THE (ANTI-)COMPETITIVE EFFECTS OF TRADE LIBERALIZATION IN NORTH AMERICA

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Abstract

This paper tests predictions on the behavior of aggregate prices and productivity in response to trade liberalization derived from the Melitz-Ottaviano model of international trade with heterogeneous firms. The model's equilibrium conditions for the short- and long-run distribution of the aggregate variables are amended to yield regression equations that identify the effects of tariffs and trade openness on domestic competition in the marketplace. Model predictions on the effects of third-country openness to trade are also tested and information on industry market structure is used to separately test the model's short- and long run predictions. Our framework is estimated on a data set covering 64 manufacturing industries in the NAFTA member countries Canada, Mexico and the USA from 1988 to 2008. Consistent with the theoretical predictions, we find that in the short–term there are competitive effects of trade openness on prices and productivity, whereas in the long–term some of these effects are reversed. Third-country effects, however, run contrary to theoretical predictions and direct tests of short- and long-run industry reactions remain inconclusive. We posit that these mixed, long-term outcomes stem from Chinese import penetration, as well as the endogeneity of trade liberalization lobbying efforts.

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1 Introduction

The economic benefits of free trade are arguably one of the most uncontroversial results of economic research, both theoretically and empirically. However, to date, free trade is by no means uncontroversial in the public sphere, as is evidenced by the recent wave of protectionism across advanced economies. Hence, international trade has remained an active field in economic and political science research. These fields have seen major advancements in the past two decades in incorporating firm-level heterogeneity coupled with consumer love of variety into trade models that can account for the firm-level responses to increasing trade openness and the large share of intra-industry trade in the international flow of goods and services.[1] This new vintage of trade models predicts additional welfare gains from trade stemming from a reallocation of production to more productive firms (Melitz, 2003) or increases in firms' efforts to innovate (Grossman and Helpman, 1990). To some extent, these new models of trade also help reconcile the unambiguously positive stance of economic researchers on trade liberalization with the public opposition to it. Models that account for the heterogeneity across firms within a country show that while on aggregate there are significant efficiency gains from free trade, there are also firms and workers who will lose out individually. These individuals only benefit from trade liberalization if either the aggregate gains are redistributed in some way to ensure a Pareto improving allocation, or if they can benefit from the reallocation of production to more productive firms by switching to those firms.[2] Dix-Carneiro (2014) builds a structural model of the Brazilian labor market to estimate the labor market effects of trade liberalization and finds that, depending on the assumptions about capital mobility, the reallocation of workers across sectors can take up to 30 years.

While these new models of international trade are well grounded in empirical evidence coming

[1] A comprehensive survey of trade models with love of variety preferences and firm-level heterogeneity can be found in Melitz and Trefler (2012). For how these models account for political outcomes, see Madeira (2014) and **?**.

[2] These findings have been discussed in the political science literature dating back to Stolper and Samuelson 1941.

from micro data, there are surprisingly few tests of the models' predictions for aggregate variables which are decisive for the predicted welfare gains from trade. Arkolakis, Costinot and Rodriguez-Clare (2012) and Arkolakis et al. (2012) call into question the importance of firm-level heterogeneity by showing that in a class of trade models, the additional welfare gains are fairly small and actually even smaller if consumers do not have constant elasticity of substitution (CES) utility. The response of Melitz and Redding (2013) shows that there is still considerable disagreement over how to theoretically evaluate the additional welfare gains from firm selection. Costinot and Rodriguez-Clare (2014) review the effects of trade liberalization in a wider class of new trade models to highlight the importance of the market structure under consideration—depending on whether a single- or multi-sector model is used and the degree of competition assumed, gains from trade are estimated to range from 4% to 40% of non-free-trade welfare.

These facts motivate us to test the Melitz and Ottaviano (2008) model directly with aggregate data on prices and productivity.[3] To do so, we estimate the effects of trade liberalization on the competitive environment in manufacturing markets of the member countries of the North American Free Trade Agreement (NAFTA). We employ an estimation procedure introduced by Chen, Imbs and Scott (2009), who derive estimable regression equations from the model's equilibrium conditions that allow us to test the effects of trade openness on relative price levels and labor productivity of bilateral trading partners. It is further possible to differentiate between the effects of trade in the short run, which, in the model, refers to an economy without relocation decisions for firms, and in the long run, when firms are free to choose their home market for production. However, as the underlying model is static, no direct results on the time path of the impact of trade liberalization can be obtained. We try to address this issue by dividing our sample in ways that make it more amenable to a model-based estimation. Contrary to Chen, Imbs and Scott (2009), we directly

[3] Note that we do not test the model's predictions on short- and long-run markups, for which data is sparse over the number of industries in our sample.

observe tariff rates between the three countries in our sample and hence use those as a direct measure of trade openness. Additionally, we test for the effects of third-country trade openness on the relative performance of two countries linked through trade, predictions for which can be derived from the multi-country version of the Melitz and Ottaviano model. Our data set comprises of 64 manufacturing sectors in Canada, Mexico and the U.S., covering the time period from before the introduction of NAFTA in 1988 up to 2008, which gives us reason to believe that we are able to capture the long run effects of policy changes even in industries with low firm churning rates.

Our findings support the main model predictions, with the removal of tariff barriers stoking domestic competition, which we see in reduced relative prices and increased relative productivity. The results in the long-run, however, are not as clear cut, with some effects reversing as predicted by the model while some effects persist. This is also confirmed by directly looking at the reaction of industries with different entry barriers to changes in trade openness. We investigate the industries with the strongest lobbying efforts during the NAFTA negotiations and find that they also had the swiftest reduction in tariffs, strongest short-term competitive effects, and mixed effects in the long-term. We posit this may stem from Chinese import penetration, which we suggest may prove useful in future investigations into these long-term effects of trade liberalization. While *prima facie* trade seems to provide consumer benefits via lower product costs, the long-term benefits seem to accrue to a small number of firms. In other words, what looks like support for lower prices and thus consumers in the Stigler-Peltzman model[4] is actually support for higher profits for firms in the long-run.

The paper is organized as follows: Section 2 gives a survey of the previous literature assessing the effects of trade liberalizations in general and of NAFTA specifically. Section 3 briefly summarizes the Melitz and Ottaviano (2008) model, derives the most important equilibrium conditions and

[4]See Peltzman (1976).

explains the estimation strategy used in Chen, Imbs and Scott (2009). Section 4 then presents our application of the model by giving an overview of the data used and our estimation procedure. The results of our regressions and possible shortcomings as well as extensions of our approach are discussed in Section 5; Section 6 concludes.

2 Related Literature

As free trade has been an active topic in economic research since the times of Ricardo, the literature on the welfare gains from trade is immense. Of particular interest to us of course are papers that investigate the economic effects of NAFTA directly, as well as papers that form the theoretical foundation for our estimation strategy.

The effects of free trade in North America have been scrutinized in a large number of papers over the past two decades, starting with work on the predecessor to NAFTA, the 1987 Canada and US free trade agreement (CUSFTA). Head and Ries (1999) document rationalization effects in Canadian plants as a reaction to decreases in Canadian import duties. Trefler (2004), focusing on the CUSFTA, uses a reduced form econometric approach to find large improvements in labor productivity and decreases in employment after the implementation of CUSFTA, coupled with slightly lower import prices and larger volumes of trade. Fukao, Okubo and Stern (2003) derive regression equations from a partial equilibrium model with imperfect competition to estimate the extent to which NAFTA was trade diverting rather than creating and find responses that vary by industry. Romalis (2007) examines both CUSFTA and NAFTA with a strategy based on estimating demand and supply elasticities and finds a large effect of NAFTA on trade volumes, with only minor price changes and, subsequently, only small changes in welfare. Calderon-Madrid and Voicu (2007) use plant-level panel data from Mexico to show that while productivity increases followed the tariff reductions, the responses of plant-level productivity are very unevenly distributed, with larger plants benefiting disproportionately from productivity increases. The Melitz (2003) model that is at the heart of our analysis is also put to a test with US manufacturing data by Bernard, Jensen and Schott (2006*a*), who use plant-level data to estimate the effects of changes in the costs of trade, as measured by tariff rates and transportation cost, on productivity growth and firm entry and exit. Their findings confirm the micro-level implications derived from the assumptions on the productivity distribution in Melitz (2003), which we will highlight in the following section.

Other papers have used the structure provided by the Melitz and Ottaviano (2008) model to assess the effects of trade liberalization in other parts of the world: Bellone et al. (2008) use price-cost margins of French manufacturing firms to test the models predictions on the effects of market size, import penetration and exporting status on markups and productivity and confirm that all predictions hold. Corcos et al. (2011) estimate structural parameters in order to simulate counterfactual scenarios by changing the costs of trade between countries. Their exercise shows that the firm selection mechanism is crucial for the magnitude of the welfare gains from trade and the potential gains for a country depend on country size as well as remoteness. The paper that is closest to our own work is Chen, Imbs and Scott (2009), who use the equilibrium expressions for prices, markups and productivity from the Melitz-Ottaviano model to estimate the effects of trade liberalization using a dataset that includes data on 10 manufacturing sectors in seven European countries for the period 1989-1999 with country-pair regressions. There results suggest that trade openness leads to an increase in competitiveness in the short-run with diminishing and at times reversed effects in the long-run, as predicted by the model. As stated at the outset, Chen, Imbs and Scott (2009) do not directly observe tariffs in their estimation strategy, nor take into account potential third-country effects. We believe the addition of these variables and modeling approaches to the analysis, will benefit the empirical trade literature as we continue to understand the long-term impact of liberalization.

3 Model and Estimation Equations

The Melitz and Ottaviano (2008) model is a synthesis of the contributions of Melitz (2003), who introduces firm heterogeneity through random draws of a cost parameter for firms entering the market, and Ottaviano, Tabuchi and Thisse (2002), who develop a model with endogenous markups arising from a linear consumer demand system with horizontal product differentiation. The model yields equilibrium conditions that determine a cost cut-off level, i.e., a level of productivity below which firms are not able to compete in the marketplace. This cut-off level uniquely determines all relevant aggregate variables in the model, namely the distribution of prices, markups, and productivity. Importantly, the equilibrium conditions of the model economy are different depending on whether firm entry is allowed or not. Without firm entry, the model captures a short-run equilibrium, with the cost cut-offs in two markets given by:

$$N = \bar{N}\left(\frac{c_D}{c_M}\right)^k + \bar{N}^* \frac{1}{\tau^k}\left(\frac{c_D}{c_M^*}\right)^k \tag{1}$$

$$N^* = \bar{N}^*\left(\frac{c_D^*}{c_M^*}\right)^k + \bar{N}\frac{1}{(\tau^*)^k}\left(\frac{c_D^*}{c_M}\right)^k \tag{2}$$

Here, a star denotes the foreign market, $\bar{N}$ is the fixed number of incumbents in a market and N is the number of firms that are producing. c_M is the upper bound of the distribution of cost draws, c_D is the cut-off level, i.e. the highest cost draw that allows a firm to earn non-negative profits. $\tau > 1$ is the iceberg cost of trade faced by foreign companies exporting to the domestic market and can be interpreted as a measure of trade costs, tariffs and other impediments to trade.

The long-run equilibrium of the economy allows for firm entry into a market, so that the number of firms in a market is now endogenously determined by a zero profit condition for entrants that balances a fixed cost of entry with the expected profits when drawing a cost level from the (known) cost distribution of a country. The equilibrium conditions pinning down the cost cut-off are:

$$c_D = \left[\frac{\phi c_M^k}{L} \frac{1 - (\tau^*)^{-k}}{1 - (\tau\tau^*)^{-k}} \right]^{\frac{1}{k+2}} \tag{3}$$

$$c_D^* = \left[\frac{\phi c_M^k}{L^*} \frac{1 - \tau^{-k}}{1 - (\tau\tau^*)^{-k}} \right]^{\frac{1}{k+2}}, \tag{4}$$

where L is the size of the domestic market. Since all aggregate variables in the Melitz and Ottaviano model are linear functions of the cost cut-off, equations describing the relative price, markup, and productivity levels in two countries connected by trade can easily be found by simply dividing the expressions for c_D by those for c_D^*. This gives, for the price level in the short run:

$$\left(\frac{\bar{p}}{\bar{p}^*}\right)^k = \left(\frac{c_D}{c_D^*}\right)^k = \left(\frac{c_M}{c_M^*}\right)^k \frac{\bar{N}^*}{\bar{N}} \frac{N}{N^*} \frac{1 + \frac{\bar{N}}{\bar{N}^*} \frac{1}{(\tau^*)^k} \left(\frac{c_M^*}{c_M}\right)^k}{1 + \frac{\bar{N}^*}{\bar{N}} \frac{1}{\tau^k} \left(\frac{c_M}{c_M^*}\right)^k} \tag{5}$$

and in the long run:

$$\left(\frac{\bar{p}}{\bar{p}^*}\right)^{(k+2)} = \left(\frac{c_D}{c_D^*}\right)^{(k+2)} = \left(\frac{c_M}{c_M^*}\right)^k \frac{L^*}{L} \frac{1 - \frac{1}{\tau^k}}{1 - \frac{1}{(\tau^*)^k}} \tag{6}$$

These two equations capture one of the central predictions of the Melitz and Ottaviano model: asymmetrical trade liberalizations will have opposing effects on competitiveness in the short and the long run. By equation (5), lowering trade barriers induces a fall in the cost cutoff, and hence decreases in prices and markups and increases in productivity. In the long run, however, the effects are reversed, as an increase in trade costs induces firms to choose the relatively more protected market for production, thereby increasing competition in markets that are shielded from foreign firms.

Chen, Imbs and Scott (2009) show that it is possible to substitute out the trade cost term with an openness term that is derived from a measure of foreign firms market share in the domestic market. However, since we are interested in the effect of tariff rates on competitiveness, we use tariff data directly as a proxy for τ. This strategy should pick up the effects of tariff rates in our estimation if other determinants of trade openness—e.g., oil prices (Kilian, Rebucci and Spatafora, 2009), credit conditions (Chor and Manova, 2012), or shared culture and language between countries—do not vary systematically across industries. However, as a first step, we will replicate their analysis exactly in our data set (albeit with different instruments for openness), which requires us to make the same substitution, which is:

$$\frac{1}{\tau^k}\left(\frac{c_M}{c_M^*}\right)^k = \frac{\theta}{1-\theta} \tag{7}$$

Similarly, an expression for the average markup can be derived. The determination of the average markup is equivalent to the one for average prices so expressions for the short– and long–run impacts of openness on markups can readily be derived. Somewhat more problematic is the index for productivity, as the model requires knowledge of a firm's unit costs c, which are not observable. Chen et al. work around this issue by assuming away differences in capital costs, so that average industry productivity can be approximated by the ratio of nominal wages to labor productivity: $\bar{c} = \frac{w}{z}$. If it is additionally assumed that unit labor costs only depend on nominal wages, the ratio of domestic to foreign labor productivity can be written as:

$$\frac{z}{z^*} = \frac{w}{w^*}\frac{\bar{c}^*}{\bar{c}} \tag{8}$$

If the least competitive firm in an industry with a productivity draw at the upper bound of the distribution c_M has labor productivity z_M and labor is perfectly mobile between firms, equation (8) implies $\frac{z}{z^*} = \frac{w}{w^*}\frac{c_M^*}{c_M}$. This relationship can then be used in an analogous fashion as before to construct an expression relating openness to productivity. In the short run, equation (8) can be amended to yield:

$$\left(\frac{z}{z^*}\right)^k = \left(\frac{z_M}{z_M^*}\right)^k \frac{(\bar{N}/N)}{(\bar{N}^*/N^*)} \frac{1 + \frac{\bar{N}*}{\bar{N}}\frac{\theta}{1-\theta}}{1 + \frac{\bar{N}}{\bar{N}^*}\frac{\theta^*}{1-\theta^*}} \tag{9}$$

Higher values of θ thus lead to higher productivity (conditional on $\bar{N}/N$), as they force lower productivity firms to shut down production. For the long run, equation (5) combined with the expression for labor productivity gives:

$$\left(\frac{z}{z*}\right)^{k+2} = \left(\frac{w}{w^*}\right)^2 \frac{L}{L^*} \left(\frac{z_M}{z_M^*}\right)^k \frac{1 - \frac{\theta}{1-\theta}}{1 - \frac{\theta^*}{1-\theta^*}} \tag{10}$$

Larger markets exhibit higher labor productivity, while the effects of θ and θ^* are the opposite of those in the short–run.

3.1 The Role of Market Entry

Following the arguments in Trefler (2004), we want to exploit the nature of NAFTA being close to a natural experiment and hence try to identify the effect of policy measures—i.e., the changes in tariff rates—separately from the effects of trade openness in general. There is evidence that trade openness—measured by the import penetration of a certain country or industry, as in Chen, Imbs and Scott (2009)—is affected by a number of external forces, including oil prices (Kilian, Rebucci and Spatafora, 2009), credit conditions (Chor and Manova, 2012), distance, shared culture, and language between countries (Baier and Bergstrand, 2004). Therefore, we deconstruct the iceberg costs of trade into two parts: $\tau^{lh} = \frac{Tr^{lh}}{\theta^{lh}}$, where $Tr^{lh} > 1$ is the tariff rate for trade between countries l and h and $\theta^{lh} > 1$ captures the additional costs of trade imposed by the aforementioned factors. Then, the import penetration can be viewed as a measure of θ^{lh}, as in Chen, Imbs and Scott (2009), while a carefully constructed tariff measure can directly account for the effect of NAFTA-mandated changes in the trade environment. Obviously, the import penetration in a sector depends on the tariff measure as well, so an instrumental variable approach has to be taken in order to identify this effect. We defer the discussion of the construction of the tariff measure and the choice of instruments to the following section. Prior work by Bernard, Jensen and Schott (2006*b*) suggests that tariff rates throughout the 1980s, at an average level between four and five percent, accounted for about the same fraction of trade costs as costs directly attached to shipping the good—i.e., freight and insurance—so we expect them to have a sizable impact on trade flows between countries and hence the competitive environment.

As we have seen in the exposition of the Melitz and Ottaviano model above, there is one crucial caveat in taking the model to the data: due to the static nature of the model, the comparative static results just compare one steady state with another, while being silent about the transitional dynamics. The estimation strategy of Chen, Imbs and Scott (2009) tries to account for this by estimating an error correction model to identify the long-run separately from the short-run, but their results—just as ours—are mixed for the long run and it cannot be ruled out that this is due to the estimation procedure. Therefore, we try to address this issue in a more direct way: as short- and long-run in the model differ only in the possibility of firm entry, we separate industries into those with a fixed number of firms and those with low entry barriers. This distinction then gives us industries that represent the short- and long-run and we can directly investigate whether the coefficients on the relevant variables differ significantly[5].

This approach, however, leads to two issues that need to be addressed before implementation. First, it is not *a priori* obvious how to measure the entry conditions in an industry; while the theoretical model uses the number of firms, this could in practice either refer to firms or to establishments—i.e., different production sites run by the same parent company—, or even to em-

[5]We were inspired to do so by Head and Ries (1999) who use the classification to test competing theories of trade that rely on different market structures.

TABLE I. Market structure measures used, numbers in percent

Study	**Subject**	**Highest Turnover**	**Lowest Turnover**
Dunn et al. (1988)	Entry Rates (4-yearly) U.S. (1963-82)	Instruments (60.3) Lumber (49.70) Printing (49.0)	Leather (29.4) Food Processing (23.9) Tobacco (20.5)
Samaniego (2008)	Entry Rates (yearly) Europe (1997-2004)	Paper, printing, software (15.6) Textiles (11.9) Petroleum and Coal (11.9)	Chemicals (9.5) Plastics (9.4) Food Products (9.1)
Brown (2004)	Employment renewal Canada (1973-1996)	Plastic (79.5) Furniture (79.4) Fabricated Metals (77.2)	Primary Metals (33.6) Paper (32.4) Tobacco (4.2)
Foster et al. (2006)	Job creation (yearly) U.S. (1972-1998)	Lumber (11.8) Apparel (11.2) Miscellaneous (11.0)	Paper (5.9) Petroleum (5.9) Tobacco (5.1)
Baldwin et al. (1994)	Job turnover (yearly) Canada (1973-1986)	Furniture (26.5) Machinery (26.3) Lumber (25.7)	Petroleum (14.1) Primary Metals (13.5) Paper (10.7)
Baldwin et al. (1994)	Job turnover (yearly) U.S. (1973-1986)	Lumber (27.2) Apparel (25.5) Leather (22.5)	Petroleum (14.6) Chemicals (14.0) Paper (13.3)

ployees, as firms in the model use unit labor input. Second, there is no reason to believe that different measures of entry and exit dynamics are exogenous with respect to trade openness—indeed in the model trade openness is a key factor in the entry decision of firms, but in the real world there might be various other factors that might lead to industries being asymmetrically affected by a change in trade costs, hence biasing our results. To tackle both these issues, we aim to construct a robust measure of industry dynamics by aggregating multiple studies that examine firm and employment turnover in Canada, Mexico and the United States as well as Europe over different time periods. With this, we hope to identify those industries that are either very dynamic or very static over a broad set of different measures, regions and time periods. Table I gives an overview of the studies used and a glance at their respective results, showing considerable variation in the dynamics of entry and job creation in different manufacturing sectors.

In order to aggregate the different studies, we compute percentile-based rankings of the industries for each study and then average the percentiles across studies. Based on these average percentiles, we can then split the sample according to the short- and long-run distinction made in the model: those industries above the 60th percentile are taken to represent the dynamic, "free entry" sample and thus the long run, while those industries below the 40th percentile are taken to represent the short run. This procedure leads us to split the sample three-ways:

1. Short-run category: machinery and transportation equipment; manufacturing not else classified; wood and cork.

2. Long-run category: food, beverages, and tobacco; textiles; chemicals, fuels, plastics, and rubber.

3. Dropped because too close to the median to be classified either way: paper and printing, basic and manufactured metal products, and other non-metallic mineral products.[6]

A little thought experiment may clarify the role that market entry effects play in muddling the distinction between short– and long–run equilibria. The Melitz and Ottaviano (2008) model yields opposing predictions on the effects of trade liberalization on country-level economic variables such as prices, productivity and mark-ups. The reason for the differences, as we have seen, lies in the assumptions on market structure: there are two different equilibria depending on whether entry into a market is allowed. We repeat them here for convenience:

$$c_D^k = c_M^k \frac{\bar{N}^*}{N^*}\left(1 + \frac{\bar{N}}{\bar{N}^*}\frac{\theta^*}{1-\theta^*}\right)$$
$$c_D^{k+2} = \frac{\phi c_M^k}{\Upsilon L}\left(1 - \frac{\theta^*}{1-\theta^*}\right)$$

In model terms, only one of these two equations holds at any given time, and it is posited that the first equation captures the short run effects of trade liberalization, while in the long run firms

[6]Due to different classification systems, the aggregation of studies was not always exact and some industry groups are quite heterogeneous when sub-industries are considered. For further details on the aggregation see Appendix B.

are allowed to enter the markets and the effects of trade barriers are determined by the second equation. No further assumptions on the nature of the firm's entry decisions or capital adjustment costs are made that could help separate short from long run. However, in reality, it seems to be more natural to assume that there is a gradual evolution from one equilibrium to the other, and this view is borne out by data on firm entry and exits showing that in a given year, only between five and ten percent of firms in a given industry are new entrants, while over longer horizons this figure goes up to 80 percent. Hence, it seems to be reasonable to model the transition from the short- to long-run equilibrium by introducing a parameter α that governs the fraction of firms entering an industry. The effects of this parameter are most clear on the productivity side, given that firms cannot change their productivity level, the new productivity distribution will be a weighted average of new entrants' and existing firms' productivity. As the examples in Chen, Imbs and Scott (2009) are formulated with respect to relative prices, and we are using their notation, we will discuss the effects of limited firm entry in the price level case as well. The argument carries through if one is ready to assume a nominal rigidity that prevents incumbents from re-optimizing their prices, similar to the assumptions made in New Keynesian monetary models. Similar to the productivity level, the price level is then a weighted average of new and old prices—for simplicity, here we abstract from substitution effects induced by the new relative prices of new and old producers:

$$
\begin{aligned}
\bar{p} &= \alpha \bar{p}^{LR} + (1-\alpha)\bar{p}^{SR} \\
&= \alpha c_D^{LR} + (1-\alpha) c_D^{SR} \\
&= \alpha \left(\frac{\phi c_M^k}{\Upsilon L} \left(1 - \frac{\theta^*}{1-\theta^*} \right) \right)^{\frac{1}{k+2}} + (1-\alpha) \left(c_M^k \frac{1}{\frac{\bar{N}}{N}\left(1 + \frac{\bar{N}^*}{\bar{N}} \frac{\theta}{1-\theta}\right)} \right)^{\frac{1}{k}}
\end{aligned}
$$

where the second line drops the constant linking price level and cost cut-off for notational simplicity.

It can easily be seen that the introduction of the α parameter makes the expression for the price level hugely complicated and eliminates the possibility to cancel out most constant terms by using relative prices as was done in Chen, Imbs and Scott (2009). The above expression is nearly impossible to take to the data in the hope of identifying any of the parameters.

Let's consider a simplified version of the above. Assume that relative prices levels in the short- and long run, respectively, are given by:

$$
\begin{aligned}
\frac{\bar{p}^{SR}}{\bar{p}^{*SR}} &= \left(\frac{c_M}{c_M^*}\right)^k \frac{(\bar{N}^*/N^*)}{(\bar{N}/N)} \frac{\rho^*}{\rho} \\
\frac{\bar{p}^{LR}}{\bar{p}^{*LR}} &= \left(\frac{c_M}{c_M^*}\right)^k \frac{L^*}{L} \frac{(1-\rho^*)}{(1-\rho)}
\end{aligned}
$$

This is a simplified version of the equilibrium conditions in Chen et al. using the notation of Melitz and Ottaviano in which trade freeness is measured by $\rho \in (0,1)$. It captures the main essence of the model, in the short run relative prices depend on the number of firms and negatively on trade freeness (increasing ρ will decrease $\bar{p}$), while in the long country size matters and prices depend positively on trade freeness (increasing ρ decreases $1-\rho$ and thus increases $\bar{p}$). Now assume further, that price setting decisions and substitution behavior of consumer is such that we can aggregate *relative* price levels in the same way we aggregated individual price levels before. Then:

$$
\begin{aligned}
\frac{\bar{p}}{\bar{p}^*} &= \alpha \frac{\bar{p}^{LR}}{\bar{p}^{*LR}} + (1-\alpha)\frac{\bar{p}^{SR}}{\bar{p}^{*SR}} \\
&= \alpha \left(\left(\frac{c_M}{c_M^*}\right)^k \frac{L^*}{L} \frac{(1-\rho^*)}{(1-\rho)} \right) + (1-\alpha) \left(\left(\frac{c_M}{c_M^*}\right)^k \frac{(\bar{N}^*/N^*)}{(\bar{N}/N)} \frac{\rho^*}{\rho} \right)
\end{aligned}
$$

Here, the fundamental identification problem becomes apparent: in the first term on the right hand side of the equation, the effect of ρ on $\bar{p}$ is positive, while in the second term it is negative.

However, the size and sign of the composite effect will be governed by α, which is unobservable. In order to estimate the effects of trade openness on prices, we have to control for firms entry behavior. While this might well be endogenous to changes in trade policy, it is reasonable to assume that different industries have different entry conditions due to fixed costs inherent in the business model. We can try to exploit this variation in entry conditions by sorting businesses according to the ease of entry; then, ceteris paribus, an industry with lower barriers to entry should exhibit a response to trade liberalization along the lines that the model predicts for the long run equilibrium (as the value of α increases, $\bar{p}$ approaches $\bar{p}^{LR}$), while an industry with high entry barriers subject to the same trade liberalization should see a very different reaction.

One way to alleviate this problem is by trying to use information on α in the estimation. Splitting the sample based on our aggregated turnover measures can be seen as a crude approximation to this, as can be the construction of dummy variables for high and low turnover industries. The most direct way, however, would be to use information on industry turnover rates directly. Obviously, this brings back the very same endogeneity problems we described above that were one reason to aggregate the studies in the first place, which makes it important to instrument for entry and exit rates in industries using turnover measurements for different periods than the one considered in the estimation. The variable construction will be explained in more detail in the next section.

4 Application

Starting from the equations for prices and productivity derived within the Melitz-Ottaviano framework, we can derive estimable log-linearized equations analogous to those in Chen et al. The estimation equation for prices is given by:

$$\Delta \ln\left(\frac{\bar{p}_{it}}{\bar{p}^*_{it}}\right) = \beta_0 + \beta_1 \Delta \ln \tau_{it} + \beta_2 \Delta \ln \tau^*_{it} + \beta_3 \Delta \ln D_{it} + \beta_4 \Delta \ln D^*_{it} \\ + \gamma \left[\ln\left(\frac{\bar{p}_{it-1}}{\bar{p}^*_{it-1}}\right) + \delta_0 + \delta_1 \ln L_{t-1} + \delta_2 \ln L^*_{t-1} + \delta_3 \ln \tau_{i,t-1} + \delta_4 \ln \tau^*_{i,t-1}\right] + \varepsilon_{ijt} \tag{11}$$

In the above equation, the number of firms serving the domestic market, N, has been replaced by the more readily observable number of domestic firms producing for the domestic market, D, where $D = N\left(\frac{c_D}{c_M}\right)^k$. The short–run dynamics are estimated in the first part of the equation, with regressors expressed in first differences. The long run is represented by the term in brackets. From the perspective of this model, we would expect $\beta_1 > 0$, an decrease in domestic import tariffs decreases relative prices in the short-run, and correspondingly $\beta_2 < 0$. The model predicts a dampening effect of the number of domestic firms on domestic prices, which should be reflected by $\beta_3 < 0$, and the opposite for foreign firms, $\beta_4 > 0$. In the long-run, $\delta_3 < 0$ provides evidence of the long-run anti-competitive effects of trade liberalization.

As previously discussed, all aggregate variables (prices and productivity) are ultimately functions of the cost-cutoff level c_D, leading to very similar estimation equations for our two dependent variables. The effect of tariffs, openness, number of firms and market size on productivity is estimated by:

$$\Delta \ln\left(\frac{\bar{z}_{it}}{\bar{z}^*_{it}}\right) = \beta_0 + \beta_1 \Delta \tau_{it} + \beta_2 \Delta \tau^*_{it} + \beta_3 \Delta \ln D_{it} + \beta_4 \Delta \ln D^*_{it} \\ + \gamma \left[\ln\left(\frac{z_{it-1}}{z^*_{it-1}}\right) + \delta_0 + \delta_1 \ln L_{t-1} + \delta_2 \ln L^*_{t-1} + \delta_3 \tau_{i,t-1} + \delta_4 \tau^*_{i,t-1} \right. \\ \left. + \delta_5 \ln w_{i,t-1} + \delta_6 \ln w^*_{i,t-1}\right] + \varepsilon_{ijt} \tag{12}$$

where δ_5 and δ_6 capture the effects of changes in nominal wages in the long run. The intercepts β_0 are introduced to capture differences in country—specific technology as Chen et al. depart from the baseline Melitz-Ottaviano model by allowing for such differences. While in the baseline, these vary by country-pair, we check the robustness of the specification by allowing fixed effects at a sectoral level.

4.1 Preferential Trade Liberalization

The model results and estimation equations presented so far all referred to a unilateral trade liberalization in a simplified two-country setup.[7] While making the exposition clearer and helping to elicit the effects at work in the model, this setup is clearly not an accurate description of the reality of trade relationships in modern industrialized economies. Taking the United States as an example, while the two other countries in our data set, Canada and Mexico, are two of its largest trading partners, they only account for approximately 14.5% of all US trade by value, each.[8] Even the largest 30 US trading partners only account for about 86% of US trade, highlighting the fragmented nature of international trade. While the Melitz-Ottaviano model can be extended to an arbitrary number of countries, it is not easily feasible to assemble a data set on all trade partners of the NAFTA countries due to data limitations. We do, however, want to recognize the multi-country structure of NAFTA by taking into account third country effects of trade barriers. Here, NAFTA can be interpreted as a preferential liberalization of Mexico *vis-a-vis* the US and Canada, as Mexico had the highest tariff barriers. In the three country case, we expect the country with the lowest sum of bilateral trade barriers to have the lowest cost cutoff, as it becomes the best export hub. To account for this, we amend equations 11 and 12 by including the relevant third country tariffs. The estimation equation for the effects of trade barriers on prices then becomes:

[7] Note that a bilateral trade liberalization – changing τ and τ^* by the same amount – would not lead to the discussed short- and long run changes in cost cutoffs for two countries, but instead to a decline in the cost cutoffs in both countries both in the short and the long run.

[8] See the https://www.census.gov/foreign-trade/statistics/highlights/top/top1812yr.html.

$$
\begin{aligned}
\Delta \ln \left(\frac{\bar{p}_{it}}{\bar{p}_{it}^{*}}\right) =& \beta_0 + \beta_1 \Delta \ln \tau_{it} + \beta_2 \Delta \ln \tau_{it}^{*} + \beta_3 \Delta \ln \tau_{it}^{ht} + \beta_4 \Delta \ln \tau_{it}^{th} + \beta_5 \Delta \ln \tau_{it}^{ft} + \beta_6 \Delta \ln \tau_{it}^{th} \\
&+ \beta_7 \Delta \ln D_{it} + \beta_8 \Delta \ln D_{it}^{*} + \beta_9 \Delta \ln D_{it}^{t} \\
&+ \gamma \Bigg[\ln \left(\frac{\bar{p}_{it-1}}{\bar{p}_{it-1}^{*}}\right) + \delta_0 + \delta_1 \ln L_{t-1} + \delta_2 \ln L_{t-1}^{*} + \delta_3 \ln L_{t-1}^{t} + \delta_4 \ln \tau_{i,t-1} \\
&+ \delta_5 \ln \tau_{i,t-1}^{*} + \delta_6 \Delta \ln \tau_{it}^{ht} + \delta_7 \Delta \ln \tau_{it}^{th} + \delta_8 \Delta \ln \tau_{it}^{ft} + \delta_9 \Delta \ln \tau_{it}^{th} \Bigg] + \varepsilon_{ijt}
\end{aligned} \tag{13}
$$

where now h is the domestic economy, f is the foreign economy, and, with a slight abuse of notation, a t superscript denotes the third country for each country pair—e.g., when estimating the Canada-US relationship, τ^{th} are Mexican tariffs on Canadian goods, while τ^{ht} are Canadian tariffs on Mexican goods. The equation for productivity is amended accordingly.

4.2 Dataset

Our database covers the period 1988-2008 for the North American Free Trade Agreement (NAFTA) member countries—Canada, Mexico, and the U.S.—and 64 (4-digit) manufacturing sectors. The main explanatory variable in this analysis is the domestic tariff imposed on foreign products. All tariff data originates from the World Integrated Trade Solution (WITS), an online software package published by the World Bank in collaboration with UNCTAD, the WTO, International Trade Center, and the UN Statistical Division. WITS publishes annual trade and tariff data from two different sources: the World Bank IDB database and the UNCTAD TRAINS database. Unfortunately, neither database provides a complete time series for each country that is devoid of erratic (and unexplained) jumps in the data. Thus, we created a data set that uses mostly TRAINS preferential tariff (PRF) data, but supplements it with observations from TRAINS or WTO IDB applied tariffs (AHS) where appropriate—this choice only makes a difference where there is no trade observed between countries and hence no applied rate, but a preferential rate still exists. All tariff data is reported according to ISIC Rev. 3.1 and converted to NAICS. This leads to the following rules for each country: (1) Canada: TRAINS PRF from 1988 to 1995, WTO AHS from 1996 to 2008. (2) Mexico: TRAINS AHS from 1988 to 1994, TRAINS PRF from 1995 to 2008. (3) USA: TRAINS PRF from 1988 to 1996; WTO AHS for 1997 to 2008.

For our factory gate price data, we use the producer price index (PPI) as reported by CANSIM, the Banco de Mexico, and the U.S. Bureau of Labor Statistics, respectively. All indices are normalized to equal 100 in 2003.

Labor productivity is calculated as the ratio between real value-added and total employment, as provided by the OECD SDBS database for Canada, the *Instituto Nacional de Estadistica y Geografia* (INEGI) for Mexico, and the NBER-CES Manufacturing Industry Database for the U.S. (Becker, Gray and Marvakov, 2013). All value-added data is converted into constant 2005 USD.

The number of establishments in each sector is taken from the OECD for Canada, INEGI for Mexico, and the Bureau of Labor Statistics for the U.S. Market size is measured by the value of GDP for each country, which is available in constant 2005 USD from the the World Bank's *World Development Indicators*. And finally, our wage data comes from the OECD SDBS database for Canada, the *Instituto Nacional de Estadistica y Geografia* for Mexico, and the NBER-CES Manufacturing Industry Database for the U.S. (Becker, Gray, and Marvakov, 2013). The Canadian and Mexican data are converted to NAICS using appropriate correspondence tables, and all values are converted to constant 2005 USD.

As discussed in the previous section, for all of the log-linearized equations, we replace the number of firms serving the domestic market, N, with the number of domestic firms producing for the domestic market, D. Unfortunately, this data is not available for all three countries during the specified time period, and thus we utilize the number of establishments, which will always be higher than the firm count as each firm may have multiple establishments. As long as the average number of establishments per firm remains constant, this should not present a problem, as our model is estimated in first differences. It is however not obvious that this relationship will remain constant in response to a trade liberalization. In fact, the main channel through which welfare gains arise in the model is the reallocation of production from unproductive to more productive firms, with less productive firms exiting the market and more productive firms expanding. If this displacement happens through larger firms taking over establishments of less productive ones, we would expect the number of establishments to stay constant, while the number of domestic producers falls—i.e., the number of establishments per firm increases. If on the other hand larger firms are simply able to expand production in existing establishments, this effect would be absent.

4.3 Estimation

As outlined at the beginning of Section 4, we follow the estimation strategy of Chen et al. (2009); however, while they use changes in domestic and foreign import penetration in sector i at time t as the main explanatory variables for changes in relative prices and labor productivity, we use this as a control variable and instead rely on the domestic tariff rate (τ) imposed on foreign goods imported from the trading partner and foreign tariff rate (τ^*) imposed on domestic goods exported to the trading partner as the main explanatory variables. To test the competitive effects of trade liberalization, we use the difference in differences approach with fixed-effects on the country-pair, industry, and year. In the short run we use the log first-difference in the explanatory and dependent variables, whereas we use a lag operator on the explanatory variables and an error correction term to estimate the dynamics in the long run. Moreover, because our variables are stationary in a unit root sense and serially correlated, we utilize a panel-specific AR(1) autocorrelation structure and perform our regressions using a Generalized Least Squares estimation strategy.

Table II outlines the comparative statics for the theoretical model, with subscript sr denoting the "short run" and lr denoting the "long run." Notice that in the long run, theory suggests that the pro-competitive effects are reversed and actually take an anti-competitive nature as firms are able to relocate to new markets. Interestingly, as we will exhibit in the following section, our analysis does not provide the same long-run dynamics.

TABLE II. Comparative Statics – Model Predictions

Regressor	**Dependent Vars.**			
	$\bar{p}_{sr}$	$\bar{p}_{lr}$	z_{sr}	z_{lr}
τ	+	−	−	+
τ^*	−	+	+	−
D	−		+	
D^*	+		−	
L		−		+
L^*		+		−

5 Results & Discussion

Tables V and VI present our results on the short-run effects of trade liberalization on prices and productivity, respectively. Column (1) in each table presents the results from our theoretical estimations in equations 11 and 12, respectively. Beginning with table V, we see that the signs on the tariff measures are as predicted—a decrease in the domestic tariff will decrease the relative price in the short-run—but only the foreign tariff measure is statistically significant. The measure of openness, on the other hand, is as predicted in the model and both coefficients are significant at the 1% level. Finally, contrary to the model's predictions the number of firms serving the domestic market does not have any effect on prices. Turning to Table VI, we see that the effects on industry productivity with different results than predicted by the theoretical model. Although the domestic tariff measure is positive and significant, we see that the openness measures have the opposite effect than the model predicts, albeit the effects are rather weak—an increase in domestic import penetration actually brings about a *decrease* in productivity in the short-run. The same holds for the number of firms serving the domestic market, which, in this case, *decreases* relative productivity in the short term, while the opposite is true for the number of foreign firms. An explanation for these results that run counter to the theory is that, as explained earlier, the number of establishments may bias the results. In this case, as the number of factories increases, the total productivity of labor decreases, which can be attributed to the amount of labor serving these new establishments. Column (2) allows for fixed effects on the dyad and industry, with the results holding.

The main contribution of this paper comes from the consideration of third-country effects as well as the role of market entry in the estimation strategy. Tables VII and VIII present our results on the short-run effects of trade liberalization on prices and productivity, taking into account these third-country and market-entry effects. In columns (1) and (2) of Table VII, we present the results using the pooled sample of country-pairs—column (1) uses county-industry fixed effects; column (2) uses country fixed effects. We note that there is a strong, anti-competitive effect of third-country tariff liberalization (τ^{tf}): as the other two countries in the PTA liberalize, it crowds out competition in the home market and increases relative prices. There are, however, competitive effects of home tariff reductions with the third country (τ^{ht}) as predicted by the model. Note that these effects are robust to each empirical modification, including country-only fixed effects (columns 2, 5, 6), and restricting the sample to industries with free market entry (columns 3 and 5) and those with fixed market entry (4 and 6).

Turning to the third-country and market entry effects on productivity, Table VIII illustrates competing effects of preferential trade liberalization. First, we see that a reduction in tariffs between home and foreign markets leads has competitive effects as predicted by the theoretical model. This effects holds across each specification, but loses significance when restricted to the fixed entry sectors. Here, there seems to be a negligible effect of trade liberalization on productivity, which follows from the theoretical predictions as these firms tend to have low churning rates and subsequently less competition. The effects is similar for the third-country and foreign country tariff liberalization, with pro-competitive effects on relative productivity. The same is true for the change in domestic firms. These findings hold when the sample is restricted to the free entry sectors.

Next we investigate the long-term impact of trade liberalization on prices and productivity using an error correction model. Table IX presents the results from this analysis, which now includes market size (L). Focusing on the first two columns, which use fixed effects on the dyad-industry and dyad only, respectively, we see that the theoretical model's predictions are flipped, albeit weakly: a decrease in the domestic tariff leads to weakly competitive effects, while a decrease in foreign tariff has weakly anti-competitive effects. The theoretical predictions on market size in the long-run are also opposite of the theoretical predictions, with a larger market leading to a decrease in relative prices. These effects hold when using Chen et al.'s measure of trade openness (θ). We posit that these surprising results may be due to the suppression of third-country effects. Table X includes third-country variables. In column (1), we see that the non-domestic tariff liberalization has anti-competitive effects—e.g., as Canada and the US liberalize under CUSFTA, Mexico has long-term increases in prices. However, contrary to the theoretical model, there are statistically strong, competitive effects of market size (L), which is robust to each empirical specification. Next we turn to the effects of liberalization on long-term productivity, to see if these findings match the theoretical predictions.

Table XI exhibits the long-term effects of trade liberalization on productivity, across all country pairs. Note again that the effect of liberalization goes against the theoretical model, albeit weakly; this holds for each model specification. Moreover, the impact of market size seems to be model dependent as it changes given the type of fixed effect used in the analysis, weakening the interpretation of these results. As before, we use the introduction of third-country variables to pinpoint the true impact of this network of liberalization between countries. In Table XII we find support for the theoretical predictions regarding the anti-competitive effects of trade liberalization. In the first three specifications, a decrease in the domestic tariff on foreign goods has similar decrease in long-term productivity. In column (3), where we isolate the sample to industries that have free entry (i.e., high entry rates), we see this anti-competitive effect holds as predicted by the theoretical model on third-country effects. Likewise, the effect disappears when restricting the sample to fixed entry industries—column (4). We should also note that the market-size effect has a strongly competitive effect in the long run, which goes against the model's theoretical predictions.

We find that the short-run effects of trade liberalization to follow the theoretical predictions of the Melitz and Ottaviano model, but the effects are mixed in the long run. The inclusion of third-country variables also has mixed results, but tends to show that decreases in tariff barriers will have anti-competitive effects on productivity, and negligible effects on prices. The latter finding may be due to decades of rather low inflation due to import penetration of low-cost Chinese goods. This analysis would benefit from the inclusion of better data, including the number of firms rather than the number of establishments.

5.1 Political Economy Explanations

The competitive effects of trade liberalization in the short-run tends to follow the model's theoretical predictions. However, these effects are mixed in the long-term. We believe this may be due to variation at the industry level which is reflected in the initial lobbying efforts for NAFTA. Chase (2003) argues that firm lobbying for liberalization increases with the intensity of their production sharing and their returns to scale. Indeed, he finds that tariffs for industries that exhibited the highest levels of production sharing and returns to scale, also had the swiftest reduction in tariffs. This explains the strong competitive effects in the short-run. Moreover, a cursory look at the industries whose tariffs were reduced the quickest—electronic components, computers, autos—shows the strongest short-run competitive effects. Thus, the competitive effects seem to be endogenous to a political economy model of trade. Where this research would stand to gain further is to consider the long-term, third-country impacts of major exporters such as China. The import competition from China after its 2001 ascession to the WTO could very well be the missing link to the mixed outcomes of the long-term model.

6 Conclusion

The only empirical application of the Melitz and Ottaviano (2008) model to date suggested that the long–run effects of trade liberalization are anti–competitive, that is, there will be a reversal in any competitive gains as firms are allowed to move to new markets. However, largely due to the year restrictions in their database, the results from are insignificant in the long run, and thus merely suggestive. While this paper replicates their analysis with only minor conceptual changes, our use of NAFTA as a defining multilateral trade agreement and the 20-years of data available after its implementation, provides new insights into the long–run dynamics of international trade agreements. While the theory suggests a reversal of competitive effects in the aggregate, this paper illustrates that the competitive effects are merely assuaged, but certainly not reversed. This adds credence to the pro-liberalization camp of policy makers who argue for the social welfare improving competitive effects of trade liberalization in the short–, medium–, and long term.

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7 Appendix A: Figures, Summary Statistics, Results

Figure 1. Canadian Tariffs on Mexican Goods

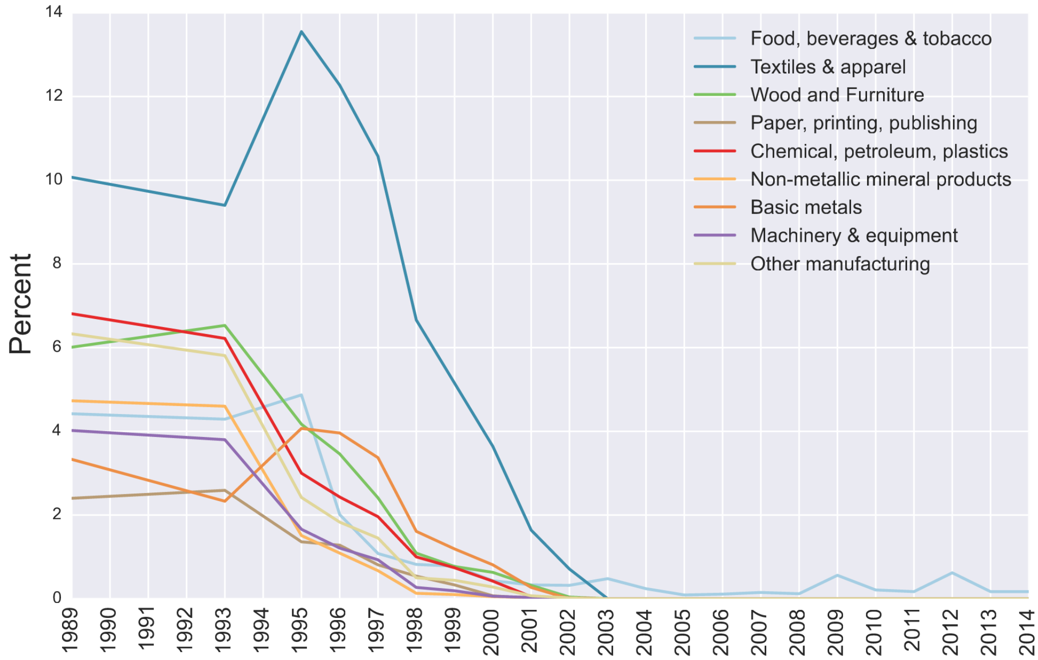

Figure 2. Canadian Tariffs on U.S. Goods

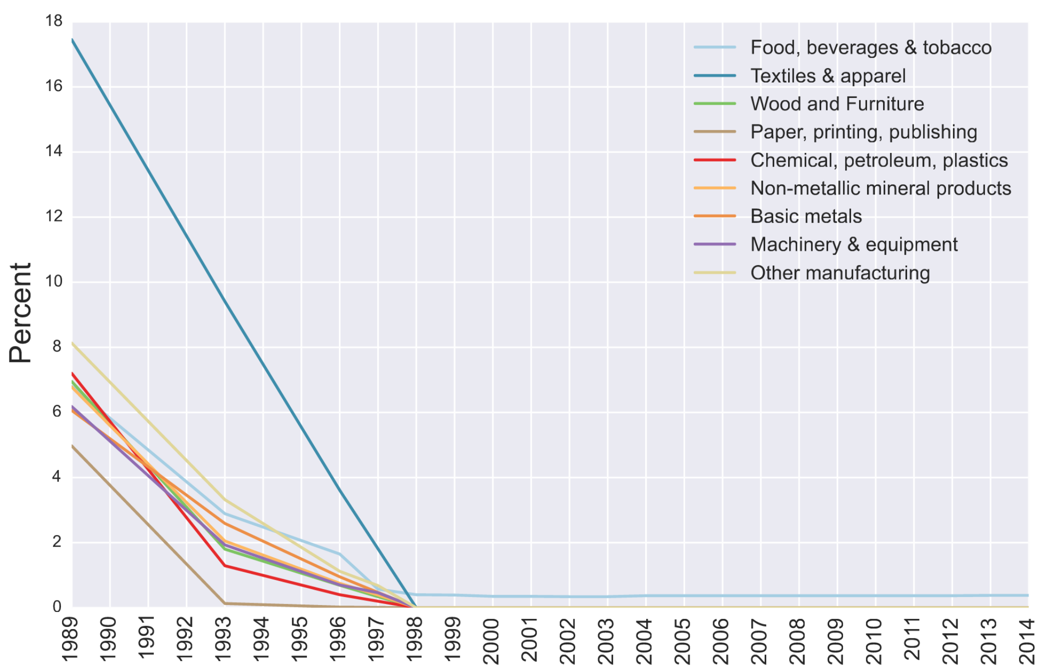

Figure 3. Mexican Tariffs on Canadian Goods

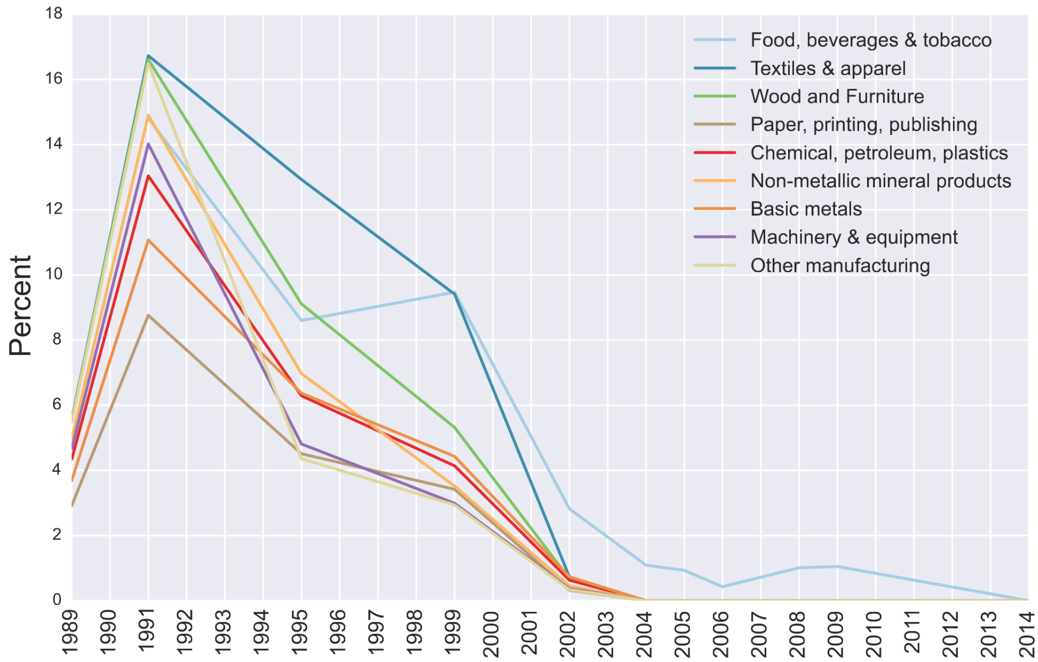

Figure 4. Mexican Tariffs on U.S. Goods

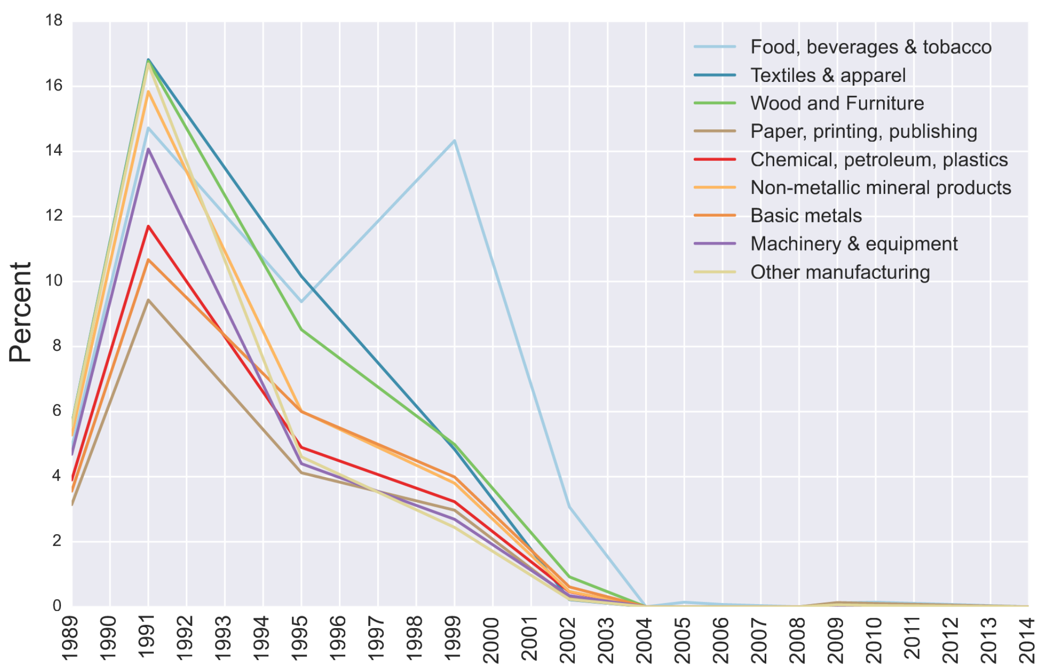

Figure 5. U.S. Tariffs on Canadian Goods

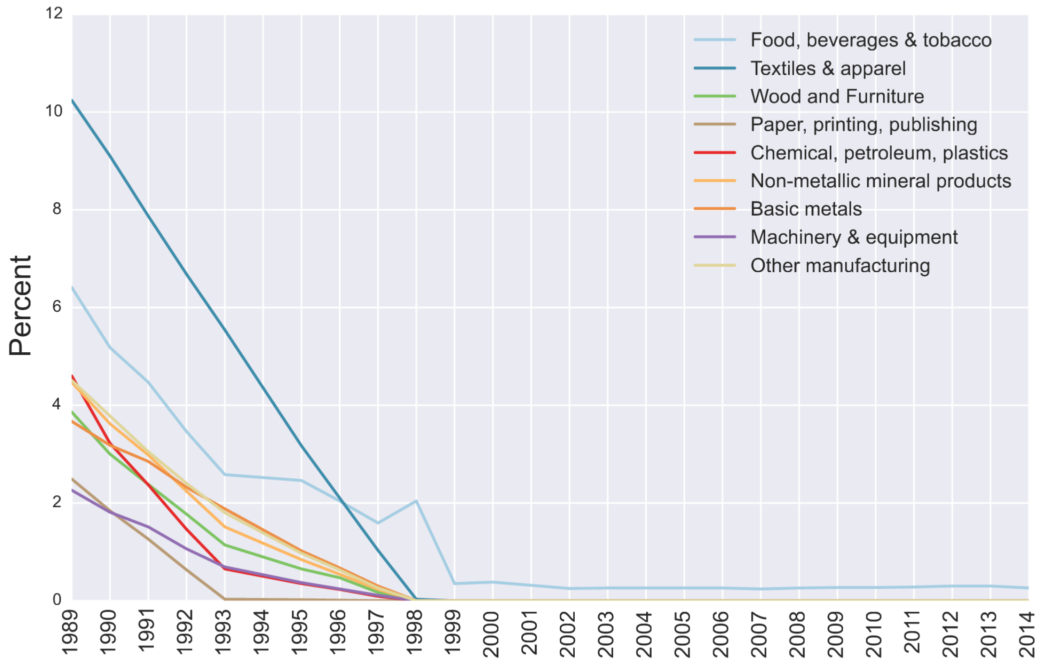

Figure 6. U.S. Tariffs on Mexican Goods

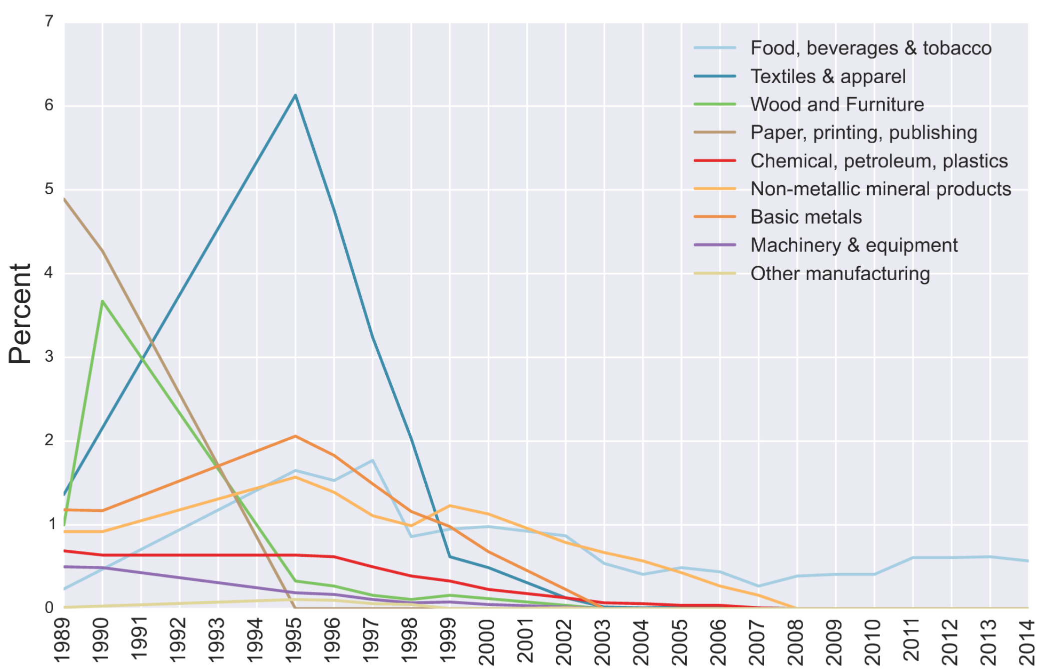

TABLE III. Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
exp_f[†]	702	76.2	198.6	0.40	1,890.0
gdp_can[†]	594	908.6	278.2	536.5	1,370.6
gdp_mex[†]	594	1,036.8	315.5	560.6	1,566.3
gdp_usa[†]	594	9,807.7	2,991.0	5,482.1	14,498.9
cpi_can	675	79.697	12.487	56.340	100.000
cpi_mex	675	48.219	32.559	1.560	100.000
cpi_usa	675	75.546	14.894	50.300	100.000
open_ind_can	810	59.378	12.446	37.550	75.580
open_ind_mex	810	34.822	17.307	13.210	62.320
open_ind_usa	810	22.673	3.691	17.190	30.970
ppi_mex	810	57.485	51.438	0.100	276.590
tau_s_can_mex	540	1.829	3.193	0.000	17.780
tau_s_can_usa	540	2.440	5.051	0.000	26.440
tau_s_mex_can	405	8.654	8.751	0.000	30.530
tau_s_mex_usa	405	7.611	8.552	0.000	28.800
tau_s_usa_can	621	0.994	1.780	0.000	10.600
tau_s_usa_mex	621	1.717	2.654	0.000	11.810

[†]: variables in constant 2005 USD, billions.

8 Appendix B: Industries in sample, NAICS classification

TABLE IV. Industry List, NAICS 4-digit

NAICS	Industry
3111	Animal Food Manufacturing
3112	Grain and Oilseed Milling
3113	Sugar and Confectionery Product Manufacturing
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3115	Dairy Product Manufacturing
3116	Animal Slaughtering and Processing
3118	Bakeries and Tortilla Manufacturing
3119	Other Food Manufacturing
3121	Beverage Manufacturing
3132	Fabric Mills
3133	Textile and Fabric Finishing and Fabric Coating Mills
3149	Other Textile Product Mills
3152	Cut and Sew Apparel Manufacturing
3159	Apparel Accessories and Other Apparel Manufacturing
3169	Other Leather and Allied Product Manufacturing
3211	Sawmills and Wood Preservation
3212	Veneer, Plywood, and Engineered Wood Product Manufacturing
3219	Other Wood Product Manufacturing
3221	Pulp, Paper, and Paperboard Mills
3222	Converted Paper Product Manufacturing
3231	Printing and Related Support Activities
3241	Petroleum and Coal Products Manufacturing
3251	Basic Chemical Manufacturing
3254	Pharmaceutical and Medicine Manufacturing
3255	Paint, Coating, and Adhesive Manufacturing
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing
3259	Other Chemical Product and Preparation Manufacturing
3262	Rubber Product Manufacturing
3271	Clay Product and Refractory Manufacturing
3273	Cement and Concrete Product Manufacturing
3274	Lime and Gypsum Product Manufacturing
3279	Other Nonmetallic Mineral Product Manufacturing
3312	Steel Product Manufacturing from Purchased Steel
3313	Alumina and Aluminum Production and Processing
3314	Nonferrous Metal (except Aluminum) Production and Processing
3315	Foundries
3321	Forging and Stamping
3322	Cutlery and Handtool Manufacturing
3323	Architectural and Structural Metals Manufacturing
3324	Boiler, Tank, and Shipping Container Manufacturing
3325	Hardware Manufacturing
3326	Spring and Wire Product Manufacturing
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing
3329	Other Fabricated Metal Product Manufacturing
3331	Agriculture, Construction, and Mining Machinery Manufacturing
3332	Industrial Machinery Manufacturing
3333	Commercial and Service Industry Machinery Manufacturing
3334	Ventilation, Heating, Air-Conditioning, & Commercial Refrig. Eq. Manuf.

3335	Metalworking Machinery Manufacturing
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing
3339	Other General Purpose Machinery Manufacturing
3342	Communications Equipment Manufacturing
3344	Semiconductor and Other Electronic Component Manufacturing
3345	Navigational, Measuring, Electromedical, and Control Instrum. Manuf.
3351	Electric Lighting Equipment Manufacturing
3352	Household Appliance Manufacturing
3353	Electrical Equipment Manufacturing
3359	Other Electrical Equipment and Component Manufacturing
3362	Motor Vehicle Body and Trailer Manufacturing
3363	Motor Vehicle Parts Manufacturing
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing
3372	Office Furniture (including Fixtures) Manufacturing
3379	Other Furniture Related Product Manufacturing
3399	Other Miscellaneous Manufacturing

9 Appendix C: Regression Results

TABLE V. Prices (Short Run), all country pairs

	Dependent variable:	
	$\Delta \log \left(\frac{p}{p^*}\right)$	
	(1)	(2)
$\Delta \log \tau_t$	0.002	0.002
	(0.002)	(0.002)
$\Delta \log \tau_t^*$	-0.003^{*}	-0.003
	(0.002)	(0.002)
$\Delta \log \theta_t$	-0.106^{***}	-0.104^{***}
	(0.014)	(0.015)
$\Delta \log \theta_t^*$	0.247^{***}	0.248^{***}
	(0.023)	(0.024)
$\Delta \log D_t$	0.015	0.016
	(0.025)	(0.025)
$\Delta \log D_t^*$	-0.034	-0.084
	(0.134)	(0.153)
Fixed Effects	dyad-industry	dyad
Observations	320	320
R^2	0.371	0.379

Note: *p<0.1; **p<0.05; ***p<0.01.
Fixed effects for country pairs.

TABLE VI. Productivity (Short Run), all country pairs

	Dependent variable:	
	$\Delta \log \left(\frac{z}{z^*}\right)$	
	(1)	(2)
$\Delta \log \tau_t$	0.009**	0.009**
	(0.004)	(0.004)
$\Delta \log \tau_t^*$	-0.003	-0.003
	(0.004)	(0.004)
$\Delta \log \theta_t$	-0.415	-0.389
	(0.264)	(0.283)
$\Delta \log \theta_t^*$	0.767*	0.681
	(0.425)	(0.482)
$\Delta \log D_t$	-0.329^{***}	-0.322^{***}
	(0.035)	(0.036)
$\Delta \log D_t^*$	0.656***	0.660***
	(0.057)	(0.059)
Fixed Effects	dyad-industry	dyad
Observations	324	324
R^2	0.428	0.432

Note: *p<0.1; **p<0.05; ***p<0.01.
Fixed effects for country pairs.

TABLE VII. Prices (Short Run), all country pairs, third country variables included

	Dependent variable:					
	$\Delta \log \left(\frac{p}{p^*}\right)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log \tau^{hf}$	-0.001	-0.001	-0.003	0.002	-0.003	0.002
	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\Delta \log \tau^{fh}$	0.0002	0.0002	-0.0005	0.002	-0.001	0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta \log \tau^{ht}$	0.005***	0.005***	0.005	0.007**	0.005*	0.007***
	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta \log \tau^{th}$	0.002	0.002	0.004	-0.002	0.004	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta \log \tau^{ft}$	-0.001	-0.001	0.00002	-0.002	0.00005	-0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta \log \tau^{tf}$	-0.007***	-0.007***	-0.008***	-0.008***	-0.008***	-0.008***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)
$\Delta \log D_t$	-0.013	-0.013	-0.067*	0.074	-0.062*	0.072
	(0.026)	(0.025)	(0.035)	(0.048)	(0.034)	(0.046)
$\Delta \log D_t^*$	0.093**	0.083**	0.071*	0.404**	0.069*	0.295*
	(0.039)	(0.037)	(0.043)	(0.205)	(0.041)	(0.167)
Fixed Effects	dyad-industry	dyad	dyad-industry	dyad-industry	dyad	dyad
Market Entry	All	All	Free	Fixed	Free	Fixed
Observations	2,522	2,522	965	743	965	743
R^2	0.023	0.022	0.028	0.044	0.027	0.040

Note: *p<0.1; **p<0.05; ***p<0.01. Fixed effects for country pairs.

TABLE VIII. Productivity (Short Run), all country pairs, third country variables included

	Dependent variable:					
	$\Delta \log \left(\frac{z}{z^*}\right)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log \tau_t^{hf}$	-0.009^{***}	-0.009^{***}	-0.016^{**}	-0.005	-0.016^{***}	-0.004
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
$\Delta \log \tau_t^{fh}$	-0.001	-0.001	0.003	0.006	0.003	0.005
	(0.004)	(0.004)	(0.007)	(0.008)	(0.007)	(0.007)
$\Delta \log \tau_t^{ht}$	0.001	0.001	-0.0002	0.002	-0.0003	0.001
	(0.003)	(0.003)	(0.006)	(0.007)	(0.006)	(0.007)
$\Delta \log \tau_t^{th}$	-0.005	-0.006	-0.002	-0.004	-0.002	-0.004
	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta \log \tau_t^{ft}$	0.009^{**}	0.009^{**}	0.010	0.007	0.010	0.007
	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta \log \tau_t^{tf}$	-0.014^{***}	-0.014^{***}	-0.019^{***}	-0.008	-0.019^{***}	-0.008
	(0.004)	(0.003)	(0.006)	(0.007)	(0.006)	(0.006)
$\Delta \log D_t$	0.176^{***}	0.166^{***}	0.218^{***}	0.063	0.223^{***}	0.035
	(0.058)	(0.056)	(0.075)	(0.123)	(0.073)	(0.117)
$\Delta \log D_t^*$	0.008	0.030	-0.104	0.525	-0.099	0.823^{*}
	(0.089)	(0.084)	(0.092)	(0.523)	(0.089)	(0.427)
Fixed Effects	dyad-industry	dyad	dyad-industry	dyad-industry	dyad	dyad
Market Entry	All	All	Free	Fixed	Free	Fixed
Observations	2,506	2,506	955	741	955	741
R^2	0.022	0.021	0.042	0.011	0.041	0.013

Note: *p<0.1; **p<0.05; ***p<0.01. (1), (3), (4): Fixed effects country-industry; (2), (5), (6): Fixed effect country pairs.

TABLE IX. Prices (Long Run), all country pairs

	Dependent variable:			
	$\Delta \log \left(\frac{p_t}{p_t^*}\right)$			
	(1)	(2)	(3)	(4)
$\Delta \log \tau_t$	-0.0004	-0.001	0.0003	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta \log \tau_t^*$	-0.002^{*}	-0.002	-0.003^{**}	-0.003^{*}
	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta \log \theta$			-0.048^{***}	-0.049^{***}
			(0.011)	(0.012)
$\Delta \log \theta^*$			0.040^{*}	0.071^{**}
			(0.020)	(0.033)
$\Delta \log D_t$	0.013	0.031^{*}	0.011	0.043^{**}
	(0.016)	(0.019)	(0.016)	(0.018)
$\Delta \log D_t^*$	-0.040	-0.031	-0.025	-0.030
	(0.091)	(0.104)	(0.091)	(0.106)
$\log \left(\frac{p_{t-1}}{p_{t-1}^*}\right)$	-0.279^{***}	-0.263^{***}	-0.270^{***}	-0.233^{***}
	(0.011)	(0.013)	(0.014)	(0.021)
$\log \tau_{t-1}$	0.001	0.001	0.002^{*}	0.001
	(0.001)	(0.001)	(0.001)	(0.002)
$\log \tau_{t-1}^*$	-0.002^{*}	-0.002	-0.003^{***}	-0.002
	(0.001)	(0.002)	(0.001)	(0.002)
$\log \theta_{t-1}$			-0.012^{**}	-0.005
			(0.006)	(0.011)
$\log \theta_{t-1}^*$			0.012^{**}	0.017
			(0.006)	(0.025)
$\log D_{t-1}$	0.0004	0.040^{**}	0.003	0.069^{***}
	(0.005)	(0.020)	(0.005)	(0.021)
$\log D_{t-1}^*$	0.001	0.088^{*}	-0.0005	0.082^{*}
	(0.004)	(0.045)	(0.004)	(0.045)
$\log L_{t-1}$	-0.082	-0.175	-0.135	-0.323^{**}
	(0.150)	(0.156)	(0.148)	(0.160)
$\log L_{t-1}^*$	0.061	0.132	0.128	0.251
	(0.152)	(0.153)	(0.151)	(0.154)
Fixed Effects	dyad-industry	dyad	dyad-industry	dyad
Observations	324	324	320	320
R^2	0.731	0.751	0.753	0.776

Note: *p<0.1; **p<0.05; ***p<0.01. Fixed effects for country pair.

TABLE X. Prices (Long Run), all country pairs, third country variables included

	Dependent variable: $\Delta \log\left(\frac{p_t}{p_t^*}\right)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log \tau_t^{hf}$	−0.001	−0.001	−0.003	0.003	−0.004	0.002
	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\Delta \log \tau_t^{fh}$	0.001	0.00001	0.00003	0.0005	0.0002	0.0003
	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
$\Delta \log \tau_t^{ht}$	0.003**	0.004***	0.003	0.005*	0.003	0.007***
	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	(0.002)
$\Delta \log \tau_t^{th}$	0.001	0.0002	0.002	0.001	0.001	−0.001
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)
$\Delta \log \tau_t^{ft}$	−0.001	−0.0002	0.001	−0.004	0.001	−0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)
$\Delta \log \tau_t^{tf}$	−0.003**	−0.004***	−0.004	−0.004	−0.005	−0.005**
	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\Delta \log D_t$	−0.013	−0.011	−0.054*	0.032	−0.050	0.046
	(0.024)	(0.023)	(0.032)	(0.041)	(0.031)	(0.040)
$\Delta \log D_t^*$	0.028	0.019	0.032	0.415**	0.034	0.093
	(0.036)	(0.034)	(0.039)	(0.190)	(0.038)	(0.151)
$\log\left(\frac{p_{t-1}}{p_{t-1}^*}\right)$	−0.135***	−0.127***	−0.120***	−0.195***	−0.117***	−0.168***
	(0.007)	(0.007)	(0.013)	(0.013)	(0.012)	(0.012)
$\log \tau_{t-1}^{hf}$	0.00001	−0.001	−0.001	0.002	−0.001	0.0003
	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\log \tau_{t-1}^{fh}$	0.001	−0.0003	0.0002	−0.003	0.0003	−0.003
	(0.002)	(0.001)	(0.004)	(0.003)	(0.003)	(0.002)
$\log \tau_{t-1}^{ht}$	−0.0002	0.001	−0.0004	0.002	0.001	0.003*
	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\log \tau_{t-1}^{th}$	0.002	0.001	0.002	0.005**	0.002	0.001
	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
$\log \tau_{t-1}^{ft}$	−0.003**	−0.001	−0.0002	−0.006***	0.0002	−0.001
	(0.002)	(0.001)	(0.004)	(0.002)	(0.003)	(0.002)
$\log \tau_{t-1}^{tf}$	0.002	0.001	0.001	0.002	0.001	0.00005
	(0.002)	(0.001)	(0.004)	(0.002)	(0.003)	(0.002)
$\log L_{t-1}$	−0.682***	−0.636***	−0.435**	−1.136***	−0.426**	−1.059***
	(0.113)	(0.103)	(0.191)	(0.191)	(0.176)	(0.182)
$\log L_{t-1}^*$	0.684***	0.611***	0.428**	1.185***	0.419**	1.046***
	(0.109)	(0.102)	(0.182)	(0.193)	(0.171)	(0.183)
Observations	2,522	2,522	965	743	965	743
R^2	0.210	0.202	0.207	0.344	0.199	0.293

Note: *p<0.1; **p<0.05; ***p<0.01. Fixed effects for country pair.

TABLE XI. Productivity (Long Run), all country pairs

	Dependent variable:			
	$\Delta \log \left(\frac{z}{z^*}\right)$			
	(1)	(2)	(3)	(4)
$\Delta \log \tau_t$	0.0002	-0.001	0.004	0.003
	(0.005)	(0.004)	(0.004)	(0.004)
$\Delta \log \tau_t^*$	0.001	0.004	-0.001	0.002
	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta \log \theta$			-0.245^{***}	-0.214^{***}
			(0.040)	(0.042)
$\Delta \log \theta^*$			0.574^{***}	0.451^{***}
			(0.070)	(0.131)
$\Delta \log D_t$	-0.428^{*}	0.409^{*}	-0.179	0.262
	(0.246)	(0.221)	(0.210)	(0.208)
$\Delta \log D_t^*$	0.336	-0.427	0.167	-0.175
	(0.393)	(0.358)	(0.345)	(0.353)
$\log \left(\frac{z_{t-1}}{z_{t-1}^*}\right)$	-0.145^{***}	-0.348^{***}	-0.089^{***}	-0.308^{***}
	(0.016)	(0.022)	(0.015)	(0.033)
$\log \tau_{t-1}$	-0.008	-0.009^{*}	-0.007	-0.006
	(0.006)	(0.005)	(0.005)	(0.005)
$\log \tau_{t-1}^*$	0.006	0.013^{**}	0.0004	0.006
	(0.005)	(0.005)	(0.005)	(0.005)
$\log \theta_{t-1}$			-0.012	-0.092^{**}
			(0.021)	(0.043)
$\log \theta_{t-1}^*$			-0.010	0.119
			(0.021)	(0.078)
$\log L_{t-1}$	0.569	-1.531^{***}	-0.523	-1.625^{***}
	(0.623)	(0.559)	(0.539)	(0.538)
$\log L_{t-1}^*$	-0.777	1.740^{***}	0.198	1.416^{***}
	(0.636)	(0.568)	(0.547)	(0.543)
$\log w_{t-1}$	0.160^{**}	0.181^{**}	0.068	0.216^{**}
	(0.063)	(0.090)	(0.058)	(0.100)
$\log w_{t-1}^*$	-0.230^{***}	-0.584^{***}	-0.063	-0.129
	(0.069)	(0.117)	(0.062)	(0.142)
Observations	324	324	320	320
R^2	0.290	0.543	0.510	0.613

Note: *p<0.1; **p<0.05; ***p<0.01
Fixed effects for country pair or industry/country pair

TABLE XII. Productivity (Long Run), all country pairs, third country variables included

	Dependent variable:					
	$\Delta \log \left(\frac{z}{z^*}\right)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log \tau_t^{hf}$	0.008***	0.008**	0.017***	0.004	0.016**	0.006
	(0.003)	(0.003)	(0.006)	(0.006)	(0.007)	(0.006)
$\Delta \log \tau_t^{fh}$	−0.003	0.002	−0.009	−0.006	−0.006	−0.001
	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
$\Delta \log \tau_t^{ht}$	−0.001	−0.005	−0.0005	0.004	−0.008	0.004
	(0.003)	(0.004)	(0.006)	(0.007)	(0.007)	(0.007)
$\Delta \log \tau_t^{th}$	−0.0003	0.002	−0.003	−0.004	−0.006	0.006
	(0.003)	(0.004)	(0.006)	(0.007)	(0.007)	(0.007)
$\Delta \log \tau_t^{ft}$	−0.001	−0.004	0.001	−0.004	0.002	−0.009
	(0.004)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)
$\Delta \log \tau_t^{tf}$	0.011***	0.011***	0.015***	0.003	0.019***	−0.001
	(0.003)	(0.004)	(0.006)	(0.006)	(0.007)	(0.006)
$\Delta \log D_t$	−0.059	−0.097*	−0.096	−0.031	−0.129*	−0.035
	(0.048)	(0.054)	(0.060)	(0.104)	(0.070)	(0.114)
$\Delta \log D_t^*$	0.170**	0.072	0.183**	−0.460	0.168**	−1.122**
	(0.072)	(0.081)	(0.072)	(0.479)	(0.085)	(0.448)
$\log \left(\frac{z_{t-1}}{z_{t-1}^*}\right)$	−0.399***	−0.052***	−0.437***	−0.325***	−0.053***	−0.045***
	(0.016)	(0.009)	(0.025)	(0.031)	(0.016)	(0.017)
$\log \tau_{t-1}^{hf}$	0.010***	0.007**	0.018***	0.004	0.009	0.007
	(0.003)	(0.003)	(0.006)	(0.005)	(0.006)	(0.005)
$\log \tau_{t-1}^{fh}$	−0.011***	−0.004	−0.021***	−0.008	−0.008	−0.003
	(0.004)	(0.003)	(0.007)	(0.007)	(0.006)	(0.006)
$\log \tau_{t-1}^{ht}$	−0.0001	0.004	−0.004	0.008	−0.004	0.014***
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.005)
$\log \tau_{t-1}^{th}$	−0.014***	−0.006**	−0.020***	−0.014**	−0.013**	−0.001
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.005)
$\log \tau_{t-1}^{ft}$	0.009***	0.002	0.012*	0.007	0.007	−0.001
	(0.003)	(0.003)	(0.007)	(0.006)	(0.006)	(0.005)
$\log \tau_{t-1}^{tf}$	0.010***	−0.002	0.017**	−0.001	0.006	−0.014***
	(0.003)	(0.003)	(0.007)	(0.006)	(0.006)	(0.005)
$\log L_{t-1}$	3.416***	2.380***	3.536***	2.687***	3.176***	0.754
	(0.206)	(0.217)	(0.320)	(0.454)	(0.358)	(0.459)
$\log L_{t-1}^*$	−3.239***	−2.204***	−3.419***	−2.636***	−3.095***	−0.604
	(0.207)	(0.219)	(0.323)	(0.468)	(0.358)	(0.469)
$\log w_{t-1}$	0.143***	−0.046***	0.122***	0.115***	−0.080***	−0.035
	(0.019)	(0.016)	(0.030)	(0.043)	(0.026)	(0.032)
$\log w_{t-1}^*$	−0.151***	0.045***	−0.146***	−0.065	0.065***	0.056*
	(0.020)	(0.016)	(0.029)	(0.047)	(0.025)	(0.033)
Observations	2,506	2,506	955	741	955	741
R^2	0.378	0.126	0.433	0.354	0.168	0.124

Note: *p<0.1; **p<0.05; ***p<0.01. Fixed effects for country pair.