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GAINS FROM TRADE WITH FLEXIBLE EXTENSIVE MARGIN ADJUSTMENT

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**ABSTRACT**

We propose a new sufficient statistic to measure the gains from trade in models where the extensive margin trade elasticity is not necessarily constant. This statistic is a function of one data moment, the market share of continuing domestic products, and one parameter, the elasticity of substitution between products. It measures the gains from trade in a Ricardian model with any productivity distribution or a Melitz model with any productivity distribution and any pattern of selection into production and exporting. We apply our statistic to measure Canada's gains from the Canada-US Free Trade Agreement and find that they are smaller than suggested by statistics that assume a constant extensive margin response of trade.

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# 1 Introduction

A seminal paper by Arkolakis et al. (2012) (henceforth ACR) shows that a country's welfare gain from trade can be measured with two simple statistics: the country's own trade share and the trade elasticity. The ACR formula can be derived from many widely used trade models. This includes the Armington (1969) model, the Krugman (1980) model, the Eaton and Kortum (2002) model, and a special case of the Melitz (2003) model in which the firm productivity distribution is Pareto.

These models share a key property crucial for delivering the ACR formula, which is that the import demand system is iso-elastic: the elasticity of bilateral trade flows with respect to bilateral trade costs is a constant parameter, and the cross-elasticity is zero. While this follows immediately from Dixit-Stiglitz preferences in models such as Armington (1969) and Krugman (1980) where trade flows only adjust at the intensive margin, it requires strong supply-side assumptions in models where there is also adjustment at the extensive margin. In particular, selection into exporting has to be exactly such that the extensive-margin trade elasticity is also constant. In a Ricardian model, this is true when productivity follows an i.i.d. Fréchet distribution, as in Eaton and Kortum (2002). In a Melitz (2003) model, this holds when productivity follows a Pareto distribution and when there is strict selection into production and exporting. Obviously, both are knife-edge cases that are unlikely to hold empirically.

In this paper, we propose a new formula to measure the gains from trade that does not assume that the extensive margin trade elasticity is constant. Our proposed formula is based on one data moment, the domestic market share of continuing domestic products, and one parameter, the elasticity of substitution between products. The key advantage of our formula is that it does not require knife-edge supply-side restrictions. It is therefore consistent with a much wider range of trade models - for example, a generalized Eaton and Kortum (2002) model with any productivity distribution or a generalized Melitz (2003) model with any productivity distribution and any pattern of selection into production and exporting.

Our approach is essentially an application of the well-known Feenstra (1994) formula, albeit one that is different from what is typically done in the literature. While prior papers

such as Broda and Weinstein (2006) use the Feenstra (1994) method to measure the *import variety* gains from trade, we apply it to measure the *overall* gains from trade. For example, in a Melitz (2003) model, the gains from trade come from lower prices for *existing* imported products and access to new imported products net of the loss from domestic products that exit. The intuition behind our application of Feenstra (1994)'s formula is that new foreign products and lower prices of existing imported products take away the market of *incumbent* domestic firms, while the exit of domestic firms increases their market share. The change in the market share of domestic incumbent firms therefore captures the net effect of all three sources of gains from trade in the Melitz (2003) model. Our formula boils down to the ACR statistic when the extensive margin elasticity of trade is constant, but it holds even when this condition is not met.

We illustrate the empirical importance of our proposed approach by measuring Canada's gains from the Canada-US Free Trade Agreement (CUSFTA) of 1988. Since this application is on the US and Canada, for which intra-industry trade is more important than inter-industry trade, we focus our analysis on firm-level data and Melitz (2003) models. As a first step, we apply our sufficient statistic in a simple before-after analysis using micro-data from US and Canadian manufacturing. This analysis suggests that CUSFTA boosted Canada's real income by about 5% from 1988 to 1996. When we apply ACR's formula with a trade elasticity calibrated to match to Canadian and US micro-data, we get much larger gains from trade, an increase in real income of at least 7.76%. Our gains are smaller primarily because many large Canadian firms exited the market after 1988.

Our simple before-after analysis is only completely valid if the observed change in our sufficient statistic between 1988 and 1996 is entirely driven by CUSFTA. As a second step, we therefore calibrate a generalized Melitz (2003) model to isolate the causal effect of CUSFTA. Our model does not impose iso-elastic import demand, but allows for it as a special case. We choose the parameters of this model using macro moments on trade as well as micro moments on firm size distributions and their overlap between non-exporters and exporters and between exiting and incumbent firms. The estimated parameters suggest that the model that best fits the data is not likely to feature iso-elastic import demand. We then use the model to estimate Canada's welfare gains from CUSFTA. This exercise suggests that about 90% of the

gains measured in our earlier before-after analysis are due to the reduction in trade costs from CUSFTA.

The paper proceeds as follows. We first derive a new sufficient statistic for the gains from trade that holds for all Ricardian or Melitz models of trade with Dixit-Stiglitz preferences, including ones where the import demand elasticity is not constant. We then use micro-data from Canadian and US manufacturing to calculate Canada's gains from trade in 1988-1996 after CUSFTA was signed. The last section calibrates the welfare effect of CUSFTA in a generalized two-country Melitz model that does not impose the assumption of iso-elastic import demand.

## 2 A New Sufficient Statistic for the Gains from Trade

This section derives our sufficient statistic for the gains from trade liberalization. In anticipation of our later application, we derive this statistic in the context of a generalized Melitz (2003) model where import demand is not necessarily iso-elastic. We do this by allowing the productivity distribution to take any form and by not imposing any restriction on selection into production and exporting. But it will become clear that our sufficient statistic also measures the gains from trade in a Ricardian model with an arbitrary distribution of productivity.

Consumers have constant elasticity of substitution preferences over differentiated varieties sourced from many countries. These varieties are produced by monopolistic firms with heterogeneous productivities at constant marginal costs using labor only and trade is subject to iceberg costs. We remain agnostic about the determinants of entry into production and exporting and simply say that  $M_{ij}$  firms from country  $i$  serve country  $j$ . Hence, there may or may not be fixed market access costs and firms may or may not sort into production and exporting according to productivity cutoffs.

In this environment, a country  $i$  firm with productivity  $\varphi$  faces a demand  $q_{ij}(\varphi) = \frac{p_{ij}(\varphi)^{-\sigma}}{P_j^{1-\sigma}} Y_j$  in country  $j$ , where  $p_{ij}$  is the delivered price in country  $j$ ,  $P_j$  is the price index in country  $j$ ,  $Y_j$  is the income in country  $j$ , and  $\sigma > 1$  is the elasticity of substitution. As a result, it adopts a constant markup pricing rule  $p_{ij}(\varphi) = \frac{\sigma}{\sigma-1} \frac{w_i \tau_{ij}}{\varphi}$ , where  $w_i$  is the wage

in country  $i$  and  $\tau_{ij} > 1$  are the iceberg trade costs. Bilateral trade flows can therefore be expressed as a function of average prices,  $X_{ij} = M_{ij} \left( \frac{\tilde{p}_{ij}}{P_j} \right)^{1-\sigma} Y_j$ , where average prices are in turn a function of average productivities,  $\tilde{p}_{ij} = \frac{\sigma}{\sigma-1} \frac{w_i \tau_{ij}}{\tilde{\varphi}_{ij}}$ , where  $\tilde{\varphi}_{ij}$  is a weighted harmonic mean of productivity.<sup>1</sup>

Consider now a shock to the economy, which causes some firms to exit and others to enter. We focus on trade liberalization in our application but our method really applies to any shock. We denote by  $M_{ij}^c$  the subset of *continuing* firms, defined as firms which are active both before and after the shock. Bilateral trade flows associated with continuing firms can be written as  $X_{ij}^c = M_{ij}^c \left( \frac{\tilde{p}_{ij}^c}{P_j} \right)^{1-\sigma} Y_j$ , where average prices and average productivity are defined only over this subset of firms,  $\tilde{p}_{ij}^c = \frac{\sigma}{\sigma-1} \frac{w_i \tau_{ij}}{\tilde{\varphi}_{ij}^c}$ . By definition, there are no changes in the set of continuing firms so that  $M_{ij}^c$  remains unchanged and  $\tilde{\varphi}_{ij}^c$  changes only if there are within-firm productivity effects (i.e. there are no Melitz-type selection effects on  $\tilde{\varphi}_{ij}^c$ ).

We derive our sufficient statistic by focusing on the domestic market share of continuing domestic firms,  $\lambda_{jj}^c \equiv \frac{X_{jj}^c}{Y_j}$ . Using our expression for  $X_{ij}^c$  above, we can express price index changes as  $\Delta \ln P_j = \Delta \ln \tilde{p}_{jj}^c + \frac{1}{\sigma-1} \Delta \ln \lambda_{jj}^c$ . From our expression for  $\tilde{p}_{ij}^c$  above, we know that  $\Delta \ln \tilde{p}_{jj}^c = \Delta \ln w_j - \Delta \ln \tilde{\varphi}_{jj}^c$  so that we can write changes in the domestic real wage as  $\Delta \ln \frac{w_j}{P_j} - \Delta \ln \tilde{\varphi}_{jj}^c = -\frac{1}{\sigma-1} \Delta \ln \lambda_{jj}^c$ . Changes in the domestic real wage are equal to changes in per-capita welfare if labor income is proportional to total income since then  $\Delta \ln \frac{w_j}{P_j} = \Delta \ln \frac{Y_j/L_j}{P_j} \equiv \Delta \ln W_j$ . This holds, for example, under free entry and we impose this assumption henceforth. We can thus write:

$$\Delta \ln W_j - \Delta \ln \tilde{\varphi}_{jj}^c = -\frac{1}{\sigma-1} \Delta \ln \lambda_{jj}^c \quad (1)$$

This equation says that anything that affects welfare, other than the productivity of continuing domestic firms, shows up as changes in  $\lambda_{jj}^c$ . One implication of this is that the effect of changes in trade costs on welfare, including the effect of any reallocation and entry and exit induced by the change in trade costs, can be measured by one simple statistic, the change in the domestic market share of continuing domestic firms  $\Delta \ln \lambda_{jj}^c$ , and one parameter, the

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<sup>1</sup>Specifically,  $\tilde{\varphi}_{ij} \equiv \left( \int_{\varphi \in \Phi_{ij}} \varphi^{\sigma-1} dG_i(\varphi | \varphi \in \Phi_{ij}) \right)^{\frac{1}{\sigma-1}}$ , where  $\Phi_{ij}$  is the set of productivities corresponding to all country  $i$  firms serving country  $j$  and  $G_i(\varphi | \varphi \in \Phi_{ij})$  is their cumulative distribution.

elasticity of substitution  $\sigma$ .

To gain intuition behind (1), we can rewrite it as:<sup>2</sup>

$$\begin{aligned}
\Delta \ln W_j - \Delta \ln \tilde{\varphi}_{jj}^c &= \underbrace{\sum_{i=1, i \neq j}^N \bar{\lambda}_{ij} \left( -\Delta \ln \tau_{ij} + \Delta \ln \frac{w_j}{w_i} + \Delta \ln \frac{\tilde{\varphi}_{ij}^c}{\tilde{\varphi}_{jj}^c} \right)}_{\text{“Intensive” Import Margin}} \\
&+ \underbrace{\bar{\lambda}_{jj} \left( \frac{1}{\sigma - 1} \Delta \ln M_{jj} + \Delta \ln \frac{\tilde{\varphi}_{jj}}{\tilde{\varphi}_{jj}^c} \right)}_{\Delta \text{ Domestic Varieties}} \\
&+ \underbrace{\sum_{i=1, i \neq j}^N \bar{\lambda}_{ij} \left( \frac{1}{\sigma - 1} \Delta \ln M_{ij} + \Delta \ln \frac{\tilde{\varphi}_{ij}}{\tilde{\varphi}_{ij}^c} \right)}_{\Delta \text{ Imported Varieties}}
\end{aligned} \tag{2}$$

where  $\frac{w_j}{w_i}$  is the wage of country  $j$  relative to country  $i$ ,  $\tilde{\varphi}_{ij}^c$  is the average productivity of continuing firms from country  $i$  in market  $j$ , and  $\bar{\lambda}_{ij}$  is the Sato-Vartia average of the share of firms from country  $i$  in country  $j$ 's market.<sup>3</sup> The left hand side of equation (2) is the change in welfare (net of the growth rate of productivity among continuing domestic firms), which is exactly what the sufficient statistic in equation (1) measures. So the sufficient statistic  $-\frac{1}{\sigma-1} \Delta \ln \lambda_{jj}^c$  is the sum of the three terms in equation (2).

The first term captures the direct effect of changes in  $\tau$ , productivity growth in the country's trading partners relative to domestic firms, and the change in the relative wage weighted by the trade shares  $\bar{\lambda}_{ij}$ . For lack of better terminology, we call this the “intensive” margin of imports. In a model such as Krugman (1980) where the trade adjustment is entirely on the intensive margin, the gain from trade will only come from this term. However, in a model where there is also adjustment on the extensive margin, this language is not entirely accurate because the change in the relative wage and the Sato-Vartia weights are endogenous objects that vary with the adjustment on the extensive margin.

The second term in equation (2) captures the direct effect of changes in the set of domestic firms in the domestic market, which is the sum of the change in the number of domestic varieties  $\Delta \ln M_{jj}$  (adjusted by  $\frac{1}{\sigma-1}$ ) and the change in average productivity due to selection

<sup>2</sup>To derive equation (2), take the difference in the log of the CES market share equation for all countries that sell in market  $j$ , and aggregate across all countries using the Sato-Vartia weights of each source country.

<sup>3</sup>Sato (1976)-Vartia (1976) weights are defined as  $\bar{\lambda}_{ij} \equiv \left( \frac{\Delta \lambda_{ij}}{\Delta \ln \lambda_{ij}} \right) / \left( \sum_{m=1}^N \frac{\Delta \lambda_{mj}}{\Delta \ln \lambda_{mj}} \right)$ .

$\Delta \ln \frac{\tilde{\varphi}_{jj}}{\bar{\varphi}_{jj}^c}$ . If the set of domestic varieties does not change, this term is zero. Similarly, the last term captures the direct effect of changes in the set of foreign firms selling into the domestic market, which is a function of the change in the number of foreign firms and their average productivity. Again, if the set of foreign varieties sold in the domestic market does not change, this term is also zero.

It is straightforward to quantify the extensive margin terms in equation (2). In particular, the net effect of domestic exit can be expressed as:

$$-\frac{1}{\sigma-1} \Delta \ln \left( \frac{X_{jj}^c}{X_{jj}} \right) = \frac{1}{\sigma-1} \Delta \ln M_{jj} + \Delta \ln \frac{\tilde{\varphi}_{jj}}{\bar{\varphi}_{jj}^c} \quad (3)$$

This says that the second term in equation (2) can be measured by the inverse of the change in the share of incumbent domestic firms in sales of all domestic firms. Note that  $\frac{X_{jj}^c}{X_{jj}}$  in equation (3) is not equal to  $\lambda_{jj}^c$  in equation (1). Exit of domestic firms lowers both terms, the more so if more firms exit and if the exiting firms are more productive. But entry of new foreign firms lowers  $\lambda_{jj}^c$  but has no effect on  $\frac{X_{jj}^c}{X_{jj}}$ .

The empirical counterpart of the effect of new foreign varieties in equation (2) (third term) is:

$$-\frac{1}{\sigma-1} \Delta \ln \left( \frac{X_{ij}^c}{X_{ij}} \right) = \frac{1}{\sigma-1} \Delta \ln M_{ij} + \Delta \ln \frac{\tilde{\varphi}_{ij}}{\bar{\varphi}_{ij}^c} \quad (4)$$

Adding equation (4) across all foreign countries that sell in the domestic market with the relevant Sato-Vartia market share weights, this says the empirical counterpart of the net effect of new imports is the inverse of the change in the market share of continuing foreign firms relative to all foreign firms in the domestic market. This is essentially what Broda and Weinstein (2006) measure as the new variety gains from trade, and it is increasing in the number of new foreign varieties and in the quality of these varieties.<sup>4</sup>

Equation (2) provides a useful perspective on some important results in the empirical gains from trade literature. Many empirical studies (such as Pavcnik (2002)) emphasize that the exit of the least productive domestic firms leads to higher average productivity. This effect is captured by  $\Delta \ln \frac{\tilde{\varphi}_{jj}}{\bar{\varphi}_{jj}^c}$ , but obviously one cannot only take into the account the effect of exit

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<sup>4</sup>As is well-known, productivity and quality are isomorphic in the Melitz (2003) model so we sometimes refer to quality instead of productivity.



on selection without also accounting for the direct effect of exit on the number of varieties. Similarly, papers such as Broda and Weinstein (2006) focus on the change in the number and quality of imported varieties due to trade liberalization, but again such analyses ignore the effect of trade liberalization on the loss of domestic varieties. Our proposed sufficient statistic in equation (1) captures the net effect of all three terms in equation (2).

We want to make clear two points about our proposed statistic for the gains from trade in equation (1). First, we assume that all the three forces in equation (2) – the reduction in the price of existing foreign products, the net effect of domestic entry and exit, and the net effect of new foreign varieties – are driven by trade. This may not be true. For example, in a closed economy the first and third terms in equation (2) are zero but the second does not have to be. Specifically, in a closed economy our sufficient statistic boils down to  $\frac{1}{\sigma-1} \Delta \ln \lambda^c = \frac{1}{\sigma-1} \Delta \ln M_{jj} + \Delta \ln \frac{\tilde{\varphi}_{jj}}{\tilde{\varphi}_{jj}^e}$ , which is simply the gains from entry of new varieties net of the losses from exit.

Second, even when all three forces in equation (2) are driven by trade, we do not know whether they are due to changes in *trade costs*. For example, differential productivity growth (domestic vs. foreign) or changes in the fixed cost of exporting can also change the gains from trade. There is no model-free sufficient statistic to measure the welfare effect of changes in trade costs. This question, we believe, can only be answered by specifying a full-blown model, which we do in section 5.

We end this section by comparing our sufficient statistic in equation (1) with two widely used statistics by Feenstra (1994) and ACR. First, our formula can be thought of as an application of Feenstra (1994), albeit one that is very different from what is typically done in the literature. While prior papers such as Broda and Weinstein (2006) use Feenstra (1994) to measure the *import variety* gains from trade, we apply it to measure the *overall* gains from trade. Feenstra (1994) decomposes price index changes ( $\Delta \ln P$ ) into a term capturing changes in the prices of continuing goods ( $\sum_{i \in I^c} \bar{\mu}_i^c \Delta \ln p_i$ , where  $I^c$  is a subset of continuing goods and  $\bar{\mu}_i^c$  are Sato-Vartia weights) and a residual commonly thought of as capturing changes in the set of available goods (the Feenstra ratio  $\frac{1}{\sigma-1} \Delta \ln \lambda^c$ ). However, the set  $I^c$  can really include any subset of continuing goods in which case the Feenstra ratio then also captures

changes in the prices of the remaining continuing goods.<sup>5</sup> Our approach essentially boils down to choosing continuing domestic goods. Intuitively, the market share of continuing domestic goods measures the net effect of all the margins of adjustment triggered by a change in trade costs. In a model with only adjustment on the intensive margin, the share of continuing domestic goods falls when a reduction in trade costs lowers the prices of foreign goods. In models that also have adjustment on the extensive margin, the share of continuing domestic goods also falls with more and better entering foreign varieties and rises with more and better exiting domestic varieties.

Our sufficient statistic in equation (1) is also a generalization of the formula by ACR. While we derived this sufficient statistic in a generalized Melitz (2003) model, it should be clear from our derivations that it holds in all models satisfying  $X_{ij} \propto M_{ij} \left( \frac{\tilde{p}_{ij}}{P_j} \right)^{1-\sigma} Y_j$ ,  $\tilde{p}_{ij} \propto \frac{w_i \tau_{ij}}{\varphi_{ij}}$ , and  $w_j L_j \propto Y_j$ . For example, it also holds in a generalized Eaton and Kortum (2002) model that allows for an arbitrary productivity distribution if  $M_{ij}$  is reinterpreted as the number of goods shipped from country  $i$  to country  $j$ . Recall that ACR require four “model primitives” - (i) Dixit-Stiglitz preferences, (ii) one factor of production, (iii) linear cost functions, and (iv) perfect or monopolistic competition - and three “macro-level restrictions” - (i) trade is balanced, (ii) aggregate profits are a constant share of aggregate revenues, and (iii) the import demand system is iso-elastic. Their model primitive (i) immediately implies our first key equation  $X_{ij} \propto M_{ij} \left( \frac{\tilde{p}_{ij}}{P_j} \right)^{1-\sigma} Y_j$ , while their model primitives (i)-(iv) together yield our second key equation  $\tilde{p}_{ij} \propto \frac{w_i \tau_{ij}}{\varphi_{ij}}$ . Our third key equation  $w_j L_j \propto Y_j$  follows from their macro-level restrictions (i) and (ii) so that we effectively relax their macro-level restriction (iii). In the appendix (section A1), we elaborate further on the link between our formula and ACR’s (as well as a related formula by Melitz and Redding (2015)).<sup>6,7</sup>

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<sup>5</sup>Note that in principle this also allows us to choose a set of continuing goods that experience no change in productivity, eliminating the “continuing firm productivity term” in equation (1). Any changes in the productivity of other continuing firms, foreign or domestic, is then captured by the Feenstra ratio. We provide an illustrative example in the appendix (section A7) where we restrict the set of continuing domestic firms in  $I^c$  to only those in sectors that had initially low tariffs and hence experienced minimal tariff decreases due to CUSFTA.

<sup>6</sup>In the appendix (section A2), we analyze a special case of our generalized Melitz model which also satisfies ACR’s macro-level restriction (iii) (the version of Melitz (2003) considered by Arkolakis et al. (2008)). In this special case, we can show that the last two terms in equation (2) sum to zero, which is a prediction that we can test. Foreshadowing our results, we will show that the gains from new import varieties to Canada from the Canada-US free trade agreement in 1988 do not offset Canada’s losses from domestic exit.

<sup>7</sup>In a previous working paper version of our paper (Hsieh et al. (2018)), we explore in detail how our decomposition in (2) (and thus also our formula (1)) generalizes to richer economic environments. In particular,

### 3 Data

The free trade agreement between Canada and the United States was signed on January 2, 1988. It mandated the elimination of bilateral import tariffs in manufacturing, phased-in over a ten-year period starting on January 1, 1989. By 1996, Canadian tariffs on US imports had fallen from an average of 8% (equivalent to a 16% effective tariff rate) to about 1%. US tariffs on Canadian imports fell from about 4% in 1988 to below 1% during this period. Bilateral manufacturing trade between the two countries roughly doubled in nominal terms during this period. For Canada, the free trade agreement was a large shock, as trade with the US accounts for about 70% of Canadian trade in manufacturing. In addition, as discussed in Trefler (2004), CUSFTA was not accompanied by other macroeconomic reforms or implemented in response to a macroeconomic crisis.

We need information on domestic sales of continuing firms in Canada before and after CUSFTA came into force. We use the micro-data from Canada’s Annual Survey of Manufacturing Establishments.<sup>8</sup> This survey covers all but the very smallest Canadian manufacturing establishments with sales below \$30,000 Canadian dollars. We focus on the 1978-1988 and 1988-1996 time periods. We consider the 1978-1988 period as the “pre-CUSFTA” and the 1988-1996 period as “post-CUSFTA” period.<sup>9</sup> The information we use from this data is the establishment’s id, exports, and sales. In each of the two time periods, we use the establishment’s id to identify firms as entrants, exiters, and continuing firms. We define an *entrant* as an establishment not in the data at the *beginning* of the time period, an *exiter* as an establishment not in the data at the *end* of the time period, and a *continuing* establishment as one that was present in the data at the beginning and at the end of a time period. We supplement these data on domestic sales by Canadian firms with data on total manufacturing exports to Canada from the United States.

Equation (1) says that all we need to measure the gains from trade is the change in the

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we consider non-traded and intermediate goods, endogenous markups, tariff revenue, multiproduct firms, and heterogeneous quality. The bottom line is that only minor (if any) adjustments are needed to accommodate these extensions so we do not elaborate on this here.

<sup>8</sup>This survey was initially called the Census of Manufactures and is now known as Annual Survey of Manufactures.

<sup>9</sup>We also chose these time periods because Statistics Canada officials indicated to us that the years with the best sampling frame are 1978, 1988, and 1996.

Canadian market share of continuing Canadian firms, which we can calculate using only the Canadian firm data together with data on aggregate US manufacturing exports to Canada. We will also measure the importance of the different margins behind the gains from trade (using equation (2)), for which we also need the share of new foreign firms in the Canadian market. We use micro-data from the quinquennial US manufacturing census, which provides data on exports at the establishment level starting in 1987, so we focus on the 1987-1997 period. From the US manufacturing micro-data, we impute the share of new imported varieties in total Canadian imports (the third term in equation (2)) using total exports of US firms that export for the first time in the 1987-1997 time period as a share of total US exports in 1997.<sup>10</sup> Likewise, we impute the share of exiting imported varieties in total Canadian imports as total exports of US firms that stop exporting over the 1987-1997 period as a share of total US exports in 1987. The last thing we need is the elasticity of substitution, and we use the estimates from Oberfield and Raval (2014) based on firm markups in US manufacturing.<sup>11</sup> The elasticities at the two-digit level range from 3.3 to 4.4 and average to 3.7. Since we only use aggregate data, we simply work with the average elasticity of 3.7.<sup>12</sup>

## 4 Canada's Gain during CUSFTA

In this section, we apply our sufficient statistic (1) to measure Canada's gains from CUSFTA in a simple before-after analysis. As we discussed earlier, this analysis is only identified if the observed change in the sufficient statistic is also entirely driven by CUSFTA. We will investigate this question in detail in the next section with the help of a quantitative model. Our conclusion will be that around 90% of the gains from CUSFTA implied by our simple before-after analysis can be causally attributed to CUSFTA.

We begin by showing key summary statistics from the Canadian and US micro-data. Table 1 shows the domestic sales of exiting (row 1) and entering (row 2) Canadian firms as a share

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<sup>10</sup>The US census does not report establishment level exports by destination country so this imputation assumes that all US exporters in manufacturing also export to Canada. Canadian customs collects transaction-level data on imports from the US, but this data is only available after 1992 and cannot be reliably matched to US firms. US customs does not separately collect transaction-level data on exports to Canada.

<sup>11</sup>See Table VII of Oberfield and Raval (2014)'s online appendix. We used the concordance from Peter Schott's website to match them to 2-digit Canadian SIC codes.

<sup>12</sup>This value is also consistent with mean elasticities estimated using panel import data for the US (Broda and Weinstein (2006)) and Canada (Chen and Jacks (2012)) at similar levels of aggregation.

of domestic sales of all Canadian firms in 1978-1988 (column 1) and 1988-1996 (column 2). The share of exiting firms is defined as the ratio of revenues of firms that exit between  $t$  and  $t + 1$  to total revenues at time  $t$ . And the share of entrants is the ratio of revenues of firms that enter between  $t$  and  $t + 1$  to total revenues in period  $t + 1$ . To compare the numbers across the two time periods we study, we convert the share of entrants and exiters in the 1978-1988 period into shares over an 8 year period.<sup>13</sup> A key fact is that the share of exiting firms increased, from 24.41% to 28.01% between 1978-1988 and 1988-1996, while the same share for entrants declined from 21.55% to 18.81%.

Row 3 in Table 1 shows the change in the share of continuing domestic firms as a share of all domestic firms implied by the change in the share of exiters in row 1 and entrants in row 2. Specifically, the third row shows that the change in the sales of continuing domestic firms as a share of sales of all domestic firms increased from 2.97% before CUSFTA (1978-1988) to 12.03% after CUSFTA (1988-1996).

Table 1: Revenue Shares in Canadian Market

	Canadian Firms		US Exporters
	1978–1988	1988–1996	1987–1997
Exiter Revenue Share <sup>1</sup>	24.41%	28.01%	35.47%
Entrant Revenue Share <sup>2</sup>	21.55%	18.81%	38.73%
$\Delta \ln X_{ij}^c / X_{ij}$ <sup>3</sup>	2.97%	12.03%	-4.14%
$\Delta \ln \lambda$ <sup>4</sup>	-1.36%	-23.86%	–
$\Delta \ln \lambda^c$ <sup>5</sup>	1.61%	-11.83%	–

<sup>1</sup> Total domestic revenues of *exiting* Canadian firms/total domestic revenues of all Canadian firms (columns 1-2) or total exports of *exiting* US exporters/total US exporters (column 3) at beginning of each period.

<sup>2</sup> Total domestic revenues of *entrant* Canadian firms/total domestic revenues of all Canadian firms (columns 1-2) or total exports of *entrant* US exporters/total US exporters (column 3) at end of each period.

<sup>3</sup> Change in domestic revenues of *continuing* Canadian firms/all Canadian firms (columns 1-2) or total exports of *continuing* US exporters/all US exports (column 3).

<sup>4</sup> Change in total domestic sales of *all* Canadian firms/total sales in Canadian market.

<sup>5</sup> Change in total domestic revenues of *continuing* Canadian firms/total sales in Canadian market.

Sources: Columns 1 and 3 impute the shares or changes over 8 years based on the change over 10 years. Calculated from micro-data of Canada’s Annual Survey of Manufacturing or US Manufacturing Census. See text for details.

<sup>13</sup>We multiply the share of entrants and exiters in 1978-1988 by 8/10.

Equation (1) says that the key statistic is the change in domestic sales of continuing domestic firms as a share of *total* sales in the domestic market. This is simply the sum of the change in sales of continuing domestic firms as a share of all domestic firms shown in row 3 and the share of domestic firms in total sales. The latter, shown in the fourth row, indicates that the market share of domestic Canadian firms fell massively after CUSFTA. The last row shows  $\Delta \ln \lambda_{jj}^c$  as the sum of row 3 and 4. The share of continuing domestic firms in total sales in the Canadian market fell by 11.83% in 1988-1996, compared to an increase of 1.61% in the period prior to CUSFTA.

Table 2 shows the gains from trade calculated as  $-\frac{1}{\sigma-1}\Delta \ln \lambda_{jj}^c$ , where the latter is measured as the difference between  $\ln \lambda_{jj}^c$  before and after CUSFTA and assuming  $\sigma = 3.7$ . The first row in the table says that CUSFTA increased Canada's real wage by almost 5% over the 1988-1996 period. The next three rows decompose this number into the components in equation (2). To do this, we need to know two more numbers: the share of exiting Canadian firms in total domestic sales of Canadian firms and the share of new foreign firms in the Canadian market as a share of total sales of foreign firms in Canada. The former is simply the statistic in row 3 in Table 1. For the latter, the third column in Table 1 shows the shares of exiting and entering US exporters in the 1987-1997 time period.<sup>14</sup> As can be seen, the revenue share of new exporters (row 2) exceeded that of exiting exporters (row 1). As a result, the share of continuing US exporters fell by 4.14% over the 1987-1997 period. If we assume that the share of continuing US exporters is the same as the share of continuing Canadian imports from the US, then this statistic is the data counterpart of the third term in equation (2). It is also the key statistic for the variety adjustment term used by Feenstra (1994) and Broda and Weinstein (2006) to calculate bias in the import price index due to new foreign varieties.<sup>15</sup>

The last three rows in Table 2 use these data moments to show the magnitude of the three terms in equation (2). The second row says that exit of domestic varieties lowered real wage

<sup>14</sup>The table shows the imputed shares of US exporters over 8 years (by multiplying the shares over ten years by 8/10) to compare with the numbers in columns 1 and 2.

<sup>15</sup>4.14% from 1988-1996 is 0.52% per year which implies a "lambda ratio" of 0.95 for 1987-1997. This number is similar to the median number reported by Broda and Weinstein (2006) for US imports between 1990-2001 in their Table 7. It is a bit higher than the 0.91 mean figure reported in Table 5 of Chen and Jacks (2012) for Canadian imports over the longer 1988-2007 period. Our independent estimates for Canada over the same period using HS10 imports from the US line up well with our estimates using US firm data over the same period.

Table 2: Effect of CUSFTA on  $\Delta$  Canadian Real Wage from 1988 to 1996

Total $\Delta \ln W_j$	4.98%
$\Delta$ Domestic Varieties	-2.40%
$\Delta$ Foreign Varieties	0.44%
$\Delta$ “Intensive” Margin	7.90%

Notes: Row 1 shows change in Canada’s gain from trade in 1988-1996 compared to 1978-1988 using equation (1). Rows 2-4 show change in the components of Canada’s gain from trade in equation (2) in 1988-1996 compared to 1978-1988. All calculations are based on data moments in Table 1.

growth by 2.40% over 1988-1996. The third row says that the entry of new foreign varieties raised real wage growth by 0.44% over the same period. The direct welfare effect of new foreign varieties is positive but it does not offset the direct welfare loss from fewer domestic varieties. Finally, there is no empirical counterpart to the “intensive” margin, so we calculate it as a residual. The intensive margin real wage gains are significantly larger than the overall gains because they do not take into account the effect of the exit of domestic varieties.

Table 3 further decomposes the last two terms in equation (2) into the change in the number of varieties (“variety” margin in the top panel) and in the average productivity of these varieties (“productivity” margin, in the bottom panel). The first two rows in Table 3 show the number of exiting and entering plants as a share of all plants, and the third row shows the implied change (over an 8-year period) in the number of plants. So the key fact here is that the number of Canadian plants decreased and the number of US exporters increased during 1988-1996. Viewed through the lens of equation (2), the fact that  $\Delta \ln M_{jj} < 0$  lowers the real wage and  $\Delta \ln M_{ij} > 0$  raises the real wage.

But entry and exit also potentially change average productivity. This effect is shown in the bottom panel in Table 3. The first two rows show the raw data, namely sales of exiting firms relative to all firms and sales of entering firms relative to all firms. As expected, exiting and entering firms are smaller than the average firm. The net effect of entry and exit on average productivity is then given by  $\Delta \ln \left( \tilde{\varphi}_{ij} / \tilde{\varphi}_{ij}^c \right) = \frac{1}{\sigma-1} \Delta \ln \left( \tilde{r}_{ij}^c / \tilde{r}_{ij} \right)$  where  $\tilde{r}$  denotes average revenues. This number is shown in the last row in bottom panel of Table 3. Net entry of new US exporters lowered the average productivity of US exporters, and net exit

Table 3: Variety and Productivity Margins of Entry and Exit

	Canadian Firms		US Exporters
	1978–1988	1988–1996	1987–1997
Variety Margin			
Exiters (% of All Plants) <sup>1</sup>	51.68%	49.56%	54.69%
Entrants (% of All Plants) <sup>2</sup>	64.46%	43.76%	72.87%
$\Delta \ln M_{ij}$ <sup>3</sup>	24.57%	-10.90%	41.04%
Productivity Margin			
Exiters (Size relative to all plants) <sup>4</sup>	47.23%	56.52%	64.86%
Entrants (Size relative to all plants) <sup>5</sup>	33.44%	42.99%	53.14%
$\Delta \ln \tilde{\varphi}_{ij}/\tilde{\varphi}_{ij}^c$ <sup>6</sup>	-10.20%	-0.42%	-13.67%

<sup>1</sup> # exiting plants/total # of plants (columns 1-2) or exiting exporters/total # of exporters (column 3) at beginning of each period.

<sup>2</sup> # new plants/total # of plants (columns 1-2) or new exporters/total # of exporters (column 3) at end of each period.

<sup>3</sup> % change in total # of plants (columns 1-2) or exporters (column 3).

<sup>4</sup> Average domestic revenues of exiting plants/all plants (columns 1-2) or average exports of exiting exporters/all exporters (column 3) at beginning of period.

<sup>5</sup> Average domestic revenues of new plants/all plants (columns 1-2) or average exports of new exporters/all exporters (column 3) at end of period.

<sup>6</sup> Productivity growth of all plants/continuing plants (columns 1-2) or all exporters/continuing exporters (column 3), measured as  $\Delta \ln \tilde{\varphi}_{ij}/\tilde{\varphi}_{ij}^c = -\frac{1}{\sigma-1} \Delta \ln \frac{\tilde{r}_{ij}^c}{\tilde{r}_{ij}}$  where  $\tilde{r}$  denotes average revenues.

Notes: Columns 1 and 3 impute 8-year change from 10-year changes. Calculated from micro-data of Canada's Annual Survey of Manufacturing and US Manufacturing Census. See text for details.

of Canadian firms increased average productivity of Canadian firms relative to the numbers observed before CUSFTA (in 1978-1988).

However, we re-emphasize the point that what matters for welfare is the net effect of the extensive and the intensive margins, and the sufficient statistic for this net effect is the share of exiting or entering firms in total revenues shown in Table 1. So in a sense, once we have data on shares of exiting and entering firms, we do not need to know the contribution of the intensive and extensive margins to these shares. Put differently, exit is always welfare reducing and entry is always welfare enhancing, and how much they matter is measured by the revenue shares of the two types of firms relative to continuing firms.

Table 4 compares our estimates of Canada's gains from trade with alternative approaches



that exclusively focus on foreign variety gains or domestic productivity gains. The first row replicates our estimate of a real wage gain of 4.98% in the 8 years after CUSFTA. The second row shows the gains if we were to consider new import varieties only as in Broda and Weinstein (2006). This number is simply the third term in equation (2) and is much smaller at 0.44%. The third row shows the gains if we only consider the effect of domestic exit on average productivity of domestic firms as in Pavcnik (2002). The welfare gain from the increase in average productivity of domestic firms is 6.87%, but this number is obviously misleading as it does not take into account the welfare loss from fewer domestic varieties. Remember from Table 2 that the net effect of domestic exit, which is what led to the improvement in average productivity, *lowers* welfare by 2.4%.

More generally the last two effects are just partial effects so our last two estimates consider all the effects in equation (2) but with more structure, specifically assuming iso-elastic import demand. In particular, we can use ACR’s sufficient statistic if we assume that firm productivity follows a Pareto distribution and there is strict productivity-based sorting into production and exporting. With these two assumptions, the gain from trade is given by:

$$\Delta \ln W_j - \Delta \ln \tilde{\varphi}_{jj}^c = -\frac{1}{\theta} \Delta \ln \lambda_{jj} \quad (5)$$

where  $\theta$  is the trade elasticity, which happens to be the shape parameter of the Pareto distribution in this particular model. There are two differences between (5) and (1). First,  $\lambda_{jj}$  in equation (5) is the share of *all* domestic firms while  $\lambda_{jj}^c$  in equation (1) is the share of *continuing* domestic firms. The former is the number in row 4 in Table 1 and the latter in row 5. Second, the elasticity in equation (5) is a function of the shape parameter of the Pareto distribution, while the elasticity in equation (1) is a function of the elasticity of substitution across varieties.

So the only additional number we need to estimate equation (5) is  $\theta$ . There are at least three ways to estimate this parameter. The first two involve data moments from a trade shock. First, we can use the fact that with an (untruncated) Pareto distribution,  $\theta = -\Delta \ln \left( \frac{M_{ij}/M_{jj}}{\tilde{\varphi}_{ij}/\tilde{\varphi}_{jj}} \right)$ . A second approach is to use the trade elasticity implied by the model. In particular, Melitz and Redding (2015) propose the “arc elasticity”  $\theta = \Delta \ln \frac{(1-\lambda_{jj})/\lambda_{jj}}{(1+\tau_{ij})}$ .

Table 4: Alternative Estimates of Canada’s Welfare Gains from Trade after CUSFTA

	$\Delta$ Welfare
Our statistic: $-\frac{1}{\sigma-1}\Delta \ln \lambda_{jj}^c$	4.98%
Foreign Varieties only <sup>1</sup>	0.44%
Domestic Productivity only <sup>2</sup>	6.87%
ACR with $\theta = 2.9$ <sup>3</sup>	7.76%
ACR with $\theta = 2.63$ <sup>4</sup>	8.56%

<sup>1</sup> Welfare gain from new foreign varieties (copied from Table 2).

<sup>2</sup> Welfare effect of change in average productivity calculated as  $\bar{\lambda}_{jj}\Delta \ln \tilde{\varphi}_{ij}/\tilde{\varphi}_{ij}^c$  in table 3.

<sup>3</sup> ACR welfare statistic (5) using  $\theta = -\Delta \ln \left( \frac{M_{ij}/M_{jj}}{\tilde{\varphi}_{ij}/\tilde{\varphi}_{jj}} \right)$  or using Zipf’s Law calculated as  $\theta = \xi \cdot (\sigma - 1)$  where  $\xi$  is the elasticity of firm rank with respect to firm employment.

<sup>4</sup> ACR welfare statistic (5) with arc-elasticity proposed by Melitz and Redding (2015) and measured as  $\theta = \Delta \ln \frac{(1-\lambda_{jj})/\lambda_{jj}}{(1+\tau_{ij})}$

Note: Table shows the gains from trade for Canada from 1988 to 1996 based on the data moments in Table 1 and 3.

A third way is to use the distribution of firm size in the steady state. Specifically, if the distribution of firm productivity follows a Pareto distribution,  $\theta$  is the product of  $\sigma - 1$  and the elasticity of the rank of firm size with respect to firm size.

We use our micro-data from Canada and the US to estimate  $\theta$  using these three methods. For the first method, we use the  $\Delta \ln M$  and  $\Delta \ln \tilde{\varphi}$  from 1978-1988 to 1988-1996 (shown in Table 3), which gives us  $\theta = 2.9$ . This estimate for  $\theta$  is almost identical to that obtained from the cross-sectional distribution of firm size. Specifically, the elasticity of firm rank with respect to firm size is 1.06, which combined with  $\sigma = 3.7$  yields  $\theta = 2.86$ . Finally, we estimate  $\theta$  from the “arc-elasticity” proposed by Melitz and Redding (2015) as  $\theta = \Delta \ln \frac{(1-\lambda_{jj})/\lambda_{jj}}{(1+\tau_{ij})}$ . As we will describe later, CUSFTA lowered the iceberg trade cost of shipping goods from the US to Canada by 23%, which combined with the change in  $\lambda_{jj}$  (shown in Table 1) yields  $\theta = 2.63$ .

The last two rows in Table 4 calculate the ACR statistic using these two values of  $\theta$ . Using  $\theta=2.9$ , ACR’s statistic suggests that CUSFTA increased welfare by 7.76%. Using  $\theta = 2.63$ , ACR’s gains are even larger, at 8.56%. These numbers are 50%-70% larger than our estimate of 4.98%, shown in the first row of the table.

## 5 Simulation of welfare effects of CUSFTA

In this section, we use a quantitative trade model to isolate the causal effect of CUSFTA on our sufficient statistic (1). This is meant to complement our simple before-after analysis from the previous section which simply attributed the entire change observed in the data to CUSFTA. We build on a standard Melitz-Pareto model but want to relax the strong supply side assumptions necessary to generate an iso-elastic import demand system. Therefore, we consider two generalized Melitz-Pareto models, both of which have as a special case the model with iso-elastic import demand. We then calibrate these models to the data, and let the data tell us about the extent of the departure from a model with iso-elastic import demand.

Our first model follows Melitz and Redding (2015). Specifically, we assume two countries populated by representative consumers with CES preferences, firms pay a common fixed cost to produce in each period and another fixed cost to export, and the steady-state distribution of firm productivity follows a *truncated* Pareto distribution.<sup>16</sup> In this model then the truncation parameter determines the extent of the departure from an iso-elastic import demand. With a large truncation parameter, the model boils down to a Melitz-Pareto model with iso-elastic import demand.

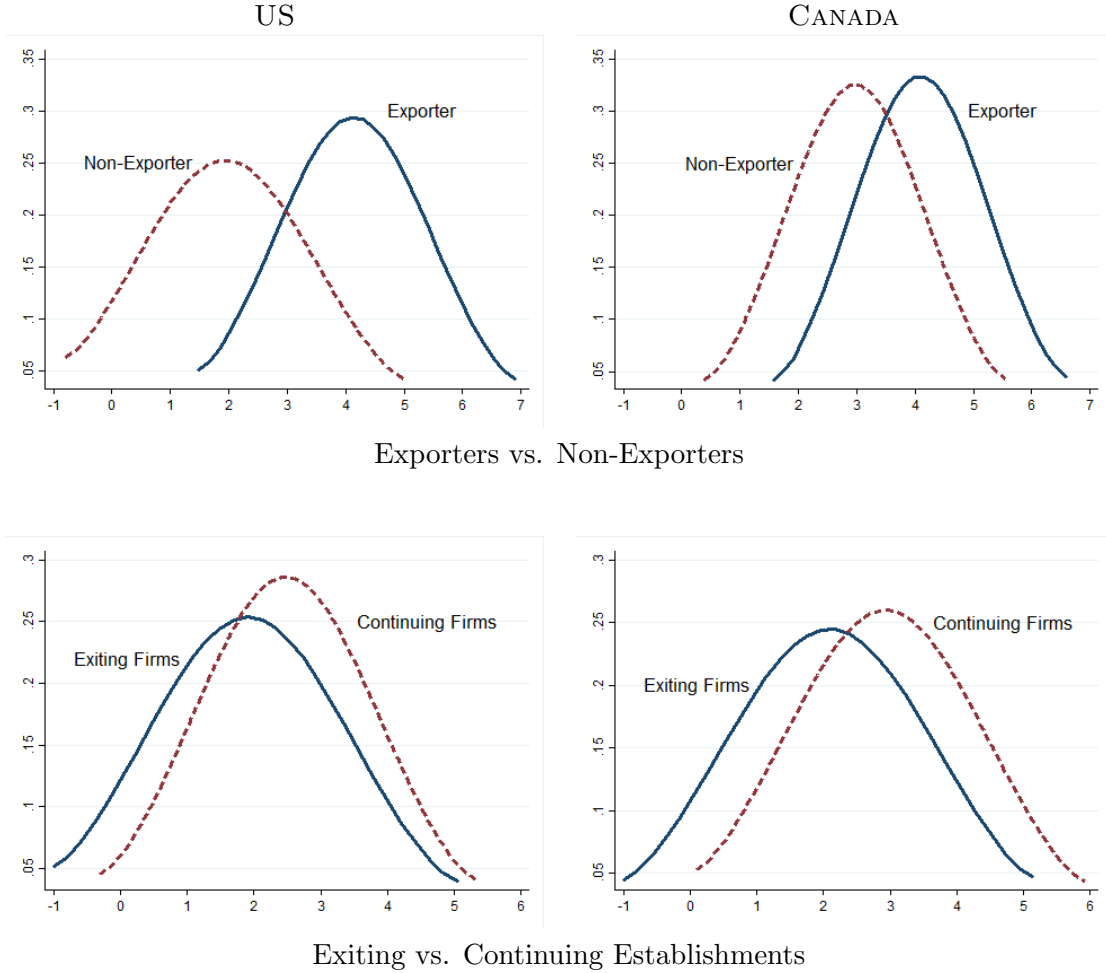
Our second generalization drops the assumption that all firms face the same fixed cost of production and exporting. We do this for two reasons. First, there is abundant evidence that strict sorting into exporting may not hold empirically. Eaton et al. (2011) and Armenter and Koren (2015) show that there is a substantial overlap in the size distribution between exporters and non-exporters in France and the US. Figure 1 (top panel) plots the distribution of employment for exporters and non-exporters in our Canadian and US data, and shows that a similar fact holds in Canada and the US. We can capture the fact that many exporters are smaller than non-exporters, and vice versa, by allowing the fixed cost of exporting to differ across firms. Specifically, we assume that export fixed costs in each country are i.i.d. Pareto, as in Armenter and Koren (2015).

Second, the bottom panel in Figure 1 plots the ex-ante distribution of plant size for exiting vs. continuing firms in US and Canadian manufacturing. As can be seen, many exiting plants

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<sup>16</sup>We also assume free entry (after paying the fixed cost of entry), balanced trade, and that firm productivity is subject to a shock that follows a mean zero log normal distribution.

Figure 1: Distribution of Employment



Note: Top panel shows the distribution of log employment of exporting and non-exporting establishments in Canada in 1996 and the US in 1997. Bottom panel shows distribution of log employment of exiting and continuing establishments in Canada in 1988 and US in 1987. Exiting plants leave the data between 1988 and 1996 (Canada) or between 1987 and 1997 (US). Continuing plants are in the data in the initial and final years. Statistics calculated from the micro-data of manufacturing firms in Canada and the US

are ex-ante substantially larger than continuing plants, and vice versa. We will also allow our model to reproduce this pattern, this time by relaxing the assumption that the fixed cost of domestic production are the same across firms. Specifically, we allow production fixed costs to vary with firm productivity according to  $f_d + \beta \ln \varphi$  (note that we do not impose  $\beta \neq 0$  but calibrate it using the data). The appendix (section A3) provides more detail on our models and our solution algorithm.

## 5.1 Model Calibration

Table 5 summarizes the key parameters of the two models. In both models, we assume  $\sigma = 3.7$  and  $\theta = 2.9$  and take as given employment in manufacturing in the two countries. In the model where all firms have common fixed production and exporting cost (Melitz and Redding (2015)), we then choose the parameters in the first column in Table 5 to fit the trade share, the number and relative employment of exporting and non-exporting firms, and the exit rate in the two countries.<sup>17</sup> The first column in Table 5 shows the resulting estimates of these parameters for this model.<sup>18</sup>

Table 5: Parameters for Canada

	<b>Melitz-Redding</b> <i>truncated Pareto only</i>	<b>Full model</b> <i>truncated Pareto + fixed cost heterogeneity</i>
Productivity Pareto truncation	3.8	4.3
Trade friction $\tau$	2.15	2.15
Entry fixed cost	0.83	0.83
Production fixed cost intercept $f_d$	0.65	0.2
Production fixed cost slope $\beta$	-	3
Export fixed cost location $f_x$	0.6	0.09
Export fixed cost shape $\alpha$	-	0.17
Exit shock standard deviation	0.07	0.051

Notes: Column 1 shows the model parameters for the model with a truncated Pareto distribution and common fixed costs (the Melitz and Redding (2015) model). Column 2 shows the calibrated parameters for the model a truncated Pareto distribution and heterogeneity in fixed costs of production and exporting. See Table 9 in the appendix (section A5) for US parameters.

Our second model, which features heterogeneity in fixed production and export costs, has two more parameters: the elasticity of production fixed costs with respect to firm productivity  $\beta$  and the shape parameter of the Pareto distribution of export fixed cost  $\alpha$ . We choose these additional parameters using data on the overlap in firm size between exporting and non-

<sup>17</sup>Table 8 in the appendix (section A4) shows the values of the moments we target.

<sup>18</sup>Table 5 only shows the model parameters for Canada. Table 9 in the appendix (section A5) shows the parameters for the US

exporting firms and exiting vs. continuing firms in Canada and the US<sup>19</sup> The second column in Table 5 reports the parameters of the model that allows for overlap in the distribution of exporters and non-exporters and exiters and continuing firms. We need a very high level of dispersion in the fixed exporting costs to match the degree of overlap in employment between exporters and non-exporters in the data, with a (Pareto) shape parameter of  $\alpha = 0.17$  for Canada. In addition, we need a positive elasticity of fixed operating cost with respect to productivity to match the overlap in the distribution of exiters vs. continuing firms. The appendix (sections A4 and A5) provides more detail on our calibration.

Figure 2 shows the trade elasticity for varying levels of changes in trade costs implied by the estimated parameters in the two models. As can be seen, the estimated model parameters imply significant departures from an iso-elastic import demand structure. So the gains from trade in our two models will not be measured accurately by ACR’s formula. Of course, this observation alone does not tell us the degree of bias if we use ACR’s statistic in these two models, which is a question we address in section 5.3.

## 5.2 Predicted welfare effects of CUSFTA

We now simulate the effect of the reduction in trade costs due to CUSFTA on Canada in the two models. We assume that Canadian trade costs for US imports fell by 23% due to CUSFTA. This includes a 16% decline in tariffs and the elimination of non-tariff barriers equivalent to about a 7% tariff.<sup>20</sup> On the US side, CUSFTA lowered US tariffs on Canadian imports by about 58% of the decline in Canadian tariffs on US imports. So we assume that US trade costs for Canadian imports fell by 13.3% due to CUSFTA.<sup>21</sup>

The first panel in Table 6 shows the predicted change of the key data moments in response

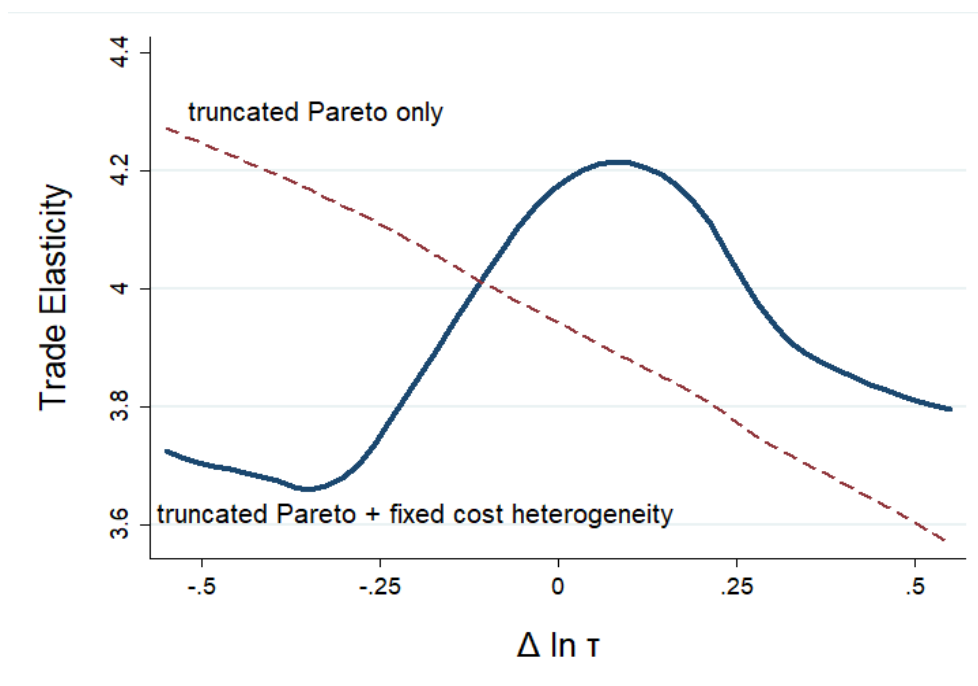
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<sup>19</sup>Specifically, we target the 20th, 50th, and 80th percentiles of the employment distribution of exporting versus non-exporting firms, and continuing versus exiting firms. Table 8 in the appendix (section A4) shows the precise moments of the firm size distribution we target.

<sup>20</sup>See Treffer (2004) for the reduction in tariffs and Head and Ries (2001) for the tariff equivalent of non-tariff barriers.

<sup>21</sup>In Table 10 in the appendix (section A6) we also consider a simulation where fixed exporting costs fall by a similar magnitude as tariffs, i.e. the fixed cost of exporting to Canada falls by 23% and the fixed cost of exporting to the US falls by 13%. Unsurprisingly, this results in larger changes in all of the table entries for both models except the “intensive margin” term. It has a much larger effect in the Melitz-Redding model than our full model because the dispersion of export fixed costs is so large in our model that there are many fewer marginal firms induced to export due to falling export fixed costs relative to a truncated Pareto model with strict sorting. We focus our analysis on changes in variable trade costs as we are not aware of direct evidence or previous studies that quantify changes in fixed exporting costs during this period.

Figure 2: Heterogeneous Trade Elasticities in Simulated Models



Note: Figure shows the simulated trade elasticity for different values of changes in trade cost in the model with a truncated Pareto distribution only and the model that also has heterogeneity in production and export costs. See text for details.

to the change in trade costs due to CUSFTA in the two models. For comparison, the table also replicates the same moments in the data in column 1.<sup>22</sup> Recall that we are using the models to isolate the effect of trade cost reductions so these are not moments we are trying to match. In the first row, we show that the growth in the domestic market share of incumbent Canadian firms is lower in both models than in the data. This is because the share of exiting firms is lower in both models than in the data. The second row shows the change in the share of all domestic firms. The model with only a truncated Pareto distribution predicts a change in the domestic spending share almost exactly in line with the data, while the model that also allows for heterogeneity in export and production fixed costs predicts a lower fall in the domestic spending share. The third row, the share of *continuing* domestic firms in domestic spending, is simply the sum of the previous two rows and the key summary statistic in equation (1). So, the model with only the truncated Pareto distribution (column 2) predicts higher gains from CUSFTA than our earlier before-after comparison based on the raw data

<sup>22</sup>Specifically, “data” refers to the difference between 1988-1996 and 1978-1988 shown in Table 1.

Table 6: Simulated effects of CUSFTA: Data vs. Model

	Data 1988-1996	<b>Melitz-Redding</b> <i>Truncated Pareto Only</i>	<b>Full model</b> <i>Truncated Pareto + Fixed Cost Het.</i>
Market Shares:			
$\Delta \ln X_{jj}^c / X_{jj}$ <sup>1</sup>	9.04%	6.68%	5.91%
$\Delta \ln \lambda$ <sup>2</sup>	-22.50%	-22.55%	-18.04%
$\Delta \ln \lambda^c$ <sup>3</sup>	-13.44%	-15.87%	-12.13%
Total Welfare Change <sup>4</sup>	4.98%	5.88%	4.49%
$\Delta$ “Intensive” Margin	7.90%	5.51%	5.46%
$\Delta$ Domestic Varieties	-2.40%	-1.76%	-1.59%
$\Delta$ Foreign Varieties	0.44%	2.14%	0.63%

<sup>1</sup> Percentage change in domestic revenues of *continuing* Canadian firms/all Canadian firms. (Difference to 1978-1988 pre-trend.)

<sup>2</sup> Percentage change in total domestic sales of *all* Canadian firms/total sales in Canadian market. (Difference to 1978-1988 pre-trend.)

<sup>3</sup> Percentage change in total domestic revenues of *continuing* Canadian firms/total sales in Canadian market. (Difference to 1978-1988 pre-trend.)

<sup>4</sup> Gains from trade calculated from equation (2) from simulated data. Note: Simulated effect of a 23% (13%) reduction in Canadian (US) tariffs in model with a truncated Pareto distribution of productivity and common fixed costs (column 2) and heterogeneous fixed costs (column 3). “Data” in top panel is the difference between the annualized change in 1988-1996 compared to 1978-1988 shown in Table 1, accumulated over 8 years. See text for details.

moments, while the model that also allows for heterogeneity in fixed costs (column 3) predicts slightly lower welfare gains.

The bottom panel in Table 6 shows the change in welfare implied by the moments in the top panel. The first row shows the change in welfare. In the data, this is about 5%. The Melitz-Redding model predicts that CUSFTA increased welfare by 5.9%, while the predicted gains in the model that also allows for heterogeneity in fixed costs are closer to the gains suggested by the raw data, at 4.5%. So the full model suggests that CUSFTA “explains” about 90% of the gains reported in our earlier before-after analysis, while the model that only allows for truncation in the Pareto distribution suggests that CUSFTA accounts for about 120% of the observed gains.

The last three rows in the bottom panel decompose the welfare gain into the three terms in equation (2): the “intensive” margin, the loss from exit of domestic varieties, and the gains



from entry of new foreign varieties. In the data, the welfare loss from the exit of domestic Canadian varieties is significantly more negative (-2.40%) than the gain from entry of new foreign varieties (+0.44%) in the Canadian market. The model with only a truncated Pareto distribution in column 2 cannot capture this pattern. In our calibration of this model, the gain from new foreign varieties is larger than in the data, and is also larger than the losses from exit of domestic varieties (+2.14% vs -1.76%). In contrast, our full model with fixed cost heterogeneity in column 3 predicts that the gains from new foreign varieties due to CUSFTA are significantly smaller than the losses due to exit of Canadian varieties. And this is exactly what we see in the data.

### 5.3 Comparing welfare statistics

The last thing we do is compare alternative welfare statistics in our two calibrated models. Remember that the estimated parameters for our two models imply that the import demand is not iso-elastic. The question then becomes, how large is the bias if we were to use welfare statistics that assume iso-elasticity?

The answer depends on what the two models predict in terms of the change in  $\lambda$ , as well as the elasticity  $\theta$ . In section 4, the numbers we use for  $\theta$  are 2.9 and 2.65. Table 7 shows the gains from trade liberalization due to CUSFTA in the simulation of the two models. The first row repeats the simulated gains from CUSFTA calculated from the formula in equation (1) shown earlier in Table 6. The second and third rows show ACR's statistic calculated from the simulated data with the two estimates of  $\theta$ . In both models, the gains from trade calculated ACR's formula are larger than that obtained from equation (2) shown in row 1.

The last two estimates in Table 7 show the gains from trade calculated from formulas that do not rely on iso-elastic import demand functions. The first formula, from Melitz and Redding (2015) and Head et al. (2014), is a local approximation to the gains from trade that holds for any productivity distribution:

$$\Delta \ln W_j = -\frac{1}{\epsilon_L} \Delta \ln \frac{\lambda_{jj}}{M_j^e} \quad (6)$$

where  $M^e$  is the number of *potential* entrants and  $\epsilon_L$  is the local trade elasticity. Note that

Table 7: Welfare Measurement in Simulated Data

<u>Welfare Statistic</u>	<b>Melitz-Redding</b>	<b>Full model</b>
	<i>Truncated Pareto Only</i>	<i>Truncated Pareto + Fixed Cost Het.</i>
Our statistic: $-\frac{1}{\sigma-1} \Delta \ln \lambda_{jj}^c$	5.9%	4.5%
ACR, $\theta = 2.9$ <sup>1</sup>	7.8%	6.2%
ACR, $\theta = 2.65$ <sup>2</sup>	8.5%	6.8%
Melitz and Redding (2015), local elasticity <sup>3</sup>	6.2%	3.8%
Melitz and Redding (2015), $\Delta$ lowest prod. <sup>4</sup>	6.0%	0%

<sup>1</sup> ACR welfare statistic with extensive-margin based estimate of trade elasticity  $\theta = -\Delta \ln \left( \frac{M_{ij}/M_{jj}}{\bar{\varphi}_{ij}/\bar{\varphi}_{jj}} \right)$  or using Zipf's Law calculated as  $\theta = \xi \cdot (\sigma - 1)$  where  $\xi$  is the elasticity of firm rank with respect to firm employment.

<sup>2</sup> ACR welfare statistic with arc-elasticity proposed by Melitz and Redding (2015) and defined by  $\theta_{arc} = \Delta \ln \frac{(1-\lambda_{jj})/\lambda_{jj}}{(1+\tau_{ij})}$

<sup>3</sup> Local welfare statistic (6) with elasticity estimation using  $\epsilon_L = (1 - \sigma) + \frac{1}{\bar{X}_{jj}/X_{jj}^{MIN}} \cdot \Delta \ln \frac{M_{jj}}{\tau_{ij}}$  from Bas et al. (2017)

<sup>4</sup> Welfare statistic based on change in minimum productivity  $\Delta \ln W_j = \Delta \ln \varphi_d$ , where  $\varphi_d$  is the productivity of the marginal firm.

Note: Simulated effect of a 23% (13%) reduction in Canadian (US) tariffs in model with a truncated Pareto distribution of productivity and common fixed costs (column 1) and heterogeneous fixed costs (column 2). See text for details.

the number of potential entrants  $M^e$  is not something that can be observed empirically, but we can use our models' predictions of this variable. As for the local trade elasticity, Bas et al. (2017) estimate it as  $\epsilon_L = (1 - \sigma) + \frac{1}{\bar{X}_{jj}/X_{jj}^{MIN}} \cdot \frac{d \ln M_{jj}}{d \ln \tau_{ij}}$ , where  $\bar{X}_{jj}/X_{jj}^{MIN}$  denotes the ratio of the sales of the average firm to the smallest firm. In our simulated data, this formula gives us  $\epsilon_L = 3.75$  and  $\epsilon_L = 2.74$  for the models in columns 1 and 2 in Table 7, respectively.

The local approximation of the gains from trade given by equation (6) is shown in row 4 in Table 7. As can be seen, the gains from trade calculated from the local approximation are very similar to those obtained from equation (2) (shown in the first row). The difference of course is that equation (6) is valid only for small changes in trade costs, while we simulate a 23% (13%) tariff cut in Canada (the US). However, note that in our full model with fixed cost heterogeneity, the local approximation is strongly downward biased relative to formula (1), mostly driven by the fact that  $M_j^e$  falls in this model.

The last row in Table 7 shows the gains from trade calculated as the change in the minimum productivity of surviving firms. Head et al. (2014) and Melitz and Redding (2015) show that the minimum productivity is a sufficient statistic for the gains from trade for any change in trade costs and for any productivity distribution, but the statistic is only valid if all firms face the same fixed cost of production and exporting. In contrast to  $M^e$  which is unobservable, the productivity of the smallest surviving firm can be imputed from the size of the smallest surviving firm. Not surprisingly, the gain from trade calculated from this statistic in the simulated data in the Melitz and Redding (2015) model (column 1) is almost identical to that obtained from our formula in equation (1). This is not the case in the full model that also features heterogeneity in fixed costs. In the simulation of that model, shown in column 2, the productivity of the smallest surviving firm does not change due to CUSFTA so the gains from trade from CUSFTA predicted by that statistic is zero. The reason is of course heterogeneity in fixed costs, where some low productivity firms survive when trade costs fall because some of these firms face low fixed costs.

## 6 Conclusion

We propose a new sufficient statistic to measure the gains from trade that is valid for models where the import demand system is not necessarily iso-elastic. This includes a Ricardian model of trade with an arbitrary distribution of productivity and a Melitz model with any pattern of selection into exporting and production as well as any distribution of productivity. The statistic is simple to calculate, as it is just a function of one data moment, the market share of continuing domestic firms, and one parameter, the elasticity of substitution across varieties.

There are however some limitations of our proposed statistic. First, it does not measure the potential effect of trade liberalization on productivity growth among incumbent domestic firms (except when applied as described in the appendix (section A7)). Second, the statistic by itself does not tell us what fraction of the implied welfare change is due to changes in trade costs. And third, the approach can be applied to measure the gains from past trade reforms, but it cannot tell us the potential gains from a *future* change in trade costs.

There is no sufficient statistic that will allow one to address the last two issues. The only way to do this is to adopt a specific model. We calibrate a generalized Melitz model that does not impose iso-elastic import demand to answer these questions in the context of Canada's gain from the trade due to CUSFTA.

We raise one point for future research. In our calibrated model, we interpret the overlap in size between exporters and non-exporters as due to heterogeneity in fixed exporting costs. Similarly, we model the overlap in size between survivors and exiters as reflecting heterogeneity in fixed production costs. That is obviously a simplification, and perhaps not a good one. Our proposed sufficient statistic does not rely on a specific interpretation of this fact, but we hope that future work will provide richer models for this important stylized fact.

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