it}S_{it} - \Delta H_{kt}S_{kt}).$$

and,

$$u_{it} \equiv \frac{(\Delta\varepsilon_{it} - \Delta\varepsilon_{kt})(\Delta\delta_{it} - \Delta\delta_{kt})}{\gamma(1 + \omega)}.$$

We shall assume that the error terms in demand and the pricing equation are uncorrelated, which means that the error term in (25) becomes small, $\bar{u}_i \rightarrow 0$ in probability limit as $T \rightarrow \infty$.

That error term is therefore uncorrelated with any of the right-hand side variables as $T \rightarrow \infty$, and we can exploit those moment conditions by simply running OLS on (25). Feenstra (1994) shows that procedure will give us consistent estimates of γ and ω in a slightly simpler system, provided

that the right-hand side variables in (25) are not perfectly collinear as $T \rightarrow \infty$. As in the CES case of Feenstra (1994), that condition will be assured if there is some heteroskedasticity in the error terms across countries i . More efficient estimates can be obtained by running weighted least squares on (28).

We had to solve a number of data problems before proceeding. First, while, theoretically we could have estimated γ at the 10-digit level, but in practice this is impossible because we do not have enough 10-digit varieties in most sectors. In order to make sure that we had enough data to obtain precise estimates, we decided to assume that the γ s at the 10-digit level within an HS-4-digit sector were the same. This assumption meant that we typically had 99 varieties when we estimated a γ for an HS-4 sector.

A second complication arises because we have U.S. shipments data at the NAICS-6 digit level but we need to compute shares at the HS-10 digit level. Thus, we had to allocate NAICS-6 production data to each HS-10 sector. In order to do this, we assumed that the share of U.S. production in each HS-10 was the same as that of the U.S. in the NAICS-6 digit sector that contains it, as discussed in the data Appendix.

A third complication arises because we use unit-values of import prices from each source country rather than the geometric mean, which introduces measurement error, especially for import flows that are very small. Broda and Weinstein (2006) propose a weighting scheme based on the quantity of imports at the HS-10 level. Unfortunately, we could not implement precisely that scheme because the U.S. quantity indexes were defined at the NAICS-6 digit level and not at the HS-10 digit level. We therefore decided to implement the Broda and Weinstein weighting scheme using value of shipments instead of quantity of shipments, since shipment values are likely to be highly correlated with shipment quantities.

Finally, as in Broda and Weinstein (2006), we also faced the problem that only 86 percent of our estimates of γ had the right sign if we estimate them without constraints. If γ is less than zero, then this implies that demand is inelastic and the welfare gains associated from new and disappearing varieties are infinite. Since we wanted to rule this out and because the formula for V is very sensitive to small values of γ , we decided to place a constraint on γ limiting it to have a smallest value of 0.05. In order to do this, we used a grid search procedure over γ and ω to minimize the sum squared errors in equation (25). In this procedure we set an initial γ of 0.05 and increased it by 10 percent over the range $[.05, 110]$. Similarly, we set an initial ω of -5 and increased it by 0.1 over the range $[-5, 15]$.

Plots of the Data

Equations (12) and (21) are the key equations for understanding how new varieties affect consumers through increased choice and lower markups. Before we present the final results, it is worth going through the components so that we can understand the forces at play.

We begin with the partial variety effect, V , in (15). Its coefficient $1/2\gamma$ captures the fact that consumers care more about goods that are inelastically demanded (i.e. have low γ 's) than goods that have close substitutes. The term in curly brackets in (15) can be understood by breaking it up into its components. First, $H_{it}s_{it}$ is the typical firm's market. In order to compute the net impact of variety creation and destruction, we need to aggregate these, but we place more weight on goods that have higher market shares than those with lower shares. As a result, we aggregate these across varieties by weighting them by s_{it} and create $\sum_{i \in I} H_{it}s_{it}^2$. Essentially, the partial variety effect will have negative effect on the price level if the market share of new entrants is, on average, larger than that of firms that exit. Likewise, the second term in curly

brackets measures the country share of new suppliers versus disappearing supplies. Thus, equation (12) indicates that the partial variety effect will be driven by how important new varieties are in demand.

Before we turn to the estimation, we can obtain some intuition for what our results will be by plotting the distribution of $2\gamma V$, which corresponds to the negative of the term in curly brackets in (12). Since $\gamma > 0$, the sign of the variety change will be the same as the sign of $2\gamma V$ but requires no estimation. Since we simply observe Herfindahls and not firms, we decided to define a new variety as the appearance or disappearance of an HS-10 digit export from a country or whenever the Herfindahl in 2005 relative to that in 1992 fell in the range of $[1/1.3, 1.3]$. We will explore the robustness of our results to this criterion later, but this seems like a reasonable starting point. Figure 4a plots the distribution of $2\gamma V$. The distribution is fairly symmetric although there appears to be a slightly negative mass.¹⁰ Indeed, both the median and the mean are negative (-0.13 and -0.28 percent) confirming our visual impression of the data.

If we ignore the third term in (22) and remember that $2\gamma V$ is also not a function of any parameter, we can see that we can also express our approximation of $2\gamma P$ as purely a function of the raw data. We plot this distribution in Figure 4b. As one can see from the histogram, the distribution of $2\gamma P$ is much more sharply shifted to the left. The median and mean are -0.14 and -2.3 percent respectively, suggesting fairly substantial potential markup effects as long as gamma is not too large.

Finally, Figure 4c plots the distribution of $\sum_{i=1}^M (H_{it} s_{it}^2 - H_{it-1} s_{it-1}^2)$ which corresponds to $2\gamma(P - V)$, ignoring for the moment the last term in (25). This value tells us the unweighted

¹⁰ There are a few larger positive and negative outliers that we do not show in any version of Figure 4 because they would compress the distribution too much. All of our results are robust to dropping the top and bottom 1 percent of the V distribution.

impact of firm market shares on markups. Again the mass of this distribution is greater to the left of the zero indicating that firm market shares fell on average during this period which put downward pressure on prices in addition to that due to entry. In order to understand the full impact of these changes on welfare, we need to estimate γ for each sector.

Estimation Results

Because we ultimately estimated over one thousand γ s, it is not possible to display all of them here. We display the sample statistics for γ in Table 2. The median γ was 0.25 and the average was 14. The large average γ is driven by the fact that their distribution is not symmetric and γ can take on very large values. It is difficult to have strong priors for what a reasonable value of gamma should be. One way possible benchmark is the implied markup. Given that the median U.S. Herfindahl in 2005 was 0.25 and the U.S. market share of the U.S. market was 0.67, our estimated gamma implies that the typical U.S. firm the merchandise sector had a markup of 0.50 which is not that different from other studies of markups in manufacturing (c.f. Domowitz, Hubbard, and Petersen, 1988).

It is difficult to have good intuition for the values of γ because the markup depends on the value of the firm's market share as well. However, we can get some sense of the reasonableness of our estimates by looking at the most important sectors in U.S. absorption. In Table 3, we report the share of U.S. absorption from the ten largest sectors, where we define the share to be the average share of absorption in 1992 and 2005. In the first column we report our estimate of γ , and in the second column we report the implied markup for a firm with a 5 percent share of the U.S. market. Based on this measure, we estimate that three sectors in which firms are likely to have the most market power are wooden furniture, aircraft, and passenger vehicles. On the other

hand, firms are likely to have the least market power in crude petroleum, natural gas, and other gaseous hydrocarbons. This pattern in the markups seems broadly sensible.

We now are ready to present aggregate estimates of P and V for all merchandise consumed in the U.S.. In order to do this, we aggregated P and V computed at the HS-4 level according to the following formula

$$\hat{P} = \sum_k \frac{1}{2}(s_{kt} + s_{kt-1})P_k \text{ and } \hat{V} = \sum_k \frac{1}{2}(s_{kt} + s_{kt-1})V_k \quad (26)$$

where we reintroduce the sectoral subscript, k, and hence P_k and V_k are the values for P and V computed at the HS-4 level and $s_{k\tau}$ is the share of that sector in U.S. absorption. Our baseline estimate for P and V are -0.0173 and -.0154, which means that the partial gain from varieties is about 1.54 percentage points and the associated decline in markups due to new varieties is 1.73 percentage points. Thus the combined impact is to lower the U.S. merchandise price index by 3.3 percentage points between 1992 and 2005. Given that U.S. merchandise demand constituted 18.5 percent of GDP in 2002, this corresponds to a 0.61 percent gain for U.S. consumers.¹¹ Of this gain, 0.32 percentage points comes from lower markups and the remaining 0.28 percentage points comes from the pure variety effect.¹²

We can obtain some intuition for these numbers by returning the results we presented in the discussion of Figures 4a and 4b. There, we found that the mean value of $2\gamma V$ was -0.28 percent and the mean value of $2\gamma P$ was -2.3 percent. If we simply apply our median estimates of γ to these numbers, we would obtain a partial variety impact on prices of -0.5 percent and partial markup effect of -4.4 percent and therefore an aggregate impact of -5.0 percent. This is somewhat larger in magnitude than the -3.3 percent we estimate and suggests that full

¹¹ We define merchandise demand as U.S. GDP in agriculture, mining, and manufacturing less exports plus imports in those sectors.

¹² The numbers do not sum up to the total due to rounding.

distribution of γ s serves to lower our point estimate to some extent but that the estimates are reasonable given the values of $2\gamma_P$ and $2\gamma_V$ and the median value of γ .

In Table 4 we present some robustness tests of estimated impacts. The first robustness check consists of varying the sensitivity of the estimates to the cutoff Herfindahl we use to determine whether a country is in the set \bar{I} or not, i.e. whether it is a “common” country in both time periods with unchanged export shares. In our baseline case we examined fluctuations in the Herfindahl of [.77, 1.3], but we also examined fluctuations of as tight as [.91, 1.1] and as loose as [.67, 1.5]. These are reported in the first three rows of Table 4. Theoretically our aggregate estimates should be invariant to this cutoff, although in practice we see some sensitivity. The sensitivity arises for a number of reasons. First as we tighten the Herfindahl criterion, we lose some sectors because we no longer have any “common” countries, and hence Theorem 1 cannot be applied. For example, there are 21 more sectors when we use a criterion of [.77, 1.3] than when we use [.91, 1.1]. Secondly, our estimation relies on the assumption that the number of firms equals the inverse of the Herfindahl, which is not exact.

The fact that V tends to rise and then fall in Table 4 as we change the cutoff can be explained by looking at the second term in curly brackets in (12). If we have a very tight cutoff for “common” countries, then a large share of the trade flows will be new or disappearing and the corresponding shares of new and disappearing goods in the second term will *both* approach one. Thus V will tend to be small because the difference between two squared share terms will approach zero. If the cutoff is very loose, however, then this will mean that the number of common firms, \bar{N} , will be large and V will also tend to be small. Thus, the partial variety effect is dependent on the cutoff we choose.

Comparison with CES Case

Our baseline estimate of the impact of new goods and changing markups on prices is 3.3 percent, although depending on the cutoff for common goods this estimate can be as low as 2 percent, shown in the fourth row of Table 4 (we do not regard the estimates in the 1st and 5th rows as reliable). The magnitudes of these numbers are perhaps easiest to understand relative to Broda and Weinstein's (2006) estimates for the period 1990 to 2001. Those authors used a CES aggregator and obtained a gain to consumers of 0.8 percent over the 1990-2001 period. That is slightly higher than the 0.61 percent estimate in this paper, i.e. 3.3 percentage points times the 0.185 share of merchandise in overall consumption. But the two estimates are not directly comparable because Broda and Weinstein used both a different functional form (CES) and assumed that there was no firm entry or exit in sectors in which a country exported in the beginning and end of the sample. Interestingly, when Broda and Weinstein tried to calibrate their estimates to a model in which there was endogenous exit in response to new entry, they obtained an adjusted estimate of 0.67 percentage points which is remarkably close to the aggregate estimates obtained in this paper. This suggests that the aggregate welfare gains are quite similar in the two papers.

Nevertheless there are some important differences. In particular, while the CES aggregator ascribes all of the welfare gain to new varieties, the pure impact of new varieties is only one third as large. By contrast, over half of the gain due to new varieties is due to declines in markups in the translog case. Indeed, trade has its most important impacts through this channel in the translog setup. We can obtain some sense of important the pure functional form assumptions are by setting the Herfindahls of all countries equal to their 1992 values and recalculating the variety gain. In this case, we are assuming, as in Feenstra (1994) and Broda and

Weinstein (2006), that the only source of new varieties is the entry and exit of all firms from in an individual product market. Eliminating the impact of firm entry and exit within sectors gives us a variety impact on the price level of 0.4 percent – only a third as big as before. This suggests that the translog functional form tends to ascribe a much smaller role for variety than the CES.

This, however, is not the whole story. The translog also suggests that the impact on prices from reduced markups is -1.2 percent so that the total impact on prices -1.6 percent, and the impact on welfare is 0.3 percent. This is an aggregate impact that is roughly one third as large as the CES case and indicates importance of two biases in the CES case. First the CES functional form tends to result in larger effects of new varieties, but second, the CES is biased upwards by not including the impacts of firm exit and entry on markups.

A second major difference between the translog and CES case is that the translog case makes explicit adjustments for changes in domestic firm-level entry and exit. To get some sense of how important this is for our results, we can recompute P and V setting only the Herfindahls equal to their 1992 values. This is equivalent to running a counterfactual in which we consider what would have happened if the set of U.S. firms had not changed, but foreign entry and exit decisions had occurred as they did in reality. One of the notable features of this experiment is that P falls to -3.3 percent – almost double what it was in the baseline case. This suggests that had U.S. firms not exited manufacturing, foreign competition would have driven down U.S. margins by twice as much. Thus a major reason why foreign competition did not drive U.S. prices down by more was that U.S. firms exited the merchandise sector.

5. Conclusions

Our results suggest that in order to understand the role played by new varieties in the global economy at a macro level, it is important to understand what has been happening at the

firm level. The tremendous amount of entry of foreign countries into U.S. markets has been offset to some degree by the exit of firms within countries. Nevertheless we find that the level of exit has not been sufficiently large to offset the gains from new varieties.

We also find that while the translog specification suggests that the pure variety effects are smaller than the CES specification, this is largely offset by the fact that the translog specification allows for substantial markup effects. As a result of these markup effects the point estimates of the CES and translog are quite similar with the major difference being where the two functional forms assign the gains and losses.

Appendix A: Proofs of Theorems

Proof of Theorem 1:

For convenience we denote the firm-country pairs (i,j) instead by just the product index i , where products $i=1,\dots,N$ are available in period $t-1$ or t . These are divided into two (overlapping) sets: the products $i \in I_\tau$ sell in period $\tau = t-1,t$; with their union $I_{t-1} \cup I_t = \{1,\dots,N\}$ and non-empty intersection $I_{t-1} \cap I_t \neq \emptyset$. We shall let $\bar{I} \subseteq I_{t-1} \cap I_t \neq \emptyset$ denote any non-empty subset of their intersection, and without loss of generality we order the goods so that the first N_1 goods denoted $i=1,\dots,N_1$ are in \bar{I} , and therefore available both periods (N_1 equals \bar{N} as used in the text); while the next N_2 goods denoted $i=N_1+1,\dots,N$ are available in either one or both periods, but are not in \bar{I} . These two categories exhaust the N goods, $N=N_1+N_2$. The expenditure function is as shown in equations (5) – (8), and Törnqvist price index is,

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = \sum_{i=1}^N \frac{1}{2}(s_{it} + s_{it-1})(\ln p_{it} - \ln p_{it-1}).$$

Let B denote the $N \times N$ matrix $B = -\gamma I_N + (\gamma/N)L_{N \times N}$, where I_N is the $N \times N$ identity matrix and L_N is an $N \times N$ matrix with all elements equal to unity. We partition the B matrix into the same two mutually exclusive groups, and likewise for the vector a :

$$a = \begin{bmatrix} a^1 \\ a^2 \end{bmatrix}, \text{ and } B = \begin{bmatrix} B^{11} & B^{12} \\ B^{21} & B^{22} \end{bmatrix}.$$

The diagonal elements in the matrix B are $B^{kk} = -(\gamma/N)[N I_{N_k} - L_{N_k \times N_k}]$, and the off-diagonal elements are $B^{12} = B^{21} = (\gamma/N)[L_{N_1 \times N_2}]$. Similarly, we partition the share vectors $s_\tau^1 = (s_{1\tau}, \dots, s_{N_1,\tau})'$ and $s_\tau^2 = (s_{N_1+1,\tau}, \dots, s_{N\tau})'$, and likewise for the price vectors p_τ^1 and p_τ^2 , $\tau=t-1,t$. If $\bar{I} = I_{t-1} \cap I_t$, then all the goods $i=N_1+1,\dots,N$ are new or disappearing, with either

$s_{it-1}^2 = 0$ or $s_{it}^2 = 0$. More generally, with $\bar{I} \subset I_{t-1} \cap I_t$ then *some* of the goods $i = N_1+1, \dots, N$ are new or disappearing, with zero share. So we use the notation \tilde{p}_τ^2 to denote the reservation prices for those goods with zero share in period $\tau = t-1, t$, but the same vector uses *actual* prices for those goods with positive shares.

Then the share equations in periods $t-1$ and t for the goods $i = N_1+1, \dots, N$ are:

$$\begin{aligned} s_{t-1}^2 &= a^2 + B^{21} \ln p_{t-1}^1 + B^{22} \ln \tilde{p}_{t-1}^2, \\ s_t^2 &= a^2 + B^{21} \ln p_t^1 + B^{22} \ln \tilde{p}_t^2, \end{aligned}$$

where some of these shares can be zero. From these equations we solve for the reservation prices for new and disappearing goods (and actual prices for the goods with positive shares):

$$B^{22} \ln \tilde{p}_{t-1}^2 = (s_{t-1}^2 - a^2 - B^{21} \ln p_{t-1}^1),$$

and,

$$B^{22} \ln \tilde{p}_t^2 = (s_t^2 - a^2 - B^{21} \ln p_t^1).$$

It follows that,

$$(\ln \tilde{p}_t^2 - \ln \tilde{p}_{t-1}^2) = [B^{22}]^{-1} [(s_t^2 - s_{t-1}^2) - B^{21} (\ln p_t^1 - \ln p_{t-1}^1)]. \quad (\text{A1})$$

Substituting (A1) into the Törnqvist price index, we obtain:

$$\begin{aligned} \ln \left(\frac{e_t}{e_{t-1}} \right) &= \frac{(s_t^1 + s_{t-1}^1)'}{2} (\ln p_t^1 - \ln p_{t-1}^1) - \frac{1}{2} (s_t^2 + s_{t-1}^2)' [B^{22}]^{-1} B^{21} (\ln p_t^1 - \ln p_{t-1}^1) \\ &\quad + \frac{1}{2} (s_t^2 + s_{t-1}^2)' [B^{22}]^{-1} (s_t^2 - s_{t-1}^2) \end{aligned} \quad (\text{A2})$$

From the definition of matrix B , the matrix appearing in (A1) can be written as:

$$B^{22} = - \left(\frac{\gamma}{N} \right) [N \ I_{N_2} - L_{N_2 \times N_2}], \quad (\text{A3})$$

where $[N \ I_{N_2} - L_{N_2 \times N_2}]$ has an eigenvector $L_{N_2 \times 1}$ with the associated eigenvalue of N_1 , so its inverse matrix has the reciprocal eigenvalue. Then by definition of B^{21} we can simplify the second term on the right of (A2) as:

$$\begin{aligned}
& -\frac{1}{2}(s_t^2 + \tilde{s}_{t-1}^2)' [B^{22}]^{-1} B^{21} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \frac{1}{2}(s_t^2 + s_{t-1}^2)' \left(\frac{N}{\gamma} \right) [N I_{N_2} - L_{N_2 \times N_2}]^{-1} B^{21} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \frac{1}{2}(s_t^2 + s_{t-1}^2)' [N I_{N_2} - L_{N_2 \times N_2}]^{-1} L_{N_2 \times N_1} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \left(\frac{1}{2N_1} \right) (s_t^2 + s_{t-1}^2)' L_{N_2 \times N_1} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \left(\frac{1}{2N_1} \right) \begin{bmatrix} \sum_{i=N_1+1}^N (s_{it} + s_{it-1}) \\ \vdots \\ \sum_{i=N_1+1}^N (s_{it} + s_{it-1}) \end{bmatrix}' (\ln p_t^1 - \ln p_{t-1}^1).
\end{aligned}$$

Notice that $\frac{1}{2} \left(\sum_{i=N_1+1}^N (s_{it} + s_{it-1}) \right)$ equals $1 - \frac{1}{2} \left(\sum_{i=1}^{N_1} s_{it} + s_{it-1} \right)$. Substituting these results into the right-hand side of (A2), we can combine the first and second terms as:

$$\begin{aligned}
& \frac{(s_t^1 + s_{t-1}^1)'}{2} (\ln p_t^1 - \ln p_{t-1}^1) - \frac{1}{2}(s_t^2 + s_{t-1}^2)' [B^{22}]^{-1} B^{21} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \left\{ \frac{(s_t^1 + s_{t-1}^1)'}{2} + \left(\frac{1}{N_1} \right) \begin{bmatrix} 1 - \frac{1}{2} \left(\sum_{i=1}^{N_1} s_{it} + s_{it-1} \right) \\ \vdots \\ 1 - \frac{1}{2} \left(\sum_{i=1}^{N_1} s_{it} + s_{it-1} \right) \end{bmatrix}' \right\} (\ln p_t^1 - \ln p_{t-1}^1) \\
&= \sum_{i=1}^{N_1} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) (\ln p_{it}^1 - \ln p_{it-1}^1),
\end{aligned}$$

where,

$$\bar{s}_{i\tau} \equiv s_{i\tau} + \frac{1}{N_1} \left(1 - \sum_{i=1}^{N_1} s_{i\tau} \right), \text{ for } i = 1, \dots, N_1, \text{ and } \tau = t-1, t.$$

Reintroducing the notation (i,j) to denote each product, and noting that N_1 equals \bar{N} as used in the text, this gives us equation (11).

The final term in (A2) is also simplified using (A3). Substituting for B^{22} and dropping the negative sign for notation convenience, the final term in (A3) becomes:

$$\begin{aligned}
& \left(\frac{1}{2\gamma}\right)(s_t^2 + s_{t-1}^2)' \left[I_{N_2} - \left(\frac{1}{N}\right) L_{N_2 \times N_2} \right]^{-1} (s_t^2 - s_{t-1}^2)' \\
&= \left(\frac{1}{2\gamma}\right)(s_t^2 + s_{t-1}^2)' \left\{ I_{N_2} + \left(\frac{1}{N}\right) L_{N_2 \times N_2} + \left(\frac{1}{N}\right)^2 L_{N_2 \times N_2}^2 + \left(\frac{1}{N}\right)^3 L_{N_2 \times N_2}^3 \dots \right\} (s_t^2 - s_{t-1}^2)' \\
&= \left(\frac{1}{2\gamma}\right) \left\{ \sum_{i=N-N_2}^N [(s_{it})^2 - (s_{it-1})^2] + \left(\frac{1}{N}\right) \left[\left(\sum_{i=N-N_2}^N s_{it} \right)^2 - \left(\sum_{i=N-N_2}^N s_{it-1} \right)^2 \right] \left[1 + \left(\frac{N_2}{N}\right) + \left(\frac{N_2}{N}\right)^2 + \dots \right] \right\} \\
&= \left(\frac{1}{2\gamma}\right) \left\{ \sum_{i=N-N_2}^N [(s_{it})^2 - (s_{it-1})^2] + \left(\frac{1}{N_1}\right) \left[\left(\sum_{i=N-N_2}^N s_{it} \right)^2 - \left(\sum_{i=N-N_2}^N s_{it-1} \right)^2 \right] \right\}.
\end{aligned}$$

Again reintroducing the notation (i,j) to denote each product, and noting $i = N-N_2, \dots, N$ are not in the set \bar{I} this gives us equation (12). QED

Proof of Theorem 2:

First, we need to show that (19) is a second-order approximation to (18), around the point where (20) holds and $(1/\gamma)=0$. To this end, write the term on the right of (18) as $\sum_j s_{jt}^i \ln(1 + s_{jt}^i x)$, with $x = s_{it} N_t / \gamma(N_t - 1)$. We wish to show that the first and second derivatives of this function with respect to s_{jt}^i and x equal the first and second derivatives of $\ln[1 + \sum_j (s_{jt}^i)^2 x]$, evaluated at the point where (20) holds and $x = 0$. We have:

$$\begin{aligned}
\frac{\partial}{\partial s_{jt}^i} \Big|_{\substack{(23) \\ x=0}} \sum_j s_{jt}^i \ln(1 + s_{jt}^i x) &= 0 = \frac{\partial}{\partial s_{jt}^i} \Big|_{\substack{(23) \\ x=0}} \ln[1 + \sum_j (s_{jt}^i)^2 x] \\
\frac{\partial^2}{\partial s_{kt}^i \partial s_{jt}^i} \Big|_{\substack{(23) \\ x=0}} \sum_j s_{jt}^i \ln(1 + s_{jt}^i x) &= 0 = \frac{\partial^2}{\partial s_{kt}^i \partial s_{jt}^i} \Big|_{\substack{(23) \\ x=0}} \ln[1 + \sum_j (s_{jt}^i)^2 x] \\
\frac{\partial}{\partial x} \Big|_{\substack{(23) \\ x=0}} \sum_j s_{jt}^i \ln(1 + s_{jt}^i x) &= \sum_j (s_{jt}^i)^2 = \frac{\partial}{\partial x} \Big|_{\substack{(23) \\ x=0}} \ln[1 + \sum_j (s_{jt}^i)^2 x]
\end{aligned}$$

$$\frac{\partial^2}{\partial s_{jt}^i \partial x} \Big|_{x=0, (23)} \sum_j s_{jt}^i \ln(1 + s_{jt}^i x) = 2s_{jt}^i = \frac{\partial^2}{\partial s_{jt}^i x} \Big|_{x=0, (23)} \ln[1 + \sum_j (s_{jt}^i)^2 x]$$

$$\frac{\partial^2}{\partial x^2} \Big|_{x=0, (23)} \sum_j s_{jt}^i \ln(1 + s_{jt}^i x) = -\frac{1}{\bar{N}_i^2} = \frac{\partial^2}{\partial x^2} \Big|_{x=0, (23)} \ln[1 + \sum_j (s_{jt}^i)^2 x],$$

where the last line relies on $s_{jt}^i = (1 / \bar{N}_i)$, from (20).

Then using (20), we replace s_{ijt} in (11) by s_{it} / N_i , and use this in (10) to obtain:

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = V + \sum_{i \in \bar{I}} \frac{1}{2} (s_{it} + s_{it-1}) \sum_{j \in \bar{J}_i} \frac{1}{N_i} (\ln p_{ijt} - \ln p_{ij,t-1}) +$$

$$\frac{1}{N} \left(1 - \frac{1}{2} \sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} \frac{s_{it}}{N_i} - \frac{1}{2} \sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} \frac{s_{it-1}}{N_i} \right) \sum_{i \in \bar{I}} \sum_{j \in \bar{J}_i} (\ln p_{ijt} - \ln p_{ij,t-1})$$

$$= V + \sum_{i \in \bar{I}} \frac{1}{2} (s_{it} + s_{it-1}) (\overline{\ln p_{it}} - \overline{\ln p_{it-1}}) + \frac{1}{N} \left(1 - \frac{1}{2} \sum_{i \in \bar{I}} s_{it} - \frac{1}{2} \sum_{i \in \bar{I}} s_{it-1} \right) \sum_{i \in \bar{I}} N_i (\overline{\ln p_{it}} - \overline{\ln p_{it-1}}),$$

where $\overline{\ln p_{it}} \equiv \frac{1}{N_i} \sum_{j \in \bar{J}_i} \ln p_{ijt}$ is the unweighted mean of the log-prices for country j . Again from

assumption (20), these are identical to the weighted mean of log-prices we define in the text,

$\ln p_{it} \equiv \sum_{j \in \bar{J}_i} s_{jt}^i \ln p_{ijt}$. Then using the shares in (11) with (19), we re-write the above result as:

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = V + \sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) (\ln p_{it} - \ln p_{it-1}) = V + \sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) (\ln C'_{it} - \ln C'_{it-1}) + P,$$

with P defined as in (21). Then using $\ln(1 + x) \approx x$, P can be re-written as:

$$\sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) \left\{ \ln \left[1 + \frac{H_{it} s_{it} N_t}{\gamma(N_t - 1)} \right] - \ln \left[1 + \frac{H_{it-1} s_{it-1} N_{t-1}}{\gamma(N_{t-1} - 1)} \right] \right\}$$

$$\approx \sum_{i \in \bar{I}} \frac{1}{2} (\bar{s}_{it} + \bar{s}_{it-1}) \left[\frac{H_{it} s_{it} N_t}{\gamma(N_t - 1)} - \frac{H_{it-1} s_{it-1} N_{t-1}}{\gamma(N_{t-1} - 1)} \right]$$

$$= \frac{1}{2\gamma} \sum_{i \in \bar{I}} (\bar{s}_{it} + \bar{s}_{it-1}) \left[(H_{it} s_{it} - H_{it-1} s_{it-1}) + \frac{H_{it} s_{it}}{(N_t - 1)} - \frac{H_{it-1} s_{it-1}}{(N_{t-1} - 1)} \right]$$

Using the formula for the defined shares in (11), we can re-write P as:

$$\begin{aligned} P &= \frac{1}{2\gamma} \sum_{i \in \bar{I}} \left[(s_{it} + s_{it-1}) + \frac{N_i}{N} \left(\sum_{i \notin \bar{I}} s_{it} + \sum_{i \notin \bar{I}} s_{it-1} \right) \right] (H_{it} s_{it} - H_{it-1} s_{it-1}) \\ &\quad + \frac{1}{2\gamma} \sum_{i \in \bar{I}} (\bar{s}_{it} + \bar{s}_{it-1}) \left[\frac{H_{it} s_{it}}{(N_t - 1)} - \frac{H_{it-1} s_{it-1}}{(N_{t-1} - 1)} \right] \\ &= \frac{1}{2\gamma} \sum_{i \in \bar{I}} (s_{it} + s_{it-1}) (H_{it} s_{it} - H_{it-1} s_{it-1}) + \frac{1}{2\gamma} \left(\sum_{i \notin \bar{I}} s_{it} + \sum_{i \notin \bar{I}} s_{it-1} \right) \sum_{i \in \bar{I}} \frac{N_i}{N} (H_{it} s_{it} - H_{it-1} s_{it-1}) \\ &\quad + \frac{1}{2\gamma} \sum_{i \in \bar{I}} (\bar{s}_{it} + \bar{s}_{it-1}) \left[\frac{H_{it} s_{it}}{(N_t - 1)} - \frac{H_{it-1} s_{it-1}}{(N_{t-1} - 1)} \right] \end{aligned}$$

From (20) note that $H_{it} = H_{it-1} = 1/N_i$ for $i \in \bar{I}$ and using this repeatedly we can simplify P as:

$$\begin{aligned} P &= \frac{1}{2\gamma} \sum_{i \in \bar{I}} (H_{it} s_{it}^2 - H_{it-1} s_{it-1}^2) - \frac{1}{2\gamma N} \left(\sum_{i \notin \bar{I}} s_{it} + \sum_{i \notin \bar{I}} s_{it-1} \right) \left(\sum_{i \notin \bar{I}} s_{it} - \sum_{i \notin \bar{I}} s_{it-1} \right) \\ &\quad + \frac{1}{2\gamma} \sum_{i \in \bar{I}} (\bar{s}_{it} + \bar{s}_{it-1}) \left[\frac{H_{it} s_{it}}{(N_t - 1)} - \frac{H_{it-1} s_{it-1}}{(N_{t-1} - 1)} \right] \end{aligned}$$

Then substituting for V from (12), we obtain the result shown in (22). QED

Appendix B: Data

A challenge for our empirical work was obtaining the Herfindahl indexes for exporters to the U.S., depending on the mode of transport. For land shipments from Canada we purchased Herfindahl indexes at the 4-digit Harmonized system (HS) level, constructed from firm-level export data to the U.S., in the years 1992 and 2005. For Mexico the Herfindahl indexes were constructed as described in the data Appendix. For all other major exporters to the U.S., we computed these Herfindahl for *sea* shipments from PIERS, for 1992 and 2005.

PIERS collects data from the bill of lading for every container that enters a U.S. port. Although purchasing the disaggregated data is prohibitively expensive, we were able to obtain information on shipments to the U.S. for the 50,000 largest exporters to the U.S., for 1992 and 2005. For each exporter and year, we obtained the estimated value, quantity and country of origin of the top five HTS-4 digit sectors in which the firm was active. We also obtained this information for the top ten HTS-4 digit sectors for the largest 250 firms in each year.

The Piers data has a number of limitations relative to other firm level data sets. The first is relatively minor: we do not have the universe of exporters but only the largest ones. This turns out not to be a serious problem because the aggregate value of these exporters is typically within 5 percent of total sea shipments. Thus, smaller exporters are unlikely to have a qualitatively important impact on our results.

A larger problem is that the PIERS data only comprises sea shipments and thus we have no information in these data on land and air shipments. For Canada we obtained the Herfindahl indexes of land exports to the U.S. from Statistics Canada. Constructing the Mexican Herfindahls was somewhat more involved. We were able to obtain information from the *Encuesta Industrial Anual* (Annual Industrial Survey) of the *Instituto Nacional de Estadística y Geografía*. Firm-

level exports for 205 CMAP94 categories for 1993. We also obtained the export Herfindahl for 232 categories at the NAICS 6-digit level. These categories cover the most important Mexican export sectors. We then used a concordance file to match these to HS 4-digit categories. For other countries, the median country exports about 80 percent of its goods by sea. Thus for the typical country in our sample, the sea data covers a large fraction of their exports.

The true Herfindahl of country i 's exports in sector k can be written as

$$H_{it}^k = H_{it}^{kSea} \left(\frac{V_{it}^{kSea}}{V_{it}^{kTotal}} \right)^2 + H_{it}^{kNon-Sea} \left(1 - \frac{V_{it}^{kSea}}{V_{it}^{kTotal}} \right)^2, \quad (B1)$$

where V_{it}^{kSea} (V_{it}^{kTotal}) denotes the value of sea (total) shipments and $H_{it}^{kNon-Sea}$ is the Herfindahl for non-sea exporters, which is defined analogously as the sea Herfindahl. We do not have a measure of $H_{it}^{kNon-Sea}$, but theory does place bounds on the size of the Herfindahl since the true index must be contained in the following set, obtained with $H_{it}^{kNon-Sea} = 1$ or 0 :

$$\left[H_{it}^{kSea} \left(\frac{V_{it}^{kSea}}{V_{it}^{kTotal}} \right)^2, H_{it}^{kSea} \left(\frac{V_{it}^{kSea}}{V_{it}^{kTotal}} \right)^2 + \left(1 - \frac{V_{it}^{kSea}}{V_{it}^{kTotal}} \right)^2 \right].$$

For most sectors the share of sea shipments in total shipments is quite high, so these bounds are quite tight. For the rest of the analysis we will assume that $H_{it}^{kSea} = H_{it}^{kNon-Sea}$, but our results do not change qualitatively if we assume that $H_{it}^{kNon-Sea} = 1$ or 0 .¹³

For the U.S. Herfindahls, we rely on data from the Census of Manufactures, which like the Mexican Herfindahls, are at the NAICS 6-digit level. Unfortunately, this is more aggregate

¹³ One can see this from a simple example. Our median sea Herfindahl is 0.6 and our median share of sea shipments is 0.8. This means that the true Herfindahl ranges from .38 to .42 and our estimate would be 0.41. Nevertheless, we are implicitly assuming that goods shipped by air and goods shipped by sea are not the same. We justify this assumption because it costs substantially more to ship goods by air, and thus the mode of shipment is likely to differentiate the goods in some important ways.

than the 4-digit HS level at which we have the foreign export Herfindahl indexes. Accordingly, we need to convert the U.S. and Mexican Herfindahl indexes from the NAICS 6-digit level to the HS 4-digit level. Slightly abusing our earlier country notation, let $i \in I_k$ denote a 4-digit sector i *within* the NAICS code k . Then the Herfindahl for 4-digit sector i is $H_{it}^k \equiv \sum_{j \in J_i} (s_{jt}^i)^2$, where s_{jt}^i is the share of firm $j \in J_i$ in sector i . We see that the overall Herfindahl in NAICS code k is:

$$\sum_{i \in I_k} H_{it}^k (s_{it}^k)^2 = \sum_{i \in I_k} \sum_{j \in J_i} (s_{jt}^i)^2 (s_{it}^k)^2 = \sum_{j \in J_k} (s_{jt}^k)^2 \equiv H_t^k, \quad (\text{B2})$$

where s_{it}^k is the share of 4-digit HS sector i within NAICS sector k , and $s_{jt}^k = s_{jt}^i s_{it}^k$ is the share of product j within the NAICS sector, $j \in J_k$. In words, the inner-product of the Herfindahl firm indexes and the squared sector shares, on the left of (B2) is exactly the right way to aggregate these indexes to obtain an *overall Herfindahl for the good k in question*, on the right of (B2).

One of the problems that we faced is that we know H_t^k but not H_{it}^k . A solution can be obtained by assuming that H_{it}^k is equal across all 4-digit sectors $i \in k$, in which case we solve for H_{it}^k as:

$$H_{it}^k = H_t^k / \sum_{i \in I_k} (s_{it}^k)^2. \quad (\text{B3})$$

In other words, the 4-digit HS Herfindahl is estimated by dividing the 6-digit NAICS Herfindahl by the corresponding Herfindahl index of 4-digit HS shares within the 6-digit sector. This simple solution assumes that the 4-digit HS Herfindahl indexes are constant within a sector, but is the best that we can do in the absence of additional data.

References

- Badinger, Harald, 2007a, "Has the EU's Single Market Programme Fostered Competition? Testing for a Decrease in Markup Ratios in EU Industries," *Oxford Bulletin of Economics and Statistics*, 69 (4): 497-519
- Badinger, Harald, 2007b, "Market size, Trade, Competition and Productivity: Evidence from OECD Manufacturing Industries." *Applied Economics*, 39 (17): 2143 - 2157.
- Badinger, Harald, 2008. "Trade Policy and Productivity," *European Economic Review*, 52, 867-891.
- Bergin, Paul and Robert C. Feenstra, 2009, "Pass-through of Exchange Rates and Competition Between Fixers and Floaters," *Journal of Money, Credit and Banking*, February, 41(s1), 35-70.
- Behrens, Kristian, Giordano Mion, Yasusada Murata, Jens Südekum, 2008, "Trade, Wages, and Productivity," Institute for the Study of Labor, September.
- Blonigen, Bruce A., Benjamin H. Liebman, and Wesley W. Wilson, 2007, "Trade Policy and Market Power: The Case of the U.S. Steel Industry, NBER working paper no 13761.
- Bresnahan, Timothy F., 1982, "The Oligopoly Solution Concept is Identified," *Economic Letters*, Vol.10: 87-92.
- Bresnahan, Timothy F., 1989, "Empirical Studies of Industries with Market Power," in Richard Schmalensee and Robert Willig, eds., *Handbook of Industrial Organization, Volume 2*. Amsterdam: North-Holland, 1011-57.
- Broda, C. and D. E. Weinstein, 2006, "Globalization and the Gains from Variety," *Quarterly Journal of Economics*, May, 121(2), 541-585.
- Christensen, Laurits R., Dale W. Jorgenson and Lawrence J. Lau, 1975, "Transcendental Logarithmic Utility Functions", *American Economic Review* 65, 367-383.
- Diewert, W. E., 1976, "Exact and Superlative Index Numbers," *Journal of Econometrics*, 4, 115-145.
- Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen, 1988. "Market Structure and Cyclical Fluctuations in U.S. Manufacturing," *The Review of Economics and Statistics*, 70(1), February, 55-66.
- Feenstra, Robert C., 1994, "New Product Varieties and the Measurement of International Prices," *American Economic Review*, 84(1), March, 157-177.

- Feenstra, Robert C. and Clinton Shiells , 1997, "Bias in U.S. Import Prices and Demand," in Timothy Bresnahan and Robert Gordon, eds. *New Products: History, Methodology and Applications*, NBER and Univ. of Chicago Press, 1997, 249-276.
- Harrison, Ann E., 1994, "Productivity, Imperfect Competition and Trade reform: Theory and Evidence," February, 36(1/2), 53-73.
- Hummels, David, 2007, "Transportation Costs and International Trade in the Second Era of Globalization," *Journal of Economic Perspectives* 21, 131-154
- Head, Keith C. and John Ries, 1999, "Rationalization Effects of Tariff Reductions," *Journal of International Economics*, 47(2), April, 295-320.
- Head, Keith C. and John Ries, 2001, "Increasing Returns Versus National Product Differentiation as an Explanation for the Pattern of US-Canada Trade," *American Economic Review*, 91(4), September, 858-876.
- Levinsohn, James, 1993, "Testing the Imports-As-Market-Discipline Hypothesis," *Journal of International Economics*, August, 35(1/2), 1-22.
- Melitz, Marc J., 2003, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695-1725.
- Melitz, Marc J. and Gianmarco I. P. Ottaviano, 2008. "Market Size, Trade, and Productivity," *Review of Economic Studies*, 75(1), 295-316.
- Simonovska, Ina, 2008, "Income Differences and Prices of Tradables," University of Minnesota and University of California, Davis.
- Trefler, Daniel, 2004, "The Long and Short of the Canada-U.S. Free Trade Agreement," *American Economic Review*, 94(4), September, 870-895.
- Tybout, James, R., Jaime de Melo, and Vittorio Corbo, 1991, "The Effects of Trade Reform on Scale and Technical Efficiency: New Evidence from Chile," *Journal of International Economics*, 31(3/4), 231-250.
- Tybout, James R. and M. Daniel Westbrook, 1995, "Trade Liberalization and Dimensions of Efficiency Change in Mexican Manufacturing Industries," *Journal of International Economics*, 39(1/2), 53-78.

Table 1
Ranking in Terms of Share of U.S. Total Absorption

		1992				2005					
Rank	Country	Herfin -dahl Index	Share	Avg. HitSit	Weighted Avg. HitSit	Rank	Country	Herfin -dahl Index	Share	Avg. HitSit	Weighted Avg. HitSit
1	United States	0.229	0.858	0.197	0.157	1	United States	0.252	0.672	0.191	0.165
2	Canada	0.351	0.027	0.046	0.062	2	Canada	0.346	0.059	0.053	0.075
3	Japan	0.454	0.025	0.038	0.039	3	China	0.283	0.043	0.030	0.016
4	Mexico	0.403	0.009	0.017	0.046	4	Mexico	0.409	0.032	0.021	0.065
5	German	0.448	0.007	0.028	0.023	5	Japan	0.473	0.026	0.023	0.058
6	China	0.430	0.007	0.020	0.018	6	German	0.409	0.016	0.025	0.044
7	Taiwan	0.442	0.006	0.013	0.013	7	United Kingdom	0.475	0.009	0.014	0.017
8	South Korea	0.488	0.005	0.007	0.013	8	South Korea	0.445	0.009	0.006	0.018
9	United Kingdom	0.455	0.005	0.019	0.018	9	Venezuala	0.674	0.008	0.006	0.071
10	France	0.522	0.003	0.013	0.020	10	Saudi Arabia	0.756	0.006	0.005	0.044
11	Saudi Arabia	0.683	0.003	0.008	0.050	11	Taiwan	0.431	0.006	0.008	0.015
12	Singapore	0.483	0.003	0.005	0.011	12	France	0.508	0.006	0.012	0.017
13	Italy	0.502	0.003	0.013	0.021	13	Italy	0.437	0.006	0.012	0.010
14	Venezuala	0.647	0.003	0.009	0.025	14	Ireland	0.668	0.006	0.007	0.150
15	Hong Kong	0.389	0.003	0.007	0.007	15	Nigeria	0.639	0.006	0.005	0.025
16	Malaysia	0.540	0.003	0.009	0.018	16	Malaysia	0.568	0.006	0.011	0.012
17	Brazil	0.511	0.002	0.007	0.019	17	Brazil	0.527	0.005	0.009	0.015
18	Thailand	0.526	0.002	0.008	0.015	18	India	0.494	0.004	0.013	0.008
19	Nigeria	0.604	0.002	0.005	0.017	19	Russia	0.574	0.004	0.006	0.015
20	Indonesia	0.497	0.001	0.012	0.021	20	Thailand	0.540	0.003	0.007	0.014
21	Netherlands	0.460	0.001	0.008	0.016	21	Israel	0.591	0.003	0.007	0.012
22	Phillippines	0.534	0.001	0.010	0.016	22	Belgium/Lux	0.494	0.003	0.009	0.044
23	Belgium/Lux	0.478	0.001	0.008	0.014	23	Netherlands	0.472	0.003	0.006	0.013
24	India	0.502	0.001	0.008	0.005	24	Singapore	0.522	0.003	0.003	0.011
25	Switzerland	0.590	0.001	0.007	0.021	25	Indonesia	0.517	0.003	0.010	0.009
26	Sweden	0.601	0.001	0.005	0.009	26	Sweden	0.593	0.003	0.005	0.013
27	Australia	0.616	0.001	0.011	0.028	27	Algeria	0.797	0.002	0.008	0.023
28	Colombia	0.609	0.001	0.003	0.008	28	Switzerland	0.578	0.002	0.006	0.015
29	Israel	0.567	0.001	0.005	0.007	29	Iraq	0.293	0.002	0.016	0.016
30	Angola	0.593	0.001	0.006	0.012	30	Angola	0.561	0.002	0.003	0.009

Note: Averages are taken across sectors.

Table 2

Gamma Distribution		
Statistic	Value	Standard Deviation
Mean	13.73	1.61
Median	0.25	0.01
Median Number of Varieties	98	n/a

Table 3

Gamma Values From Sectors with High Shares of Domestic Absorption			
Hs4	γ	Markup with a 5% market share	Average Share of US Absorption
Passenger Vehicles	0.13	0.37	0.064
Mechanical Vehicle Parts	0.43	0.12	0.045
Crude Petroleum	0.76	0.07	0.037
Computers and Parts	0.20	0.26	0.031
Aircraft	0.09	0.57	0.024
Cell Phones, Camcorders, and Transmitters	0.42	0.12	0.017
Boxes, Sacks, and Bags	0.31	0.16	0.015
Natural Gas	1.56	0.03	0.015
Other Gaseous Hydrocarbons	109.99	0.00	0.014
Wooden Furniture	0.05	1.00	0.013

Table 4

Partial Markup and Variety Effects			
Hs4	P	V	Total (P+V)
HI Ratio of Common Sectors E(1/1.1,1.1)	-0.013	-0.004	-0.017
HI Ratio of Common Sectors E(1/1.2,1.2)	-0.016	-0.013	-0.028
HI Ratio of Common Sectors E(1/1.3,1.3)	-0.017	-0.015	-0.033
HI Ratio of Common Sectors E(1/1.4,1.4)	-0.012	-0.007	-0.019
HI Ratio of Common Sectors E(1/1.5,1.5)	-0.010	-0.004	-0.014
HIs Set to 1992 Values*	-0.012	-0.004	-0.016
US HIs Set to 1992 Values*	-0.033	-0.006	-0.039
Import HIs Set to 1992 Values*	-0.012	-0.012	-0.024

*HI Ratio of Common Sectors E(1/1.3,1.3)

Figure 1

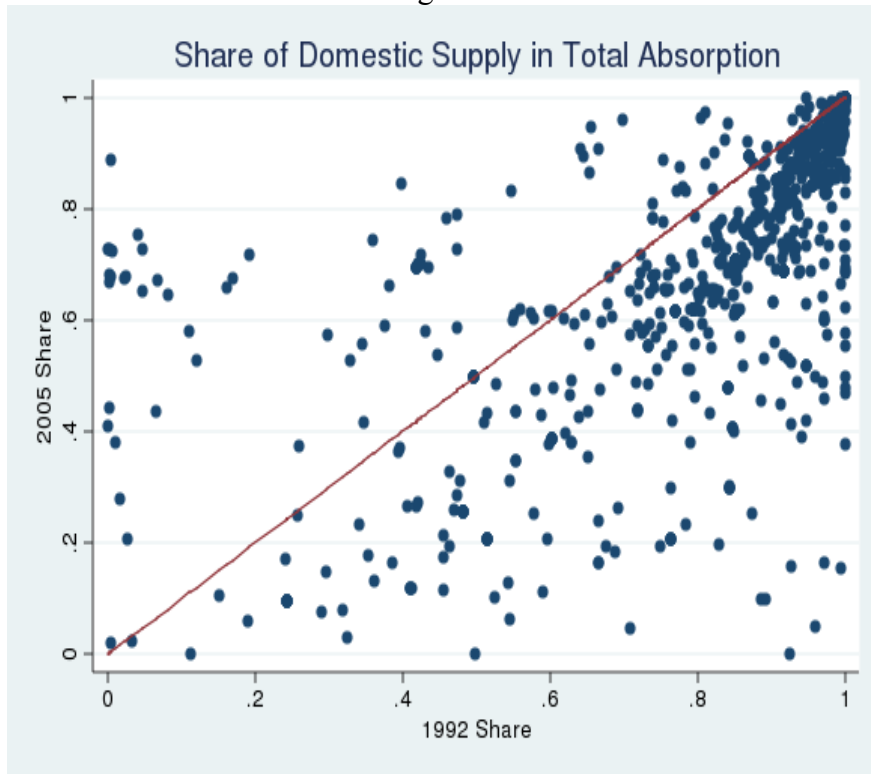


Figure 2

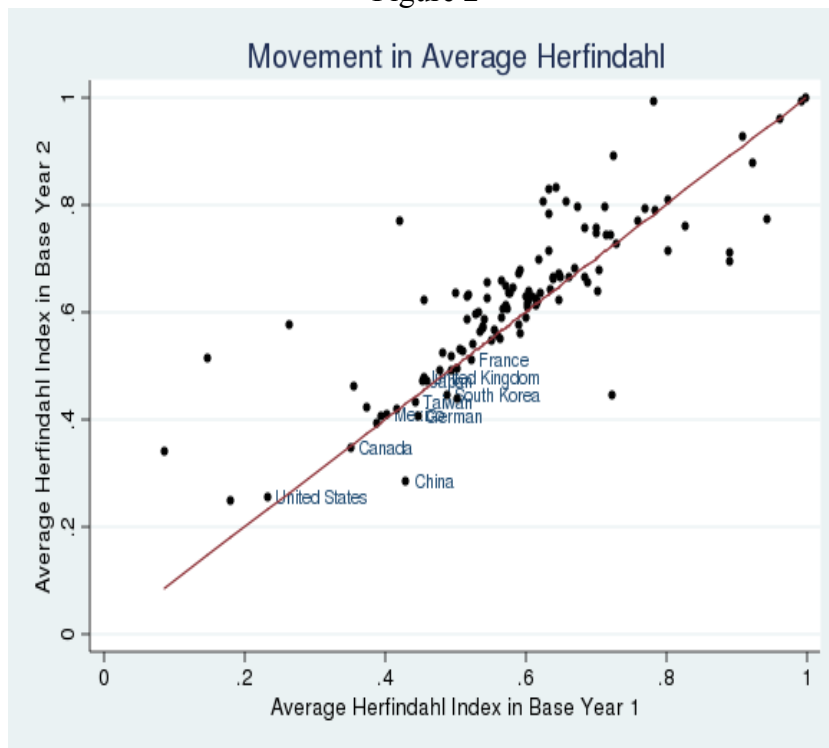


Figure 3

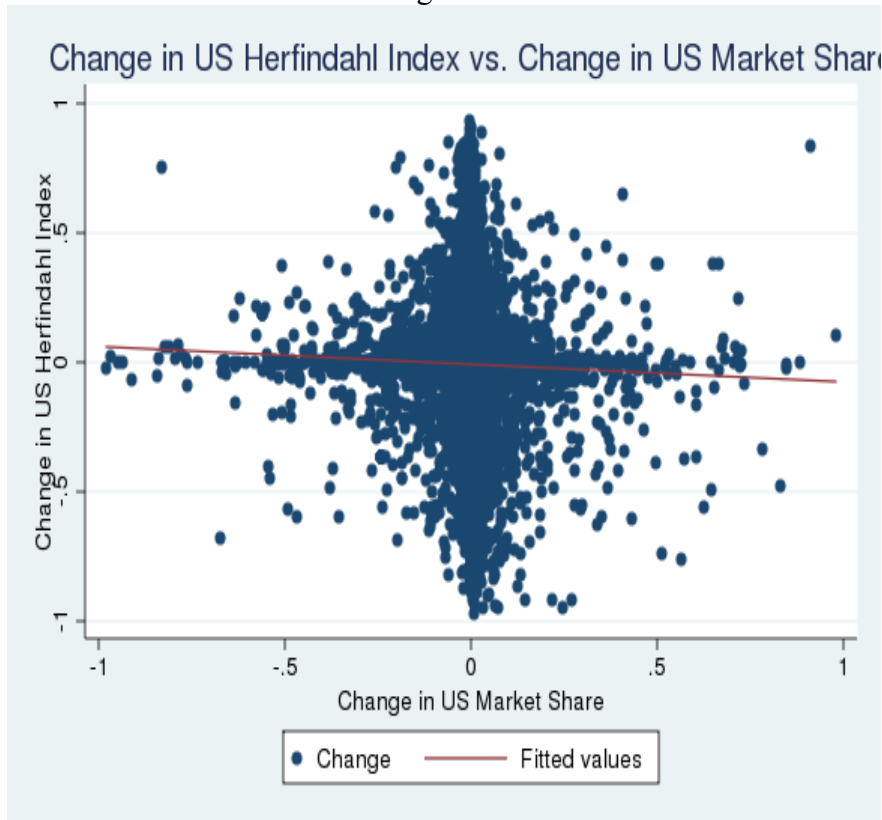


Figure 4a: Distribution of $2\gamma V$

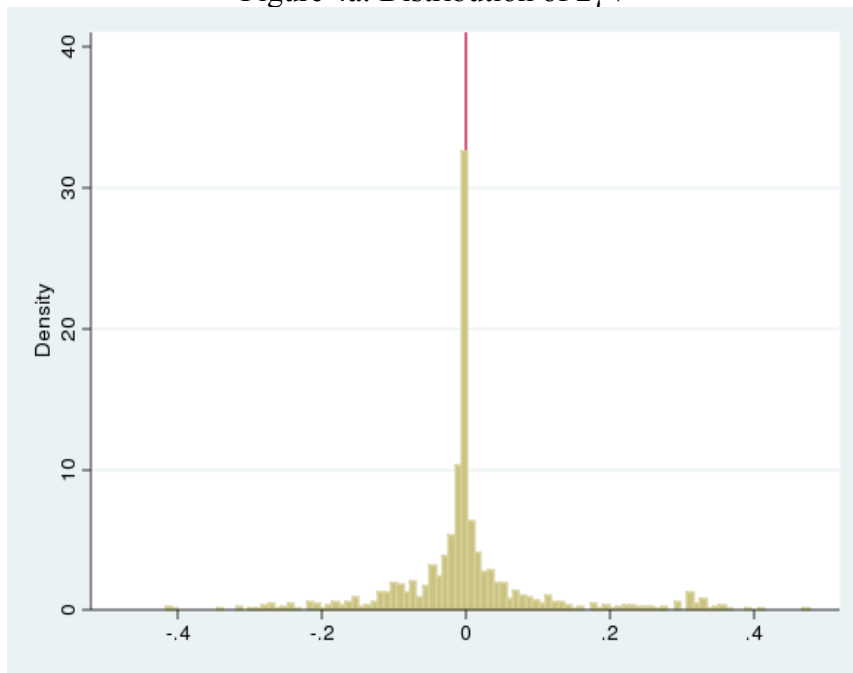
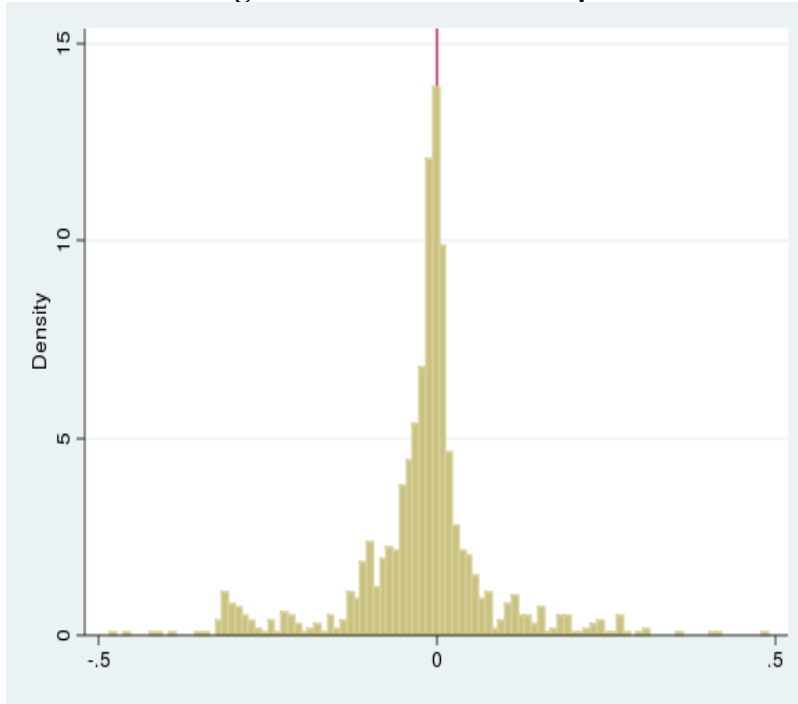


Figure 4b: Distribution of $2\gamma P$ **Figure 4c: Distribution of $2\gamma(P-V)$** 