The Impact of NAFTA on Prices and Competition: Evidence from Mexican Manufacturing Plants*

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Abstract

This paper assesses the impact of the North American Free Trade Agreement on Mexican manufacturing plants' output prices and markups. We distinguish between Mexican goods that are exported and those sold domestically, and decompose their prices separately into markups and marginal costs. We then analyze how these components were affected by the reductions in Mexican output tariffs, intermediate input tariffs, and U.S. tariffs on Mexican exports. We find that domestically sold products saw a decline in prices as Mexican plants faced more competition and gained access to cheaper inputs. Prices of exported goods fell only slightly as plants increased their markups in response to a favorable competitive environment due to declines in U.S. tariffs.

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1 Introduction

The past few decades have seen drastic reductions in tariffs, a large share of which can be attributed to reciprocal multilateral or bilateral trade liberalizations. Reciprocal trade liberalizations have been negotiated through multilateral organizations such as the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO), a notable example being the Uruguay Round from 1986 to 1994. At the same time, reciprocal trade liberalizations have been pursued through bilateral and regional agreements among groups of countries, exemplified by the North American Free Trade Agreement (NAFTA) in 1994. Given the rising policy debate over globalization in recent years, understanding how domestic firms respond to reciprocal tariff changes is of great policy relevance.

Reciprocal trade liberalization differs from unilateral trade liberalization because it involves reductions in tariffs on both exports to and imports from participating countries. These tariff reductions may affect domestic firms' prices and the competition they face through multiple channels. As tariffs on imports fall, domestic firms face more competition but can simultaneously take advantage of cheaper imported inputs. In addition, as foreign tariffs on exported goods fall, exporters may enjoy greater access to foreign markets. Empirical studies that fail to account for these effects may not fully grasp the implications of trade liberalization for firms' competition.

There are two main challenges in empirically studying the effects of reciprocal tariff reductions on firms' prices. The first challenge is the scarcity of detailed data. Import tariff reductions may primarily affect prices in the domestic market through increased competition with imported goods, while reductions in tariffs on exported goods may primarily affect prices on exported goods. Therefore, it is critical to obtain data that record firms' output prices at a disaggregated product–destination market level for a broad set of industries. The second challenge is that markups and marginal costs are not observable, even when detailed price data are available. Decomposing prices into markups and marginal costs and analyzing how these components are affected by the tariff reductions is informative in assessing both the total gains from reciprocal trade liberalization and the distribution of gains between producers and consumers. Therefore, a structural model is needed to decompose prices into markups and marginal costs.

In this paper, we empirically analyze the impact of reciprocal trade liberalizations by focusing on how Mexican firms responded to NAFTA. We overcome our first challenge by relying on a confidential dataset that includes disaggregated plant–product-level data on Mexican manufacturing plants for the period 1994–2008. The data record quantity and price (unit value) information for both domestic and exported goods produced by plants, covering 85% of total value added in manufacturing. A unique feature of this dataset is the distinction between domestic and foreign markets, which enables us to distinguish between the impact of reciprocal trade liberalization on exporters and the impact on producers serving the domestic market.

Equipped with these data, we overcome the second challenge by following the empirical framework developed by de Loecker, Goldberg, Khandelwal, and Pavcnik (2016) to derive estimates of markups and marginal costs at the plant–product–destination level. This method estimates production functions to identify markups from the wedge between the output elasticity of a variable input and its expenditure share out of total revenue, which is now a standard approach in the industrial organization literature.[1] One advantage of this approach is that we do not need to make any assumptions about market structure or consumer preferences to recover markups.[2] In addition, we are able to estimate the product–destination-level markups and marginal costs of multi-product firms across a broad set of manufacturing industries using data on plants' physical output, which is a novel contribution to existing studies on NAFTA.

Tariff reductions under NAFTA affected the markups and marginal costs, and hence prices, of Mexican manufacturing plants via multiple channels. We illustrate these channels by examining the impact of Mexican output tariffs, tariffs on intermediate inputs, and U.S. tariffs on prices, markups, and marginal costs at the plant–product–destination level. We first focus on the impact of tariff reductions under NAFTA on domestically sold products. We find that Mexican plants reduced the prices of domestically sold products in response to the reductions in Mexican output tariffs—tariffs that the Mexican authorities imposed on the same products from abroad—through increased competition. Meanwhile, reductions in Mexican tariffs on intermediate inputs affected the prices of domestically sold products through two channels. First, they directly reduced marginal costs, thereby reducing prices. Second, the reduction in marginal costs enabled plants to increase markups. Overall, we find that the first channel dominated the second, resulting in a slight reduction in prices. These results so far are consistent with those of de Loecker et al. (2016), who look at the impact of the unilateral trade liberalization episode in India, although they do not distinguish between domestically sold and exported products.

Unlike domestically sold products, the prices of exported products did not respond to the Mexican output tariffs, as these tariffs did not have a direct effect on the competitive environment in the export market. Input tariffs, however, had a similar effect on export prices as on domestic prices: export prices decreased as the direct effect of cost reduction dominated the markup increase. Furthermore, we find significant evidence of the impact of NAFTA on Mexican exporters through reductions in U.S. tariffs imposed on Mexican exports. We find that the markups on exported products increased, leading to only a slight decline in the prices of exported products. This suggests that Mexican exporters took advantage of greater access to the U.S. market, which we consider to be evidence for the anti-competitive effect of reciprocal trade liberalizations. This channel has not been studied extensively because it requires plant–product-level data that distinguish between exporters and domestic producers.

[1] See Olley and Pakes (1996), Levinsohn and Petrin (2003), de Loecker (2011), de Loecker and Warzynski (2012), and Ackerberg, Caves, and Frazer (2015) for production function estimation at the plant level. de Loecker et al. (2016) and Garcia-Marin and Voigtländer (2019) are examples of production function estimation at the product level. As we will describe in detail, de Loecker et al. (2016) recover markups at the plant–product level by assuming that productivities are specific to each plant and that multi-product plants employ the same technology for each product as single-product plants do.

[2] An alternative approach to markup estimation, exemplified by Berry, Levinsohn, and Pakes (1995), Goldberg (1995), and Goldberg and Hellerstein (2013), assumes specific preferences and market structure to derive estimates of markups. The detailed product–destination-level data required as well as the particular assumption on market structure makes it infeasible to use this approach for a broad set of industries as we do in this work.

Overall, our estimates imply that the observed output and input tariff declines led to an average reduction in prices of Mexican domestic products by around 11.3%. This was the result of the decline in marginal costs being partially offset by the increase in markups. For products exported to the U.S., the input and U.S. tariff reductions led to a slight decrease in prices, by around 2.4%. These reductions in prices are in response to an average 14.6 percentage point decline in the Mexican tariffs and 5.1 percentage point decline in the U.S. tariffs during the 1994–2008 period under NAFTA. Marginal costs declined in response to input tariff reductions, but markups increased by almost the same magnitude as plants faced a more favorable competitive environment in the export market. These results suggest that Mexican consumers benefited from NAFTA through lower prices. Mexican producers, at the same time, benefited from larger profit margins realized through lower input prices and higher markups.

The main contribution of this paper is to separately estimate the effects of tariff reductions on goods that are exported and goods that are sold domestically. In this regard, we contribute to the existing empirical research on trade liberalizations. In this strand of literature, our work is most closely related to de Loecker et al. (2016), who estimate product-level markups and analyze the unilateral trade liberalization episode in India.[3] They find pro-competitive effects from output tariff declines and an incomplete cost pass-through to prices. That is, output tariff declines led to a reduction in the markups of Indian firms, and input tariff declines led to a slight increase in markups, in turn leading to a smaller decline in prices. Focusing on the reciprocal trade liberalization episode of NAFTA, we find similar results for prices and markups of goods sold domestically in Mexico. In addition to these effects, we also find evidence of markup increases in the export market. That is, U.S. tariff declines led to an increase in the markups that Mexican plants charged on their exported goods. This channel, which plausibly comes from improved market access, is unique to reciprocal trade liberalizations and does not exist in unilateral trade liberalizations.

The empirical findings presented in this paper are in line with the theoretical literature that analyzes the competitive effects of trade reforms. Within this literature, our work is closely related to the trade model analyzed by de Blas and Russ (2015) in which the endogenous distribution of markups responds to changes in trade costs.[4] By lowering trade costs, trade liberalization indirectly reduces the residual demand for domestic goods, leading to a decline in domestic markups (pro-competitive effects) and an increase in welfare. However, in a regional free trade agreement, the

[3] Other contributions to this literature are the studies by Levinsohn (1993) on Turkey, Harrison (1994) on the Ivory Coast, Krishna and Mitra (1998) on India, Amiti and Konings (2007) on Indonesia, and Brandt, Van Biesebroeck, Wang, and Zhang (2017) on China. Caselli, Chatterjee, and Woodland (2017) also follow the same method as de Loecker et al. (2016) to estimate markups of Mexican plants at product level, but the focus of that paper is on exchange rate pass-through. Relatedly, Blum, Claro, Horstmann, and Rivers (2024) estimate production technologies and markups of Chilean manufacturing firms for each destination market in order to disentangle demand and cost drivers of firm heterogeneity. Dhyne, Petrin, Smeets, and Warzynski (2022b) estimate production functions in a multi-product setting, although their focus is not on the effects of trade liberalizations.

[4] Quantitative trade models, such as the one from Eaton and Kortum (2002) with perfect competition and the monopolistic competition model of Melitz (2003), are unable to capture the competitive effects of trade liberalization, since they assume constant markups. Even in models with variable markups, few predict changes to competition from liberalization. Bernard, Eaton, Jensen, and Kortum (2003) and Arkolakis, Costinot, Donaldson, and Rodríguez-Clare (2019), for example, allow for variable markups and find that the distribution of markups is invariant to changes in trade costs.

increase in welfare is offset by a rise in foreign markups (the anti-competitive effects in de Blas and Russ, 2015), which lowers the overall gains from trade. Our paper contributes to this literature by providing the first empirical evidence for both pro-competitive and anti-competitive effects of reciprocal trade liberalizations.

Lastly, our work is also related to the large body of literature that studies the impact of NAFTA. Previous studies have found how tariff reductions under NAFTA increased trade volume (Romalis, 2007), enhanced productivity (Lopez-Cordova, 2003; Iacovone, 2012; de Hoyos and Iacovone, 2013), triggered quality-upgrading (Verhoogen, 2008; Iacovone and Javorcik, 2012), and increased income (Easterly, Fiess, and Lederman, 2003), but did not improve wage inequality in Mexico (Esquivel and Rodríguez-López, 2003). Furthermore, viewing free trade agreements from the demand side, Faber (2014) uses microdata from the Mexican Consumer Price Index and finds that the NAFTA tariff cuts reduced consumer prices mostly through improved access to cheaper high-quality products. We complement this literature by illustrating how NAFTA affected the markups and marginal costs of manufacturing plants at the plant–product level, which is informative in inferring the impacts on Mexican producers and consumers.

The rest of the paper is structured as follows. Section 2 discusses the data used in the estimation, before performing a preliminary analysis on the impact of tariff reductions under NAFTA on prices in Section 3. Section 4 introduces the empirical framework used in the estimation of markups and marginal costs, and then establishes the validity of the estimation results. Section 5 analyzes the impact of tariff reductions on prices, markups, and marginal costs, and the last section concludes.

2 Data

We mainly rely on two sets of data to conduct the analysis of this paper. The first is the manufacturing survey datasets available at the Mexican Institute of Statistics and Geography (INEGI). We use these datasets to estimate the markups and marginal costs of Mexican manufacturing plants. The second is the tariff data from the World Bank's World Integrated Trade Solution (WITS), which enable us to construct tariff shocks to the Mexican manufacturing plants after NAFTA came to effect.

2.1 Manufacturing survey datasets

We use manufacturing plant and product data from two surveys conducted and maintained by INEGI: the Monthly Industrial Survey (EIM) and the Annual Industrial Survey (EIA) for the period of 1994–2008. For plants that were listed in the 1994 Economic Census, the EIM reports monthly data on plants' employment and wage bill, as well as quantities and sales value in Mexican pesos (MXN) at the product level. Products are disaggregated at the 8-digit level of the CMAP94 classification.[5] A unique feature of the EIM is that the quantities and sales value of

[5] We use the 1994 Mexican Classification of Activities and Products (CMAP94), a precursor to NAICS. See Appendix A.1 for examples of these product lines.

each product are recorded separately for products that are sold domestically and for those that are exported.[6] To accommodate this feature, we use the term variety or product variety when we need to distinguish the same product sold in different destinations. While the EIM does not record the export destinations, more than 85% of exports were destined for the U.S. during our sample period of 1994–2008, according to trade flow data from WITS. Motivated by this high concentration of Mexican exports, we implicitly assume in the empirical analyses that the U.S. is the destination country of all exported products.

For plants listed in the 1994 Economic Census, the EIA records yearly information on plant-level inputs, total production, and other detailed data on plant operations. In our analyses, we use data on material expenditures, total employment, capital, and import and export status. To construct a capital series of Mexican plants, we use the perpetual inventory method with investment by type and the initial book value of a capital stock.[7] All monetary variables are deflated by their appropriate price deflators.

We focus on the plants that are covered by both the EIM and EIA, which are the plants listed in the 1994 Economic Census. Each plant in the surveys is classified according to a unique 6-digit CMAP94 *clase* (class) code, which is similar to the 6-digit North American Industrial Classification System (NAICS) industry code. The plants in the 1994 Economic Census are categorized into 206 6-digit class codes in manufacturing, and were chosen to ensure that the plants covered at least 85% of the value added in each class and contained all plants with more than 100 employees.[8] Despite the detailed records at the micro level and decent coverage, we acknowledge the limitations of the two surveys. First, the sample is skewed toward larger plants. Furthermore, since the plants included in our sample are those that appeared in the 1994 Economic Census, these data are not suitable to track the changes in the extensive margin of Mexican manufacturing plants.[9]

We aggregate monthly values from the EIM as annual data and match the EIM and EIA information using a unique plant identifier provided by INEGI. The resulting panel consists of approximately 180,000 product–plant–year observations from 1994 to 2008.[10] Table A3 in Appendix A.3 shows the average number of plant–product–destination observations by sector (defined at the CMAP94 2-digit level), as well as the average number of products by a plant in the sample. Table A4 in the same appendix presents the number of plants in the sample, as well as summary statistics of the main variables from the EIA that we use in the estimation by sector. The tables show that while the majority of plants in the sample are multi-product and non-exporter plants, single-product plants account for a significant fraction (between 20% and 50%) of plants in each

[6]Domestic sales are recorded based on factory gate prices, and export sales are free-on-board values in MXN.

[7]See Appendix A.2 for further details.

[8]For a more detailed description of the sampling methodology, see Appendix A.3.

[9]The survey also lacks information on certain dimensions that may be important for Mexican exports. First, it does not cover the so-called Maquiladora plants that mostly engage in processing exports specializing in labor-intensive products (Utar and Ruiz, 2013). Second, it does not record whether the plants are part of multinational enterprises.

[10]The merged panel includes roughly 3,600 plants per year and 12,000 plant–product observations per year. By comparison, the analysis in Iacovone and Javorcik (2012) includes 5,000 plants and 16,000 plant–product observations per year using the same datasets for 1994–2003. Given the longer sample period and attrition over time, our sample has a smaller number of observations per year on average.

sector. This feature contributes to the empirical strategy discussed in later sections.

2.2 Tariff data

We use the preferential tariff data for Mexico and the U.S., available from WITS at the HS 6-digit level. We manually construct the concordance between this classification and the CMAP94 classification. As discussed in more detail in Appendix A.4, we match approximately 5,000 CMAP94 8-digit products to one or multiple HS codes using the CMAP94 product description provided by INEGI. When multiple HS 6-digit codes correspond to a single CMAP94 product, we use the simple average tariff across the corresponding HS 6-digit codes. With this concordance, we construct a measure of output tariffs—the tariffs applied by the Mexican government to goods coming from the U.S.—and a measure of U.S. tariffs—the tariffs applied by the U.S. government to goods coming from Mexico.

To capture the tariff changes applied to imported intermediates, we construct class-level intermediate input tariffs using the Mexican input–output (IO) table provided by INEGI for 2003.[11] Because the 2003 IO table uses the NAICS classification, we convert it to the CMAP94 classification using the concordances provided by INEGI. For each class, we calculate the simple average output tariff and then use the IO coefficients to compute weighted-average input tariffs. Formally, the intermediate input tariff of plant j in class c at time t is given by:

$$\tau_{c(j)t}^{input} = \sum_{k} \Phi_{kc(j)} \tau_{kt}^{output},$$

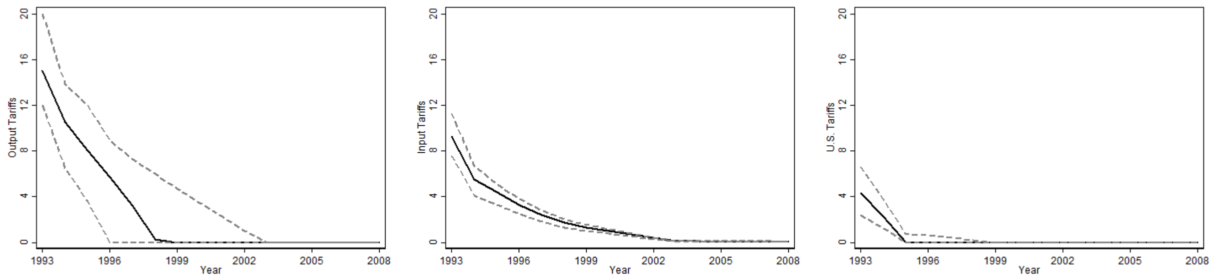
where $\Phi_{kc(j)}$ is class c's share of intermediate inputs coming from class k, and τ_{kt}^{output} is the simple average output tariff in class k.[12]

Taken together, the output and U.S. tariffs we construct vary at the product level, whereas the intermediate input tariffs vary at the class level. Appendix A.5 presents more details on the construction of these tariff measures. Figure 1 presents the median and the 25th and 75th percentiles of these tariffs over time, showing a substantial decline in all three tariffs after NAFTA came into effect in 1994. The figure also shows that the initial levels of Mexican tariffs were higher than those of the U.S. tariffs and took a longer time to decline. In later sections, we assess the impact of the changes in these tariffs on various outcome variables of Mexican manufacturing plants. One concern in doing so is that the three measures of tariffs are likely to be correlated with each other, so there may not be enough variation in the data to identify the effects of each tariff measure separately. In Appendix A.5, we report the summary statistics for the three tariff measures and their correlation matrix. Although the three tariff measures are indeed correlated with each other, the correlations between plant–product-level tariff measures used in the main analysis are low, ranging from 0.21 to 0.32. As a result, there is sufficient variation for us to identify the coefficients separately.

[11] We use the year 2003 because earlier IO tables are available only at higher levels of aggregation.

[12] We use the CMAP94 class code assigned to each plant to determine the class c for each plant j. Plants are assigned to 177 unique classes.

Figure 1: Time series of output tariffs, input tariffs, and U.S. tariffs



(a) Output tariffs (b) Input tariffs (c) U.S. tariffs

Note: The figures show the time series of output tariffs, input tariffs, and U.S. tariffs between 1993 and 2008. The solid black lines represent the median values and the dashed lines represent the 25th and 75th percentiles for each tariff.

Another concern of regressing Mexican manufacturing plants' outcome variables on the tariff measures is that the tariff changes might be correlated with omitted factors that also affect these outcomes. For example, tariff schedules under NAFTA may have been set to protect specific Mexican products or industries. However, substantial evidence, both empirical and anecdotal, indicates that the potential endogeneity arising from protectionism is not likely to be an issue. If tariffs were set for protectionist purposes, we would expect that products with high initial tariffs would face higher tariffs under NAFTA, or a slower tariff decline schedule. However, Figure A1 in Appendix A.5 shows that products with high initial tariffs faced the largest tariff declines under NAFTA. Moreover, Kowalczyk and Davis (1998) present empirical evidence that the phase-out periods for Mexican tariffs appear to be uncorrelated with their levels prior to NAFTA. Anecdotally, the circumstances surrounding NAFTA negotiations suggest that Mexican negotiators had little bargaining power in setting tariffs (Cameron and Tomlin, 2002). Therefore, both sets of evidence suggest that we can plausibly consider the tariff reductions under NAFTA to be exogenous from the viewpoint of individual Mexican plants.

3 Motivating facts

In this section, we illustrate how output prices of Mexican manufacturing plants reacted to tariff cuts under NAFTA. Furthermore, we investigate how selected proxies for output markups responded to the tariff changes. The advantage of these approaches is that we can easily produce stylized facts with readily available data on prices and tariffs before decomposing output prices into markups and marginal costs.

3.1 The impact of tariff declines on prices

We begin by illustrating how the output prices of Mexican manufacturing plants responded to the tariff cuts under NAFTA. We expect the output tariffs to change the competitive environment of the products sold domestically in Mexico. At the same time, input tariffs may affect prices for both domestic and exported product varieties through changes in input costs. Finally, since most exported varieties were destined for the U.S., changes in U.S. tariffs may affect export prices.[13] Therefore, we estimate the following specification separately for domestic and exported product varieties:

$$\log P_{ijt} = \alpha + \beta_1 \log\left(1 + \tau_{it}^{output}\right) + \beta_2 \log\left(1 + \tau_{c(j)t}^{input}\right) + \beta_3 \log\left(1 + \tau_{it}^{US}\right) + \xi_{ij} + \psi_{st} + \varepsilon_{ijt}, \quad (1)$$

where P_{ijt} is the price of product i from plant j at time t, τ_{it}^{output} is the Mexican output tariff applied to product i, $\tau_{c(j)t}^{input}$ is the intermediate input tariff for class c, which plant j belongs to, and τ_{it}^{US} is the tariff applied by the U.S. on product i from Mexico. ξ_{ij} and ψ_{st} are plant–product and sector–year fixed effects, respectively. With these fixed effects, the coefficients for the tariffs are identified by exploiting variation in prices and tariffs within a plant–product–destination (variety) over time, controlling for changes in macroeconomic conditions at the sector level. Because input tariffs vary at the class level, we also cluster standard errors at this level of variation.[14]

We present the results of the estimation of specification (1) in Table 1. The results for domestic prices are consistent with those from de Loecker et al. (2016). In particular, the decline in output tariffs pushes down domestic prices, presumably by increasing competitive pressure in the domestic market. At the same time, the effect of U.S. tariffs on domestic prices is small and statistically insignificant.[15] The effect of input tariffs is significant, consistent with our expectation that lower tariffs would be passed on to prices through lower input costs. In Appendix C.1, we further explore this channel by interacting the input tariffs with the plant's import status. Perhaps surprisingly, we find statistically insignificant coefficients on the interaction term, suggesting that all plants experienced cost reductions through input tariff reductions regardless of their direct exposure to imports.[16] This result may be explained by increased import competition among the input suppliers. A reduction in input tariffs may have induced domestic suppliers of these inputs to cut prices, thereby indirectly benefiting non-importers. This channel is consistent with the positive and significant coefficient of domestic prices on output tariffs discussed earlier. The insignificant coefficient on the interaction term can also be explained by plants being exposed to imported inputs indirectly through their domestic suppliers. Recent evidence from Dhyne, Kikkawa, Mogstad, and Tintelnot (2021) shows that in the small open economy of Belgium, a median firm in the economy

[13] One can argue that the changes in U.S. tariffs may have influenced the prices of domestic products as well. Iacovone and Javorcik (2012), for example, find that an increase in market access driven by a decline in U.S. tariffs has stimulated investment by Mexican manufacturing plants as they prepared to introduce new products into the export market. See also Head and Ries (1999), in which they explore the effect of the Canada–U.S. Free Trade Agreement on Canadian firms' productivity through increases in scale.

[14] In Section 5, we decompose these prices into markups and marginal costs and separately analyze how each component was affected by the same tariff changes. The main analysis excludes observations with markups in the top and bottom 1 percentile within each sector and destination. We impose the same sample restriction when running specification (1) to ensure consistency.

[15] This is in contrast to the finding of Almunia, Antràs, Lopez-Rodriguez, and Morales (2021) that firms with declining domestic sales increased exports.

[16] We find similar results when we interact input tariffs with plants' domestic expenditure share, a sufficient statistic capturing plants' exposure to imports (Blaum, Lelarge, and Peters, 2018; Ramanarayanan, 2020).

sources around 40% of its inputs from abroad, while more than 80% of firms do not import directly.

A unique feature of the INEGI data is that we observe export prices separately from varieties sold domestically. Column (2) in Table 1 shows that the effect of the declines in output tariffs on the prices of exported product varieties is not statistically significant. The insignificant result implies that a more competitive domestic market has no direct implication for the prices of Mexican goods exported elsewhere. We find the same effect of input tariffs on prices as in domestic varieties: input tariff reductions led to a decline in export prices as well. In addition, as shown in Appendix C.1, this effect is present for all plants, not just for plants that import directly. Finally, the decline in U.S. tariffs had a statistically significant impact on the prices of exported products. This result suggests that exporters responded to the reductions in U.S. tariffs by raising prices, partially offsetting the decrease in tariffs.

Table 1: Impact of tariffs on prices

	Domestic	Exported
	(1)	(2)
$\log\left(1+\tau_{it}^{output}\right)$	0.04^{b}	0.04
	(.02)	(.03)
$\log\left(1+\tau_{c(j)t}^{input}\right)$	0.04^{a}	0.04^{c}
	(.01)	(.02)
$\log\left(1+\tau_{it}^{US}\right)$	0.01	-0.04^{b}
	(.02)	(0.02)
Within R^2	0.002	0.002
N	$143,717$	$27,642$

Note: The dependent variable is the log of prices. Column (1) uses the sample of domestic products and Column (2) uses the sample of exported products. Regressions include plant–product and sector–year fixed effects. Standard errors are clustered at the class level. To ensure consistency with the results presented in Table 6, we exclude observation with estimated markups in the top and bottom 1 percentile within each sector and destination.
Significance: a (1%), b (5%), and c (10%).

Taken together, excluding the statistically insignificant coefficients, the estimated coefficients in Table 1 imply that the observed tariff declines during the 1994–2008 period illustrated in Figure 1 led to an 11.3% average reduction in the prices of domestic products. At the same time, the prices of exported products decreased by around 2.4% on average.[17]

The results in Table 1 treat domestically sold and exported product varieties independently. The differences in how prices reacted to tariffs may be driven by plants serving both markets reacting differently to different tariff changes, or by different sets of plants specializing in the domestic market or in exporting. In Appendix C.2, we investigate whether the results in Table 1 hold if we focus on domestic products from two groups of plants: plants that never exported any of their

[17] When accounting for the point estimates of the insignificant coefficients in Table 1, the declines in the prices of domestic products and exported products become 12.3% and 8.6%, respectively.

products, and plants that also sold products to the export market. We find that the coefficients of prices on the tariffs for the two groups of plants are similar to those in Column (1) of Table 1.[18] This implies that the pricing response of domestic varieties did not depend on whether the plants were exporting at the same time. We then turn our attention to exported varieties from plants that also sold to the domestic market. We find that the coefficients of prices on the tariffs are similar to those in Column (2). This result is consistent with the fact that most exported goods were from plants that also served the domestic market.

Lastly, we focus on plant–product pairs that sold to both markets in the same year. With this sample, we add plant–product–year fixed effects and interact the tariff changes on a dummy variable indicating whether the variety was exported. The coefficients on the interaction terms would isolate the differential responses that plants may have had across destinations for the same product. As shown in Table 2, we find a negative coefficient on the interaction term with the input tariffs, implying that plants decreased prices less for exported varieties. As we discuss later in Section 5, this can be rationalized by plants raising markups to a larger extent for exported varieties. Meanwhile, coefficients on both output and U.S. tariffs are insignificant. Nevertheless, the point estimate of the interaction term with U.S. tariffs is negative, which is consistent with plants raising prices for exported goods in response to U.S. tariff reductions.[19]

Table 2: Plant–product pairs that serve both markets

	$\log P_{ijt}$
$\log\left(1+\tau_{it}^{output}\right) \times EXP_{ijt}$	0.01
	(0.05)
$\log\left(1+\tau_{c(j)t}^{input}\right) \times EXP_{ijt}$	-0.11^{b}
	(0.05)
$\log\left(1+\tau_{it}^{US}\right) \times EXP_{ijt}$	-0.03
	(0.02)
N	54,014

Note: The regression result is based on the sample of plant–product pairs that served both the domestic and export markets. Regressions include plant–product–year fixed effects. Standard errors are clustered at the class level. Significance: a (1%), b (5%), and c (10%).

While the results presented in Table 1 reveal important insights into how changes in tariffs influenced prices, they do not identify the channels through which the prices were affected. Prices

[18] In addition to the sample of plants that also sell products to the export market, we consider a narrower set of plants that sell different sets of products to different destinations. We find similar results, implying that the specialization of products to destinations does not matter for the responses to tariffs.

[19] We note here that price variations across destination markets can be seen as markup variations if one assumes that marginal costs are at the plant–product level and the same across destinations (Blum et al., 2024). In this case, the results in Table 2 could be interpreted as plants' differential markup responses to the tariff reductions. Compared to the differential responses of our plants' estimated markups in Table C5 of Appendix C.2—where the estimation allows for marginal costs to vary across destinations but productivity is uniform at the plant level—we observe qualitatively similar patterns in markup adjustments. Specifically, plants tend to increase markups more significantly for exported varieties in response to input tariff reductions and U.S. tariff reductions, although the latter effect is not statistically significant.

may have responded to tariff reductions through markups that were induced by changes in market competitiveness. Alternatively, marginal costs may have also responded through changes in plants' productivity or in input prices. To further explore these mechanisms, we proceed to Section 3.2 to analyze how tariff changes impacted measures that proxy markups at the plant level. Then, we formally decompose prices into markups and marginal costs in Section 4 and analyze how the NAFTA tariff reductions affected these components in Section 5.

3.2 The impact of tariff reductions on proxy measures for markups

Before decomposing output prices into markups and marginal costs using the procedure described in Section 4, we also experiment with proxy measures for markups at the plant level. The advantage of this approach is that we can gauge the impact of tariff changes on markups with readily available data on prices and tariffs. The measure we consider is each plant's inverse material share, i.e., the material input expenditure relative to sales. This measure consistently captures plant-level markups as long as the output elasticity with respect to material inputs is constant, material inputs are static inputs to the plant, and the plant minimizes its short-run costs (de Loecker and Warzynski, 2012).

We consider the following specification in which we regress the log of plant-level inverse material expenditure shares on the three tariff measures:

$$\log Y_{jt} = \alpha + \beta_1 \log\left(1+\tau_{jt}^{output}\right) + \beta_2 \log\left(1+\tau_{c(j)t}^{input}\right) + \beta_3 \log\left(1+\tau_{jt}^{US}\right) + \xi_j + \psi_{st} + \varepsilon_{jt}. \quad (2)$$

Note that input tariffs are still measured at class level, whereas output tariffs and U.S. tariffs are now constructed at the plant level as the average of product-level tariffs weighted by the sales share of these products. As the level of observation is now at the plant–year level, we include plant fixed effects together with sector–year fixed effects.

In Table 3, we present the regression results of specification (2). Because the observations are at the plant–year level, we are not able to distinguish products that were sold domestically from those that were exported, as in Section 3.1. Therefore, we focus on two mutually exclusive sets of plants: the first two columns use the sample of Mexican plants that sold the majority of their products domestically, and the last two columns use the sample of plants that exported the majority of their products. Following the results shown in Table 1, in Columns (2) and (4) of Table 3, we drop U.S. tariffs and output tariffs in the regression for domestic-oriented and export-oriented plants, respectively. We can see that, for all the specifications, input tariffs have negative and significant coefficients. This implies that the reduction in input tariffs increased plant-level markups approximated by the inverse input material shares for both domestic- and export-oriented plants. At the same time, the coefficients on output tariffs and U.S. tariffs are all positive but insignificant, indicating that there was no clear effect of these tariffs on plant-level markups measured by the inverse material shares.

Table 3: Impact of tariffs on inverse material shares

Dependent var	log (inverse material share$_{jt}$)			
	Domestic-oriented plants		Export-oriented plants	
	(1)	(2)	(3)	(4)
$\log\left(1+\tau_{\cdot t}^{output}\right)$	0.01	0.01	0.05	
	(0.02)	(0.02)	(0.07)	
$\log\left(1+\tau_{\cdot t}^{input}\right)$	-0.25^a	-0.25^a	-0.25^a	-0.25^a
	(0.02)	(0.02)	(0.09)	(0.09)
$\log\left(1+\tau_{\cdot t}^{US}\right)$	0.03		0.07	0.06
	(0.02)		(0.05)	(0.06)
R^2	0.775	0.775	0.876	0.876
N	61,583	61,583	6,022	6,022

Note: The first two columns consider domestic-oriented Mexican plants whose domestic sales share was larger than 50%. The last two columns consider export-oriented Mexican plants whose export sales share was larger than 50%. Regressions include plant and sector–year fixed effects. Standard errors are clustered at the class level. The regressions exclude outliers in the top and bottom 1% of the inverse material shares within each sector.
Significance: a (1%), b (5%), and c (10%).

Taken together, we find that the prices of Mexican manufacturing plants responded differently to tariff reductions under NAFTA, depending on whether the goods were exported abroad or sold domestically. Export prices increased slightly with reductions in the U.S. tariffs, while the prices of domestic goods decreased with reductions in Mexican output tariffs. Plant-level markups seem to have played a role in these price changes. Markups at the plant level, as proxied by the plants' inverse material shares, increased in response to the input tariff reductions, while prices decreased. This suggests that marginal costs—the other component of prices—declined with a larger magnitude when input tariffs went down.

All these results are suggestive at best, as they come with multiple limitations. First, inverse material shares work as proxies for markups only under the assumption of output elasticity with respect to material inputs that are constant. Second, even if inverse material shares are a good proxy for markups, they are not informative in analyzing how plant–product-level markups responded to tariff declines, as inverse material shares are only measured at the plant level.[20] Lastly, one needs an estimate of markups in order to back out marginal costs, which is another important component of prices. To further investigate the markup responses that may potentially vary depending on the destination of the good, in the next section, we outline the framework developed by de Loecker

[20] One might argue that market shares may be another good proxy for markups, and these market shares can in principle be measured at the level of plant-product-destinations. Market shares can be useful measures for markups, as there is a positive mapping between market shares and markups in the class of Nash-Bertrand models (Amiti, Itskhoki, and Konings, 2019a). This positive relationship between market shares and markups also arises when one takes a "demand-side" approach to estimate plants' production functions and markups. In contrast to the "supply-side" approach that this paper and de Loecker et al. (2016) take, the "demand-side" approach typically assumes a demand structure together with a mode of competition to derive the markup for each product. As in Piveteau and Smagghue (2019) and Orr (2022), which both follow the "demand-side" approach, markups are derived to be positively correlated with plants' market shares. As our sample of plants is restricted to those that appeared in the 1994 Economics Census and is skewed toward larger plants (see Section 2.1), market shares constructed using our sample are susceptible to measurement errors.

et al. (2016), which enables us to estimate product-specific markups.

4 Recovering markups and marginal costs

In this section, we set up the empirical framework used to estimate markups and marginal costs at the product level, separately for domestic and exported products. We then discuss the estimates obtained from the framework before moving on to the main analysis in Section 5. The empirical framework we use closely follows the one developed by de Loecker et al. (2016), which relies on the estimation of quantity production functions and exploits plants' cost minimization problem. Inheriting both the advantages and limitations of this framework, we distinguish ourselves from de Loecker et al. (2016) by analyzing the domestic and exported product varieties separately.

In the main analysis of this paper, we assume that domestic and exported varieties of the same disaggregated product category are distinct products, even if they are produced by the same plant. We treat domestic and exported varieties as different products for two reasons. First, varieties destined for the domestic market may differ in quality from exported varieties from the same plant. If quality is positively correlated with consumer income, for example, one would expect the varieties exported to the U.S. to be of higher quality than those sold on the domestic market.[21] Second, since domestic and exported varieties are shipped to two different markets, plants may respond very differently to changes in tariffs, even with the exact same physical product. Such differential responses by plants are indeed what we find in Section 5.

4.1 Estimation framework

We illustrate the key steps of the framework developed by de Loecker et al. (2016) and present the remaining details in Appendix B. The starting point of this framework is the approach introduced by Hall (1986), and subsequently refined by de Loecker and Warzynski (2012) and many others. The main idea of this framework is to rely on the first-order conditions from a plant's cost minimization problem to recover the model's implied markups.

Consider the production function of product i from plant j in sector s at time t:

$$Q_{ijt} = F_i(M_{ijt}, L_{ijt}, K_{ijt}; \beta_s)\Omega_{jt}, \tag{3}$$

where Q_{ijt} is the physical output, M_{ijt} is the material input, L_{ijt} denotes the labor input, K_{ijt} is the capital input, β_s is the parameter vector of the production function that we assume to be sector-specific, and Ω_{jt} is the Hicks-neutral productivity at the plant level.

Treating materials as static inputs, one can derive the following expression for the markup plant

[21]See for example Linder (1961), Hallak (2006), Verhoogen (2008), and Hallak and Sivadasan (2013). In particular, Verhoogen (2008) documents that the same Volkswagen Puebla plant in Mexico produced two varieties of the same product with clear quality differences: the New Beetle for the U.S. market and the Original Beetle for the Mexican market.

j charges on its product i at time t from the plant's cost minimization problem:

$$\mu_{ijt} = \theta^M_{ijt} \times \left(\Psi^M_{ijt}\right)^{-1}, \tag{4}$$

where $\theta^M_{ijt} = \frac{\partial Q_{ijt}}{\partial M_{ijt}} \frac{M_{ijt}}{Q_{ijt}}$ is the output elasticity of material inputs, with M_{ijt} representing the quantity of material inputs used by plant j for product i. In addition, $\Psi^M_{ijt} = \frac{W^M_{ijt} M_{ijt}}{P_{ijt} Q_{ijt}}$ is the expenditure share of materials in product i's revenues, with P_{ijt} being its sales price and W^M_{ijt} being the material input price that the plant takes as given.[22]

Equation (4) reveals that we need estimates of output elasticity, product revenue, and input expenditures per product in order to construct markups at the product level. With estimated markups, we can obtain the estimates of the marginal costs of products, MC_{ijt}, from $MC_{ijt} = \frac{P_{ijt}}{\mu_{ijt}}$.

Since product output quantity is observed (potentially with measurement error), we take the following steps to estimate the output elasticities and input expenditures per product. First, we derive the following equation by taking logs of (3):

$$q_{ijt} = f_i(\mathbf{x_{ijt}}; \beta_\mathbf{s}) + \omega_{jt} + \epsilon_{ijt}. \tag{5}$$

The term $\mathbf{x_{ijt}} = (m_{ijt},\, l_{ijt},\, k_{ijt})$ represents the log of inputs (material, labor, and capital), q_{ijt} is the log of output, ω_{jt} is the log of Hicks-neutral plant-level productivity, and ϵ_{ijt} captures the measurement error on quantity produced. We assume a translog production function, with parameters β_s varying across nine 2-digit sectors.[23] In what follows, we highlight some of the key challenges in estimating the translog production function and how the de Loecker et al. (2016) framework deals with these challenges.

Unobserved plant-level productivity A common challenge in estimating production functions is that the productivity term, ω_{jt} in equation (5), is unobserved. This leads to a simultaneity bias that arises from the fact that plants observe their productivity draws before making their choice of inputs. For single-product plants, we overcome this challenge by following the proxy methods used by Olley and Pakes (1996) and Levinsohn and Petrin (2003). We assume that demand for materials is increasing with productivity, which enables us to invert the demand function and obtain a control function for the unobserved productivity term. Note that this method requires data on physical

[22] Note that equation (4) does not require all material inputs to be static inputs. As long as a fraction of material inputs are used as static inputs, equation (4) follows from the first-order conditions.

[23] In particular, the translog production function takes the following form:

$$\begin{aligned} f_i(m_{ijt}, l_{ijt}, k_{ijt}; \beta_s) =& \beta_{sm} m_{ijt} + \beta_{smm} m^2_{ijt} + \beta_{sl} l_{ijt} + \beta_{sll} l^2_{ijt} + \beta_{sk} k_{ijt} + \beta_{skk} k^2_{ijt} \\ &+ \beta_{sml} m_{ijt} l_{ijt} + \beta_{smk} m_{ijt} k_{ijt} + \beta_{slk} l_{ijt} k_{ijt} + \beta_{smlk} m_{ijt} l_{ijt} k_{ijt}. \end{aligned}$$

Theoretically, it is possible to conduct the estimation for each product, or for each product–destination (variety). In practice, due to the limited sample size, we estimate the parameters at the sector level. This implies that, just as different products within the same sector have common production function parameters, different varieties of the same product also have common parameters. However, the output elasticities needed to recover markups will vary across varieties due to the translog production structure, as they depend on production function parameters and input expenditures.

units of inputs, but the INEGI data only have material expenditures. We address this challenge of unobserved input prices below.

Importantly, we assume a first-order Markov process for the law of motion of the productivity term and allow tariffs at $t-1$ to influence the level of productivity at t.[24] As we discuss in later sections, tariffs can potentially affect plants' marginal costs and hence productivity. For this reason, we also include tariffs in the law of motion of productivity.[25] We follow Ackerberg et al. (2015) and estimate the production function parameters by GMM. The moment conditions require the shocks to plants' productivity to be orthogonal to lagged material inputs, current dynamic inputs of capital and labor, and their interaction terms. A key assumption to construct the moment conditions is that neither capital nor labor responds contemporaneously to the innovation to productivity shock, whereas materials do. For multi-product plants, one first needs to recover the unobserved input expenditures for each product. We address this challenge later in this section.

Unobserved product-level input prices An additional obstacle in the production function estimation is the lack of data on physical units of inputs. Instead, we have data on input expenditures deflated by industry-level input price indices. Failure to observe input prices at the plant or product level when estimating quantity production functions might lead to significant biases in the estimation (de Loecker and Goldberg, 2014). To overcome this obstacle, we proxy for unobserved plant–product-level input prices using a function of output prices, market share, and product dummies. This proxy is guided by two key insights from existing works. The first is from Khandelwal (2010), who suggests that if two products in the same category have the same price, then the product with the larger market share should be of higher quality. The second is that higher quality products require higher quality inputs that are more expensive (Kugler and Verhoogen, 2012).[26] Guided by these two insights, we construct an input price control that is a function of market shares, output prices, and product dummies. As discussed in more detail in Appendix B, the input price control function allows for different input prices among different products manufactured by the same plant (including the same products sold to different markets), and different input prices among the same products produced by different plants. This framework, however, does not permit separate control functions for each input. We estimate the parameters of the input price control function for each sector jointly with the production function parameters in the GMM estimation.

[24]For the exact equation of the law of motion, see Appendix B. We allow for lagged tariffs to influence the level of productivity, implying that the shocks to plants' productivity need to be orthogonal to changes in tariffs for identification. We test this assumption in Appendix C.9 and verify that, controlling for lagged tariffs, the changes in tariffs have an insignificant impact on plants' estimated productivity.

[25]This setup therefore accounts for productivity changes due to trade liberalization. However, this approach cannot accommodate plants' endogenous technology choices in response to tariff changes as discussed in Lileeva and Trefler (2010) and Bustos (2011).

[26]Note that this assumption implicitly rules out high-quality goods being produced through a combination of low-quality inputs and a different production process. As a result, a product with a larger market share conditional on its price should be of higher quality and therefore must be produced using more expensive inputs. Acknowledging the limitation of this approach, we nevertheless test this relationship in Appendix C.3, in which we examine the correlation between our measure of quality, the residuals from a regression of market shares on output prices and product dummies, and average wages. We find that there is an overall positive relationship between the residuals and average plant-level wages.

Unobserved input expenditures by product The procedure described so far is sufficient for the production function estimation for the set of single-product plants. For multi-product (variety) plants, we still need to recover their product-specific input expenditure shares. We do so by additionally assuming the following. First, we assume that productivity is plant-specific, not plant–product-specific. The homogeneity of productivity across products within plants is crucial for identifying the share of inputs spent on each product.[27] As highlighted in de Loecker et al. (2016), this assumption does not rule out economy of scope. Assuming that both multi-product and single-product plants use the same production technology indeed rules out physical synergies in production. However, economies of scope that operate through productivity can still be captured by the plant-specific productivity term.

Second, we assume that within plants, the production of each good consumes the same proportion of different inputs, i.e., the production function is homothetic.[28] Note that the translog production function that we assume does not guarantee homotheticity. However, one can derive relationships between production function parameters that need to be satisfied under homotheticity. We later test whether these relationships hold under the estimated parameters in Section 4.2, and find evidence that they broadly hold.

With these assumptions, for each plant, we can recover the input expenditure shares and the plant's productivity by solving a system of equations consisting of the production function and input price control function parameters.[29]

Selection correction We assume that multi-product plants and single-product plants that manufacture the same product use the same technology parameters β_s. This assumption enables us to estimate β_s from single-product plants. However, this approach introduces a sample selection bias. We correct for this bias when estimating the production function for the single-product plants in the spirit of Heckman (1979). In particular, we use the probability of remaining a single-product plant as a control. We assume, as in Mayer, Melitz, and Ottaviano (2014), that the number of products increases with productivity and include the probability of remaining a single-product plant as a control in the law of motion of productivity.

4.2 Validity of the estimates

Having estimated the output elasticities, markups, and marginal costs, we validate these estimates before investigating how markups and marginal costs responded to the tariff reductions under NAFTA. First, we focus on the estimated output elasticities. In Table 4, we report the median estimates of the output elasticities and implied returns to scale (RTS), together with the

[27] An alternative approach is to add more structure on the demand side, as in Orr (2022). This approach allows for heterogeneity in productivity across products, but at the same time imposes additional assumptions on markups.

[28] For example, if a product or variety uses 20% of labor in a plant, then it also uses 20% of capital and materials.

[29] Our assumption of plant-level productivity implies that the differences across varieties within products are from quality differences, not productivity differences. While the differences in quality are controlled for by the usage of the input price control function, the estimated productivity terms may be biased through the quality–quantity tradeoff if productivity varies within plants (Grieco and McDevitt, 2017).

Table 4: Median elasticities by sector, all products

Sector	Materials (1)	Capital (2)	Labor (3)	RTS (4)	Obs. in Estimation (5)
Food and Beverage	0.86	0.06	0.19	1.12	1,781
	(0.13)	(0.18)	(0.11)	(0.34)	
Textile Manufacturing	0.62	0.02	0.28	0.97	992
	(0.16)	(0.14)	(0.20)	(0.20)	
Apparel Manufacturing	0.86	0.05	0.11	1.00	1,691
	(0.52)	(0.56)	(0.55)	(1.64)	
Wood and Furniture Industries	0.73	0.12	0.08	0.91	490
	(0.12)	(0.24)	(0.24)	(0.33)	
Paper Industries	0.95	0.01	0.30	1.21	1,968
	(0.10)	(0.21)	(0.14)	(0.13)	
Chemical Industries	0.65	0.09	0.27	1.03	1,995
	(0.11)	(0.14)	(0.11)	(0.14)	
Non-Metallic Mineral Products	0.58	0.08	0.42	1.05	1,519
	(0.36)	(0.33)	(0.33)	(0.99)	
Metallic Manufacturing	0.67	0.18	0.23	1.09	1,493
	(0.36)	(0.34)	(0.32)	(0.99)	
Machinery and Equipment Manufacturing	0.74	0.02	0.10	0.80	1,073
	(0.21)	(0.27)	(0.24)	(0.26)	
Total	0.76	0.08	0.18	1.05	1,073

Note: Estimates of output elasticities of the production function for all products, domestic and exported, and all years in the sample (1994–2008). Columns (1)–(3) report median elasticities for each sector. Column (4) reports the median returns to scale, which is the sum of labor, capital, and material elasticities. Numbers in parentheses report the standard error of the median elasticities for each sector, obtained via 100 block bootstrapped simulations of the production function estimation. Column (5) reports the total number of observations used during estimation of the production function for each sector. The total corresponds to the median observations across all products and years.

number of observations used for estimating the production function. As explained in the previous section, only products manufactured by single-variety plants are used in the estimation. The estimated elasticities are in line with the results of other studies using product-level data, with the largest elasticities for materials, followed by elasticities for labor, and lastly the smallest elasticities for capital.[30] Despite having reasonable estimates, we acknowledge that the single-variety plants that are used for the estimation predominantly sold in the domestic market. In other words, we assume that exporting plants within the same sector share the same estimated production function parameters.[31]

We also examine the correlation between reported input expenditure shares at the plant level

[30] See, for example, de Loecker et al. (2016) and Garcia-Marin and Voigtländer (2019).

[31] We validate this assumption by estimating the production function parameters using two different sets of plants. The first set is the single-variety plants that only sell domestically throughout the sample period. The second set is the single-variety plants that exported at least once during the sample period. Given the limited observations for the second set of plants, we focus on the three sectors with the largest number of plants. For these sectors, the correlations between the two sets of parameters are all positive, with the average correlation being 0.72.

and the theoretical expenditure shares implied by the output elasticities under cost minimization. Given production function $F(L, K, M)$, cost minimization yields a material expenditure share equal to $\frac{\theta^M}{\theta^L+\theta^K+\theta^M}$, where θ^L, θ^K, and θ^M are the output elasticities of labor, capital, and materials, respectively. The expressions for labor and capital share can be defined analogously. We present in Appendix C.4 the relationships between the observed and implied expenditure shares for material inputs, labor, and capital. We find that there is a positive and significant relationship between the observed expenditure shares of materials and the expenditure share implied by our estimated elasticities. We also find broadly positive relationships for the share of labor and capital inputs.

To recover the input expenditure shares for multi-product plants, we assume homotheticity in the production function. Given the translog production function for each sector s, the following conditions have to be satisfied for the translog production function to be homothetic:

$$\begin{aligned}
0 =& 2\beta_{smm} + \beta_{sml} + \beta_{smk}, \\
0 =& 2\beta_{sll} + \beta_{sml} + \beta_{slk}, \\
0 =& 2\beta_{skk} + \beta_{smk} + \beta_{slk}, \\
0 =& \beta_{smlk}.
\end{aligned} \tag{6}$$

In Appendix C.5, we test equation (6) with the estimated parameters. We find that all four conditions are satisfied in all but one sector, suggesting that our assumption that product expenditure shares are the same across inputs is broadly consistent with the estimates.

We then focus on the estimated markups. Table 5 shows the median estimates of markups by sector and destination.[32] The values of the estimated markups are comparable to those found in studies by de Loecker and Warzynski (2012) that are at the plant level, and also to those found in de Loecker et al. (2016) and Garcia-Marin and Voigtländer (2019), both of which are at the plant–product level. Our finding that the median markup on exported goods is generally lower than the median markup on domestically sold goods is also consistent with the findings of Blum et al. (2024) using Chilean data.

We also compare the estimated markups to accounting measures of revenue over variable costs at the plant level. As reported in Appendix C.6, we find a positive and significant correlation between the estimates of markups and accounting measures of revenue over variable costs, which strengthens the validity of our estimates. Furthermore, our markup estimates concur with theoretical models in the multi-product plant literature, such as Mayer et al. (2014). Consistent with their prediction, in the same appendix, we find that a plant's most important products (measured by their revenue shares) have lower marginal costs, and plants charge higher markups on such products.

We then turn to the estimated marginal costs and ask whether marginal costs differ between domestic and exported varieties within plant–product pairs. If marginal costs are the same, then the observed price differences across destinations directly reveal the differences in markups. In this case, one would be able to infer how markups responded to tariff changes within plant–product pairs

[32]In Table 5 and all of the results that follow, we have trimmed outliers above the 99th and below the 1st percentiles of the markup distribution by sector and destination to make sure that outliers are not driving the main results.

Table 5: Median markups by destination

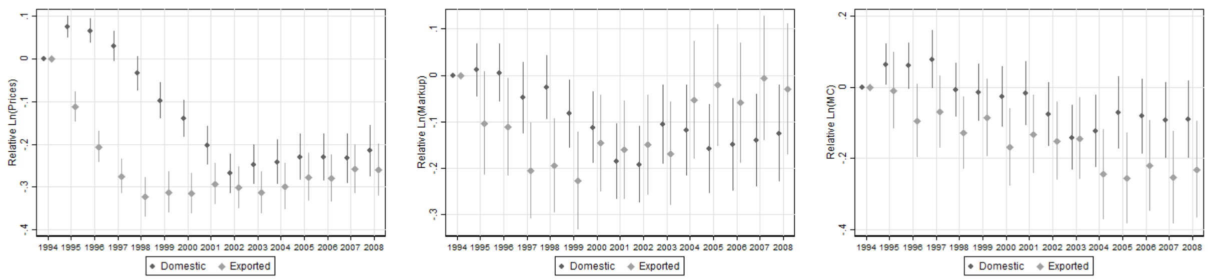
Sector	Domestic (1)	Exported (2)
Food and Beverage	1.12	1.11
Textile Manufacturing	1.11	1.32
Apparel Manufacturing	1.27	1.19
Wood and Furniture Industries	1.06	0.90
Paper Industries	1.47	1.93
Chemical Industries	1.29	1.03
Non-Metallic Mineral Products	1.96	1.79
Metallic Manufacturing	1.14	1.03
Machinery and Equipment Manufacturing	1.27	1.45
Total	1.24	1.19

Note: We trim outliers above the 99th and below the 1st percentiles of the markup distribution by sector and destination. The total corresponds to the median markup across all products and years in each sample.

across destinations by simply regressing output prices that are directly observable. However, in Appendix C.7, we find that the estimated marginal costs are larger for exported varieties on average, compared to the same set of varieties produced by the same plant but sold domestically. Because we assume a common productivity term for all product varieties within each plant, these marginal cost differences within plant–product pairs must reflect the differences in input expenditures used for production. While we do not directly observe input prices and expenditures, we verify this by regressing the plants' expenditures for each plant–product pair on its share of exported output or its export status dummy, controlling for output quantities, input price indices, and plant–product fixed effects. We find a positive coefficient on the export share or on the export status dummy, implying that varieties that are exported require larger input expenditures compared to the same products sold domestically.

Finally, before exploring how the tariff changes under NAFTA impacted prices, markups, and marginal costs in the next section, we end this section by plotting the within-plant–product trajectories of the three variables. We focus on plant–product pairs that were both sold domestically and exported throughout the sample period following a specification akin to that in Garcia-Marin and Voigtländer (2019). We regress the three variables on plant–product fixed effects including two sets of plant–product–year-specific dummy variables: one for domestically sold varieties and the other for exported varieties. The results presented in Figure 2 reveal that prices and their components declined generally throughout the sample period. While it is tempting to interpret these declining prices as a consequence of NAFTA, we note that during this period, both the U.S. and Mexico experienced increases in imports from the rest of the world (see Appendix C.8 for details). The increased competition with the rest of the world in the two markets could have contributed to the general declines in the prices, markups, and marginal costs of Mexican plants. Therefore, in the next section, we regress prices and their components on the tariff reductions to formally identify the effect of NAFTA.

Figure 2: Within-plant–product trajectories of prices, markups, and marginal costs



(a) Prices (b) Markups (c) Marginal costs

Note: The figures show the trajectories of prices, markups, and marginal costs separately for domestically sold and exported varieties during the sample period. The values are normalized to their corresponding levels in 1994. Plant–product fixed effects are controlled for, and the 99% confidence intervals for each estimate are computed using standard errors clustered at the plant–product level.

5 The impacts of NAFTA

5.1 The impacts on prices and their components

In this section, we use the estimated markups and marginal costs at the plant–product–destination level to analyze the impact of tariff declines under NAFTA on prices and their components. In particular, we consider the following regression equation:

$$\log Y_{ijt} = \alpha + \beta_1 \log\left(1 + \tau_{it}^{output}\right) + \beta_2 \log\left(1 + \tau_{c(j)t}^{input}\right) + \beta_3 \log\left(1 + \tau_{it}^{US}\right) + \xi_{ij} + \psi_{st} + \varepsilon_{ijt}, \quad (7)$$

where Y_{ijt} is either the price, markup, or the marginal cost of product i from plant j at time t. The terms ξ_{ij} and ψ_{st} are plant–product and sector–year fixed effects, respectively. We estimate equation (7) separately for domestic and exported product varieties and identify the coefficients on tariffs from variation in time of the dependent variables and tariffs within a plant–product pair. Motivated by the results in Section 3.1, we consider output and input tariffs as independent variables in regressions for domestic varieties. Similarly, for regressions of exported varieties, we consider input and U.S. tariffs as the independent variables.

We present our main results in Table 6. The first three columns show results for the domestic varieties, and the last three columns show results for the exported varieties. We first focus on the first three columns and explore how domestic prices and their components were affected by the tariff reductions. The results for prices in Column (1) are consistent with the motivating facts presented in Table 1: prices of domestic goods fell in response to reductions in output tariffs and input tariffs. Compared to Column (1) of Table 1, these coefficients and their statistical significance remain unchanged after removing the U.S. tariffs from the independent variables.

The coefficients on output tariffs in Columns (2) and (3) suggest that, although statistically insignificant, the decline in output tariffs lowered domestic prices by decreasing both marginal costs and markups. The reduction in marginal costs can be explained by increasing competition in the Mexican market. Previous studies have documented that increasing foreign competition, measured by cuts in output tariffs, can increase plant-level productivity (Pavcnik, 2002; Lopez-Cordova, 2003; Khandelwal and Topalova, 2011). In Appendix C.9, we estimate the impact of tariff declines on quantity total factor productivity (TFPQ). Consistent with existing works, we do find that the decline in output tariffs under NAFTA led to an increase in future TFPQ.[33]

Table 6: Impact of tariffs on prices, marginal costs, and markups

	Domestic			Exported		
	$\log P_{ijt}$	$\log MC_{ijt}$	$\log \mu_{ijt}$	$\log P_{ijt}$	$\log MC_{ijt}$	$\log \mu_{ijt}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\log\left(1+\tau_{it}^{output}\right)$	0.04^b	0.03	0.02			
	(0.02)	(0.02)	(0.03)			
$\log\left(1+\tau_{c(j)t}^{input}\right)$	0.04^a	0.09^c	-0.05	0.04^c	0.26^a	-0.22^a
	(0.01)	(0.05)	(0.05)	(0.02)	(0.07)	(0.07)
$\log\left(1+\tau_{it}^{US}\right)$				-0.04^b	0.06	-0.10^b
				(0.02)	(0.04)	(0.04)
Within R^2	0.002	0.001	0.000	0.002	0.005	0.004
N	143,717	143,717	143,717	27,642	27,642	27,642

Note: Dependent variables are the logs of prices, marginal costs, and markups. The regressions exclude outliers in the top and bottom 1% of the markup distribution within each sector and destination. Regressions include plant–product and sector–year fixed effects. Standard errors are clustered at the class level.
Significance: a (1%), b (5%), and c (10%).

The statistically insignificant coefficient of output tariffs on markups in Column (3) may be driven by two opposing effects. Markups can respond to changes in the competitive environment or to changes in marginal cost. To isolate the effect of the change in the competitive environment, one needs to control for marginal costs. We explore this further in Section 5.2 by re-running the specification for Column (3) but including marginal costs as controls. Indeed, we find that the decline in output tariffs reduced the markups of domestic products.

Markups may also respond to the changes in marginal costs. To illustrate this channel, in Appendix C.10, we run a pass-through regression in which we regress prices on marginal costs. We find that the pass-through of marginal costs to prices was incomplete, indicating that markups increased in response to the marginal cost reduction.[34] These two opposing effects led to an overall insignificant coefficient of output tariffs in Column (3).

[33] TFPQ is a measure of physical productivity and does not confound changes in productivity with movements in prices or markups, in contrast to revenue TFP (TFPR) (Foster, Haltiwanger, and Syverson, 2008). This difference between TFPQ and TFPR becomes particularly important when one tries to estimate the impact of trade policies on plants' productivity (Pierce, 2011; Garcia-Marin and Voigtländer, 2019). In Appendix C.9, we demonstrate how predictions on TFP responses can differ when one estimates the impact of tariff reductions on TFPR.

[34] Existing studies estimating the price pass-through of tariff changes find mixed evidence. For example, focusing on the Indian trade liberalization episode, de Loecker et al. (2016) find incomplete pass-through, which is in line with our estimates. By comparison, Amiti, Redding, and Weinstein (2019b) and Fajgelbaum, Goldberg, Kennedy, and Khandelwal (2020) document almost complete pass-through of tariff shocks to import prices in the recent U.S. trade war episodes.

The coefficients of input tariffs on domestic marginal costs and markups in Columns (2) and (3) are also consistent with our finding of incomplete pass-through of costs to prices. In response to the decline in input tariffs, prices decreased but not as much as the marginal costs. The differences can be attributed to the increases in markups, although this is statistically insignificant. These results again point to plants behaving in an oligopolistic manner whereby they respond to input price cuts by increasing their output markups, as in Amiti et al. (2019a).

We then move on to exports and discuss the responses of prices and their components shown in the last three columns. Similar to domestic goods, removing the output tariffs from the independent variables in Column (2) of Table 1 does not change the coefficients of input tariffs and U.S. tariffs on prices: the reduction in input tariffs decreased exported prices, whereas the reduction in U.S. tariffs increased the prices of exports. For input tariff reductions, marginal costs and markups of exports responded in a similar manner as those of domestic varieties, albeit with larger magnitudes.

Finally, we analyze how the cuts in the U.S. tariffs affected export prices and their components. Columns (5) and (6) show that the increase in export prices was due to the increase in markups, which more than offset the potential fall in marginal costs. As in domestic markups, markups on exported varieties are determined either through the change in the competitive environment or the change in the marginal costs. For the former, improved access to the U.S. market may have enabled exporting plants to raise markups without increasing the after-tariff prices paid by U.S. consumers—a channel which we verify in Section 5.2. For the latter, markups of exports can go up through the incomplete pass-through of costs to prices. While statistically insignificant, the lower U.S. tariffs reduced the marginal costs of exported varieties, and this could have induced plants to raise markups. We illustrate this further in Appendix C.10 by regressing prices on marginal costs for the set of exported varieties. We find low correlation between the two, suggesting that plants also charged variable markups on their exports. These two effects together led to a statistically significant coefficient of U.S. tariffs on markups in Column (6).

5.2 Pro-competitive effects

As discussed in the previous section, the coefficient of output tariffs on markups in Column (3) and the coefficient of U.S. tariffs on markups in Column (6) contain two effects: one through the change in the competitive environment and the other through the change in marginal costs. To isolate out the effects of competition on markups, we follow de Loecker et al. (2016) and consider a specification in which we control for marginal costs. In particular, we estimate the following specification:

$$\log \mu_{ijt} = \alpha + \kappa_1 \left(1 + \tau_{it}^{output}\right) + \kappa_2 \left(1 + \tau_{it}^{US}\right) + g\left(\hat{mc}_{ijt}; \eta\right) + \xi_{ij} + \psi_{st} + \varepsilon_{ijt}, \tag{8}$$

where $g(\hat{mc}_{ijt}; \eta)$ is a polynomial of marginal costs used as a control. The specification also includes plant–product fixed effects, ξ_{ij}, and sector–year fixed effects, ψ_{st}. We use a third-order polynomial on marginal costs, but the results are robust to a linear or second-order polynomial. Measurement errors in marginal costs will lead to attenuation bias. We, therefore, also instrument the polynomial of marginal costs with its lagged polynomial and intermediate input tariffs. In using this instrument, we implicitly assume that input tariffs should affect markups only through the changes in marginal costs. This assumption implies that, once controlling for marginal costs, input tariffs have insignificant effects on markups—which we verify in the data. We consider the output tariffs to be the main independent variable when considering markups of domestic varieties, and U.S. tariffs to be the main independent variable when considering markups of exported varieties.

Table 7 shows the results from the estimation of equation (8). The first two columns show the results for domestic varieties, and the last two columns show the results for exported varieties. For each set of varieties, we present specifications both with and without the instrument. We find that once we control for marginal costs, the coefficient for the impact of output tariffs on markups becomes positive and statistically significant, suggesting that output tariff declines during this period had pro-competitive effects. For exported varieties, the fall in U.S. tariffs led to a rise in markups when controlling for marginal costs. This result is in contrast to the pro-competitive effect of output tariff reductions on domestic varieties, suggesting an anti-competitive effect of trade liberalization predicted by de Blas and Russ (2015).

Table 7: The pro-competitive effects of NAFTA

	Dependent Variable: $\log \mu_{ijt}$			
	Domestic		Exported	
	(1)	(2)	(3)	(4)
$\log\left(1+\tau_{it}^{output}\right)$	0.19^{a}	0.21^{a}		
	(0.02)	(0.02)		
$\log\left(1+\tau_{it}^{US}\right)$			-0.17^{a}	-0.11^{a}
			(0.02)	(0.03)
Instruments	No	Yes	No	Yes
First Stage F		5,821		622.7
Within R^2	0.24	0.79	0.28	0.77
N	$143,717$	$124,148$	27,642	22,754

Note: The dependent variables in Columns (1) and (2) are the logs of the domestic markup, and the dependent variables in Columns (3) and (4) are the logs of the export markup. Both specifications include third-order polynomials on log marginal costs (coefficients not reported). In Columns (2) and (4), we instrument the marginal cost polynomial using its lag and intermediate input tariffs. The regressions exclude outliers in the top and bottom 1% of the markup distribution within each sector and destination. Regressions include plant–product fixed effects and sector–year fixed effects. Standard errors are clustered at the product level.
Significance: a (1%), b (5%), and c (10%).

5.3 Discussion

The results presented so far are broadly consistent with those of de Loecker et al. (2016): they find that declines in Indian output tariffs led to lower prices of Indian plants, and declines in Indian input tariffs reduced plants' marginal costs but increased their markups. de Loecker et al. (2016) focus on outcome variables at the plant–product level and only consider output and input tariffs. By contrast, we consider outcome variables at the plant–product–destination level and additionally explore the effects of U.S. tariffs.

One natural question that follows immediately is whether the responses of Mexican firms are similar to those of Indian firms in de Loecker et al. (2016) when we aggregate the outcome variables in our analysis at the plant–product level. In Appendix C.11, we answer this question by first taking the quantity-weighted averages of the outcome variables to aggregate our estimates at the plant–product level, and then regressing them on output and input tariffs. The results reported in the appendix confirm the findings shown in Table IX of de Loecker et al. (2016): lower output and input tariffs led to a decline in output prices mainly through marginal cost reductions.

Our findings so far suggest that domestic and exported product varieties of Mexican plants responded differently to different types of tariff reductions. While plants reduced the prices of their domestic varieties in response to the fall in output and input tariffs, they responded to lower U.S. tariffs by increasing markups on their exported varieties. As discussed in Section 3.1, these differences may be driven by plants serving both markets reacting differently to different tariff changes, or by different sets of plants specializing in the domestic market or in exporting. We investigate in Appendix C.2 whether these differential responses are driven by plants that produce the same products for different markets. In the appendix, we focus on plant–product pairs that sold to both markets in the same year, and add plant–product–year fixed effects with tariff changes interacted with a dummy variable indicating whether the product was exported.[35] As previously discussed in Section 3.1, the prices of exported varieties decreased less than the prices of domestic varieties in response to input tariff reductions. Decomposing the movements of prices into markups and marginal costs reveals that this difference was driven by plants raising markups to a greater extent for the exported goods. Although statistically insignificant, the point estimates of the U.S. tariff interaction terms suggest that plants raised markups on exported goods when U.S. tariffs declined. This implies that the differential responses documented in Table 6 also apply to plants producing the same products for both markets.[36]

Taken together, the results presented in this section suggest that the tariff declines under NAFTA led to more competition in the domestic market, forcing domestic producers to lower their markups and consequently their prices. In addition, lower tariffs also reduced the marginal costs of domestic products that were not completely passed through to prices. Our estimates suggest that while Mexican consumers benefited from a decrease in prices, producers also profited, as the lower marginal costs enabled them to increase their profit margins despite the increased competitive pressure. The estimated coefficients and the observed average declines in tariffs from 1994 to 2008 imply that the output and input tariff declines under NAFTA led to a 13.7% average decline in marginal costs partially offset by a 2.4% average increase in markups. These changes add up to the 11.3% decline in domestic prices that we presented in Section 3.1.

[35]Relatedly, we also investigate in Appendix C.2 how much of the effects on domestic goods' outcome variables are driven by plants that never exported anything throughout, by plants that both sold domestically and exported, or by plants that may have produced other products that were only exported. We find that these sets of plants also reacted to the tariff changes in the same way as found in Table 6.

[36]This finding is consistent with Dhyne, Kikkawa, and Magerman (2022a), in which they model firms charging different markups depending on the destination market.

While the results presented above are qualitatively consistent with those of de Loecker et al. (2016), we find contrasting effects for exported products. Our estimates suggest that both input and U.S. tariff reductions under NAFTA led to a decrease in marginal costs but an increase in markups on exported products, suggesting that these tariff cuts benefited Mexican exporters with larger profit margins.[37] The estimated coefficients and the observed average declines in tariffs from 1994 to 2008 imply that the input and U.S. tariff declines under NAFTA led to an average 31.2% decrease in marginal costs and an average 28.7% increase in markups. As a result, the prices of exports decreased slightly by an average of 2.4%.

6 Conclusion

This paper analyzed the impact of NAFTA on prices and competition in Mexico using detailed disaggregated information on Mexican manufacturing plants. Employing the methodology developed by de Loecker et al. (2016), we estimated markups and marginal costs at the plant–product–destination level by exploiting quantity and price data on domestic and exported products. Our results suggest that tariff declines under NAFTA affected the prices of domestic and exported products through different channels. For domestic products, input tariff reductions led to a decline in marginal costs and thus prices, but changes in markups were insignificant on average. Meanwhile, exporters raised markups in response to input and U.S. tariff reductions. As a result, the average export prices fell only slightly.

Overall, our empirical analysis suggests that Mexican consumers benefited from NAFTA through lower prices in the domestic market. In addition, Mexican manufacturers also benefited from NAFTA's tariff reductions through lower input prices despite increasing foreign competition. It appears that exporters disproportionately benefited, as the reductions in U.S. tariffs on Mexican products permitted an additional expansion of their profit margins.

Our analysis sheds light on how reciprocal trade liberalizations affect firms' prices and the competition firms face. The NAFTA episode and the detailed plant–product-level data from Mexican manufacturing plants provide us with an opportunity to study this question empirically. Our work complements existing literature by differentiating firms' adjustment to domestic and foreign markets. We believe that understanding firms' responses under such circumstances is very important, since a large proportion of past tariff reductions have been reciprocal.

[37] In general, higher markups do not necessarily benefit producers, as they may simply reflect high overhead fixed costs. Because we mainly focus on the intensive margins of trade wherein plants in our analysis have already paid the overhead costs, higher markups translate to larger profit margins for these incumbent firms.

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