From Slaughterhouses to Consumers: Pass-Through of Uruguay's VAT Cut on the Meat Market*

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Abstract

This paper studies the price effects and upstream traded-volume responses of a temporary VAT exemption in Uruguay's beef market. We exploit a 60-day tax exemption applied to a specific beef rib cut and trace its effects along the vertical supply chain using administrative data from INAC. The exemption reduced the relative price of the treated cut by 8.6 to 10.7 percent, implying pass-through rates of roughly 80 to 100 percent once the specific VAT regime for beef products is considered. Upstream traded volumes also increased substantially relative to a control cut. The results show that temporary consumption tax cuts can be largely passed through to prices while inducing sizable reallocations across related products.

Keywords: DiD, quasi-experimental variation, tax incidence
JEL Codes: H22

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1 Introduction

In this paper, we aim to answer the following questions. Are temporary tax cuts effective instruments to reduce inflation in the basket of food products? In what proportion are reductions in VAT passed to consumers, and in what proportion are they appropriated by suppliers? Is the Value Added Tax (VAT)-prices pass-through symmetrical when facing tax reductions or increases? To answer these questions, we exploit quasi-experimental variation in VAT rates along the vertical dimension of Uruguay's meat industry.

The Russian invasion of Ukraine caused a shock to international prices, with several implications for the food basket. In response to this exogenous shock, Uruguay temporarily exempted a specific beef rib cut from VAT for 60 days. This setting allows us to study tax incidence. We have access to a detailed database with price information before, during, and after the tax cut. The information is for products that were and were not affected by the government measure. This offers a unique scenario to study the tax incidence. Also, we have details on prices and quantities across the producer chain, which allow us to analyze how pass-through is shared in the supply chain.

We show that the VAT exemption was largely passed through to prices and generated a sizable reallocation of traded quantities along the beef supply chain. The relative price of the treated cut falls by 8.6 to 10.7 percent during the exemption period, implying pass-through rates between roughly 80 and 100 percent once the specific Uruguayan VAT regime for beef products is taken into account. The price response is observed at every stage of the chain, from slaughterhouses to downstream buyers and from retail points to final consumers. In addition, upstream quantities respond strongly: traded volumes of the treated cut increase by 43 to 63 percent in sales from slaughterhouses to downstream buyers and by 89 to 103 percent in sales from distributors to wholesale

suppliers, relative to the control cut. These findings show that the policy not only reduced prices; it also shifted quantities toward the treated product. The paper therefore contributes to the literature on tax pass-through by studying both the introduction and expiration of a temporary tax cut, by measuring transmission across multiple stages of the value chain, and by documenting quantity reallocation across related products.

Tax incidence is a central theme in economics. Taxes are among the most common market interventions, have significant economic impacts, and serve as important information for policymakers across different areas. As such, it is of relevance to understand how their changes affect the economy. Establishing their impact implies constructing counterfactual scenarios of what would happen in their absence. In some exceptional cases, quasi-experimental variation can be used, as is considered in this paper. The incidence and pass-through of taxation are classic public policy concerns. The pass-through of exchange rates and tariffs has important repercussions on firm productivity and international trade (De Loecker and Goldberg, 2014). The cost pass-through is also relevant to the policy debate in many industries, such as the health (Cabral et al., 2018) and energy sectors (Fabra and Reguant, 2014).

In industrial organization, Aguirre et al. (2010) shows that cost pass-through informs the welfare effects of price discrimination, and Pless and van Benthem (2019) documents that subsidy pass-through reveals information about market power. Pass-through rates have also been used to guide recommendations on competition policy and mergers, such as in Bonnet et al. (2013) and Jaffe and Weyl (2013). In international macroeconomics, Atkin and Donaldson (2015) uses them to recover trade costs, while Corsetti and Pesenti (2005) discusses their implications for optimal monetary policy.

In public economics, pass-through rates are used to shed light on the design of optimal taxation as in Weyl and Fabinger (2013). A well-studied topic is the distributive consequences of taxes, namely, how taxes are divided between producers and consumers.

Auerbach and Hines Jr (2002) and Fullerton and Metcalf (2002) have reviewed the literature across different levels of market competition. Since then, the literature has expanded in different directions and applied different methodologies.

Temporary VAT reductions are a new, relevant fiscal policy instrument. In light of international price shocks, they have been justified as measures to address problems in high-cost-structure economies. Although permanent VAT changes have been studied in the literature (Benedek et al., 2020; Carbonnier, 2007), there is less literature on temporal changes. In particular, because of the lack of use of this instrument until recently.

In standard models of tax incidence, if the VAT rate is first reduced and then set back to its original level, the pass-through rates should be identical. In this sense, there should be no permanent changes in the price levels. On the empirical front, things are not so clear. Analyzing quasi-experimental evidence for barbershops in Finland, Benzarti et al. (2020) suggests that prices respond more to tax increments than to tax reductions. If this is the case, tax cuts might be more harmful to consumers in the long run while benefiting producers. Nevertheless, Benzarti et al. (2023) suggests the opposite, analyzing Argentinian data on food-basket products. Fuest et al. (2024) also finds a bigger pass-through in the reduction comparing supermarkets in Germany and Austria.

The level of market competition might explain this difference. There is a consensus that, in less competitive markets, the bigger the pass-through to prices of permanent tax changes. This result has been tested in the US for the alcohol industry (Shrestha and Markowitz, 2016) and the fuel industry (Kopczuk et al., 2016). On the other hand, Genakos and Pagliero (2022) using Greek islands as a source of exogenous variation in the market size shows that the pass-through increases from 0.4 in islands with only one station to 1 in islands with four or more. Heterogeneity has also been considered in the

presence of vertical changes in the markets. Bajo-Buenestado and Borrella-Mas (2022) using data on one of the most important refineries in Spain, shows that the pass-through is 38 percent bigger in stations integrated vertically in comparison to independent ones.

The remainder of the paper is organized as follows. Section 2 presents the institutional setting of the meat tax cut and the data used in the analysis. Section 3 shows the results of the analysis. Section 4 concludes. Additional data tables and robustness figures are reported in Appendices A and B, while Appendix C provides the bounding argument used to interpret the price and quantity difference-in-differences estimates in the presence of substitution spillovers.

2 Institutional Setting and Data

Although global inflation remained relatively contained at 3.3 percent during the first year of the Covid-19 pandemic, it rose to 4.7 percent in 2021 amid growing supply-side pressures and disruptions in global supply chains. These inflationary dynamics were later exacerbated by the Russia-Ukraine war, as rising energy and food prices, fiscal uncertainty, and weakening consumer confidence added further pressure.

As inflation moved beyond acceptable levels, many countries, including Uruguay, introduced VAT reductions on basic consumption goods. These policies were unusual in both their magnitude and their prevalence across countries. They are also fiscally relevant, since VAT reductions can have substantial implications for government revenues. This is particularly important in Uruguay, where VAT is the main source of tax revenue. In the Uruguayan case, the measure targeted a product with high economic and cultural salience. Beef is a central component of domestic food consumption: according to the National Meat Institute (*Instituto Nacional de Carne*, INAC), total per capita meat consumption reached 92.5 kg per year in 2022, of which 45.1 kg was beef, making it the most-consumed meat category in the country (Instituto Nacional

de Carnes, 2024). Moreover, an earlier INAC study on meat consumption preferences ranked *asado* as the second most frequent beef cut in the national consumption basket, after minced beef, with a relative frequency of 80 percent (Costas et al., 2010).

Against this background, Law No. 20,024, passed by the Uruguayan Parliament, temporarily exempted from VAT only the beef rib cut locally known as *corte de asado de diez a trece costillas*, hereafter referred to as the treated product. The exemption applied to sales of fresh, chilled, or frozen beef, but only when the cut was prepared at a slaughterhouse or abattoir and duly individualized for final consumption. The measure came into effect on March 24, 2022, initially for 30 days, and was subsequently extended for an additional 30 days by Decree No. 128/022, so that the exemption remained in place for 60 days (República Oriental del Uruguay, 2022b,a).

The VAT exemption was introduced alongside broader efforts to contain meat prices across the supply chain. Contemporary press reports described parallel agreements between INAC, slaughterhouses, and retailers to stabilize the prices of bone-in beef cuts, as well as a reference retail price of around UYU 230 per kilogram for the treated *asado* cut. Authorities also emphasized that the tax benefit should reach final consumers rather than be absorbed by intermediaries. This distinction is important for the empirical analysis: the statutory tax exemption applied only to the treated *asado* cut, whereas other bone-in cuts were affected, if at all, by price agreements rather than by the VAT change itself.

To analyze the effect of the VAT exemption across the vertical supply chain, we use three administrative datasets from INAC containing information on beef cuts at different stages of the distribution chain. The first dataset records sales from slaughterhouses to downstream buyers. In the analysis, we split this dataset into two empirical samples according to the transaction destination: sales from slaughterhouses to distributors and sales from slaughterhouses to wholesale suppliers. The second dataset records sales

from distributors to wholesale suppliers. The third dataset contains prices charged to final consumers at the point of sale.

A key distinction is that the final-consumer dataset differs from the upstream transaction datasets. While the upstream datasets contain transaction-level information, including quantities and sales values, the final-consumer dataset records retail prices charged to final consumers, as self-reported by retail outlets to INAC. These data do not include quantities sold or transaction values. Therefore, the consumer-level analysis identifies price pass-through at the retail stage using reported retail prices, but it cannot be used to estimate quantity responses or final-consumer demand elasticities.

The three upstream empirical samples are observed weekly. They cover 30 weeks before the policy, 9 weeks during the policy window, and 30 weeks after the policy. The treatment window is defined to align with the 60-day VAT exemption as closely as possible on a weekly basis: it runs from event week 0 to event week 8. The consumer-level price sample is observed monthly and covers seven months before the policy, the treatment period of April and May 2022, and seven months after the policy. Thus, the analysis follows the policy through four empirical samples: slaughterhouse–distributor, slaughterhouse–wholesale supplier, distributor–wholesale supplier, and retail point–consumer.

Across all samples, the treated product is the beef rib cut locally known as *asado de diez a trece costillas* (product code 1127001), while the control product is *colita de cuadril* (product code 1124012). The treated product is a chilled bone-in beef cut, whereas the control product is a chilled boneless beef cut. The official descriptions and classifications of Uruguayan beef cuts are available in INAC's *Manual Uruguayo de Cortes Bovinos* (Instituto Nacional de Carnes, 2023). Table 1 describes the treatment and control products used throughout the analysis.

For the upstream samples, we observe sales values and quantities sold in kilograms,

Table 1: Treatment and Control Products

Group	Product code	Product description
Treated product	1127001	*Asado 10/13 costillas bovina enfriada con hueso*
Control product	1124012	*Colita de cuadril bovina enfriada sin hueso*

which allow us to construct unit values as a measure of prices. Specifically, the nominal unit price is defined as the ratio between the tax-inclusive sales value and the quantity sold. Let V_{ict} denote the sales value of seller i, cut c, and period t, and let Q_{ict} denote the corresponding quantity in kilograms. For the upstream samples, the nominal unit price is given by:

$$P_{ict}^{nom} = \frac{V_{ict}}{Q_{ict}}.$$

The final-consumer sample is different. In this case, we do not observe sales values or quantities. Instead, we observe retail prices charged to final consumers at the point of sale, as self-reported by retail outlets to INAC. Therefore, for the consumer sample, P_{ict}^{nom} corresponds directly to the reported retail price for point of sale i, cut c, and month t.

For all samples, we construct a real price measure by expressing nominal prices in pesos of October 2022:

$$P_{ict}^{real} = P_{ict}^{nom} \times \frac{CPI_{Oct.\ 2022}}{CPI_t}.$$

We also construct a standardized price measure:

$$P_{ict}^{std} = \frac{P_{ict}^{real} - \overline{P}_{c,pre}^{real}}{\overline{P}_{c,pre}^{real}},$$

where $\overline{P}_{c,pre}^{real}$ is the average real price of cut c in the pre-treatment period. This standardization allows us to compare price movements across cuts with different price levels.

For the upstream samples, we also construct a standardized traded-volume measure:

$$Q_{ict}^{std} = \frac{Q_{ict} - \overline{Q}_{c,pre}}{\overline{Q}_{c,pre}},$$

where $\overline{Q}_{c,pre}$ is the average traded volume of cut c in the pre-treatment period. This variable is only constructed for the upstream transaction datasets, since the final-consumer dataset does not report quantities sold.

Before constructing the final estimation panels, we remove outliers separately by cut and sample. The outlier rule is based on prices in levels. For each cut and sample, observations are removed if the price lies outside the median price for the corresponding period, plus or minus three standard deviations of the full price series for that cut. Table 2 reports the number of original observations, the number of observations after outlier removal, and the share of observations lost in each sample, while Table A.2 in Appendix A provides information on the standard deviation of prices in each sample. The share of observations removed is small in all cases, ranging from 1.11 percent in the consumer sample to 2.09 percent in the slaughterhouse–wholesale supplier sample.

Table 2: Outlier Cleaning

Sample	All observations			By product group		
	Original	Clean	Lost (%)	Group	Original	Clean
Slaughterhouse–Distributor	9,604	9,486	1.23	Treated	4,902	4,839
				Control	4,702	4,647
Slaughterhouse–Wholesale supplier	9,584	9,384	2.09	Treated	2,841	2,740
				Control	6,743	6,644
Distributor–Wholesale supplier	17,665	17,401	1.49	Treated	8,332	8,192
				Control	9,333	9,209
Retail point–Consumer	2,887	2,855	1.11	Treated	1,437	1,421
				Control	1,450	1,434

Notes: "Original" refers to the number of observations before outlier removal, and "Clean" refers to the number of observations after applying the outlier rule. The treated product is product code 1127001, *asado de diez a trece costillas*. The control product is product code 1124012, *colita de cuadril*. Outliers are removed separately by cut and sample using prices in levels.

After this cleaning step, we aggregate observations to construct the final estimation panels. In the slaughterhouse–distributor and slaughterhouse–wholesale supplier samples, each observation corresponds to a slaughterhouse–cut–week cell. In the distributor–wholesale supplier sample, each observation corresponds to a distributor–cut–week cell. For these upstream samples, when multiple transactions occur within a cell, sales values and quantities are aggregated before computing the unit value. In the consumer sample, each observation corresponds to a retail point–cut–month cell. Since this sample does not contain quantities, prices are aggregated using self-reported retail prices rather than quantity-weighted unit values. Table 3 below summarizes the structure of the resulting estimation samples.

Table 3: Sample Structure after Panel Construction

Sample	Treated obs.	Control obs.	Treated units	Control units	Common units
Slaughterhouse–Distributor	902	1,108	18	21	13
Slaughterhouse–Wholesale supplier	667	952	17	22	10
Distributor–Wholesale supplier	901	1,417	22	29	15
Retail point–Consumer	1,421	1,434	143	144	91

Notes: Treated observations correspond to product code 1127001, *asado de diez a trece costillas*. Control observations correspond to product code 1124012, *colita de cuadril*. Units are slaughterhouses in the first two samples, distributors in the distributor–wholesale supplier sample, and retail points in the consumer sample. Common units are those observed in the pre-treatment, treatment, and post-treatment periods.

Appendix A provides additional information about the dataset. Table A.1 reports outlier removal separately by treated and control group, and Table A.3 reports the number of observations after outlier cleaning. Finally, Table A.4 reports the number of units—slaughterhouses, distributors, or retail points—by treatment group and period.

3 Results

We use these datasets to study whether the VAT exemption was transmitted along the vertical supply chain. The analysis proceeds in two steps. First, we estimate the effect of the tax cut on prices at each stage of the chain: from slaughterhouses to distributors, from slaughterhouses to wholesale suppliers, from distributors to wholesale suppliers, and from retail points to final consumers. This allows us to examine where in the chain the price response emerges and whether the tax benefit reaches final consumers. Second, we study the response of quantities in the upstream transaction datasets, where traded volumes are observed. This is important because a price reduction may affect not only prices, but also the allocation of quantities across related beef cuts.

3.1 Price Responses Along the Supply Chain

For the price and quantity analyses, we estimate event-study specifications separately for each empirical sample and outcome. The baseline specification compares the treated cut, *asado de diez a trece costillas*, with the control cut, *colita de cuadril*, before, during, and after the VAT exemption. Let Y_{ict} denote the outcome for unit i, cut c, and period t, where the outcome is either the standardized real price or standardized traded volume. We estimate the following event-study specification:

$$Y_{ict} = \gamma_c + \delta_t + \sum_{k \neq -1} \beta_k \left(Treat_c \times \mathbf{1}\{e(t) = k\} \right) + \varepsilon_{ict},$$

where $Treat_c$ is an indicator for the treated cut, γ_c are cut fixed effects, δ_t are period fixed effects, and $e(t)$ denotes event time relative to the beginning of the VAT exemption. The omitted period is $k = -1$, the period immediately before the policy.

The coefficients β_k trace the evolution of the treated product relative to the control product around the policy window.

We also estimate a more saturated version of the same specification that includes market-agent fixed effects:

$$Y_{ict} = \mu_i + \gamma_c + \delta_t + \sum_{k \neq -1} \beta_k \left(Treat_c \times \mathbf{1}\{e(t) = k\} \right) + \varepsilon_{ict}.$$

This second specification absorbs time-invariant heterogeneity across slaughterhouses, distributors, or retail points, depending on the sample. In the tables below, columns with "Market-Agent FE = No" correspond to the first specification, while columns with "Market-Agent FE = Yes" correspond to the second specification.

We then summarize the average effect of the policy during the treatment window using a difference-in-differences specification that collapses the VAT-exemption period into a single indicator:

$$Y_{ict} = \gamma_c + \delta_t + \beta \left(Treat_c \times Exempt_t \right) + \varepsilon_{ict},$$

where $Exempt_t$ equals one during the VAT-exemption period and zero otherwise. The coefficient β measures the average change in the treated product relative to the control product during the policy window. As with the event-study specification, we also estimate a version including market-agent fixed effects:

$$Y_{ict} = \mu_i + \gamma_c + \delta_t + \beta \left(Treat_c \times Exempt_t \right) + \varepsilon_{ict}.$$

Estimating these equations separately for each stage of the supply chain provides a direct comparison of the price and quantity responses across upstream, intermediate, and downstream markets.

When interpreting the policy effect as tax pass-through, we compare the estimated

price reduction during the exemption period with the mechanical price change implied by the removal of the VAT burden. Under the Uruguayan VAT regime for beef cuts, the relevant tax wedge is not only the statutory 10 percent VAT. For cuts such as the treated product, the regime combines the 10 percent VAT on the upstream sale price with a VAT perception on a fictitious 20 percent retail margin. This implies a total tax wedge equivalent to 12 percent of the upstream sale price. Therefore, full pass-through of the exemption implies a reduction in the tax-inclusive price of

$$\frac{0.12}{1.12} = 0.1071.$$

Since the dependent variable is the standardized real price, the implied pass-through rate is computed as

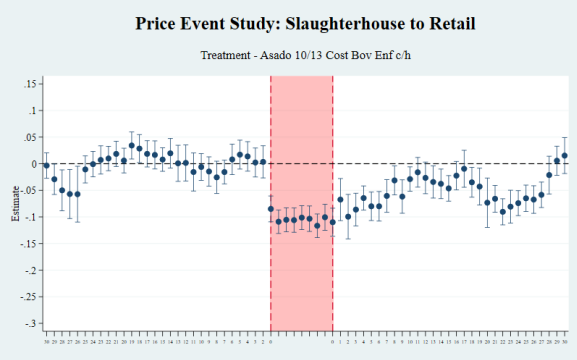
$$Pass\text{-}through = \frac{-\widehat{\beta}}{0.12/1.12}.$$

A value of one corresponds to full pass-through of the tax exemption to prices, values below one indicate incomplete pass-through, and values above one indicate over-shifting.

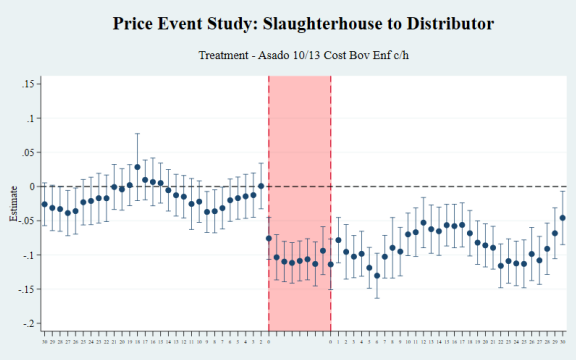
Figure 1 shows the evolution of prices for the treated cut along the vertical supply chain. Across the upstream and intermediate stages, prices fall sharply at the beginning of the VAT-exemption period. The decline is visible both in sales from slaughterhouses to distributors and wholesale suppliers, and in sales from distributors to wholesale suppliers. The timing of the drop is consistent with the implementation of the tax exemption and suggests that the policy affected prices early in the chain rather than only at the final retail stage.

The consumer-level panel shows a similar decline during the treatment period. Because these prices are self-reported by retail outlets to INAC and the dataset does not

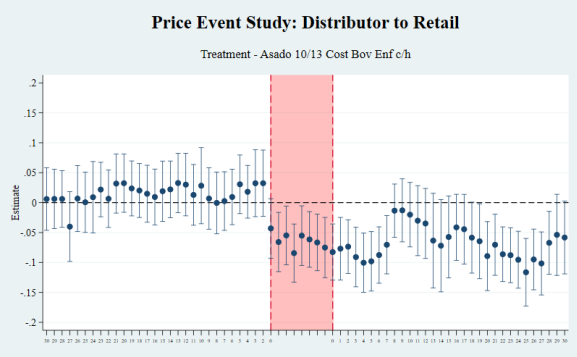
Figure 1: Price Event Studies for the Treated Product



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale

(d) Retail to Consumer

Notes: The figure reports event-study estimates for the treated beef cut, *asado de diez a trece costillas*, along the vertical supply chain. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. Panel (d) shows retail prices charged to final consumers, as self-reported by retail outlets to INAC. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

include quantities sold, the retail-stage evidence should be interpreted as evidence on reported consumer-price pass-through, not on final-consumer quantity responses. The estimated drop in retail prices is large and occurs precisely during the months covered by the exemption, indicating that at least part of the tax reduction reached final consumers. However, these figures report event-study estimates for the treated product only. They are useful for documenting the timing and magnitude of price movements, but the causal effect of the VAT cut is identified more directly in the difference-in-differences specifications that compare the treated cut with the control cut.

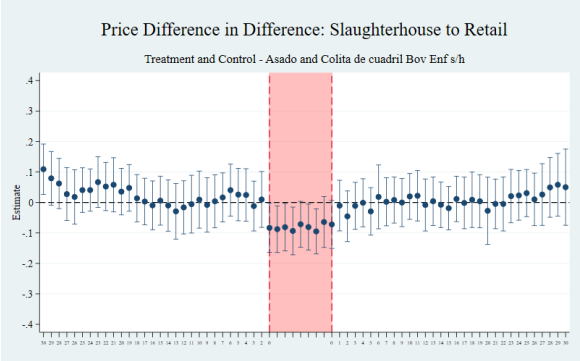
As a robustness check, Appendix B Figure B.1 repeats the event-study analysis for the treated product, restricting the sample to common units observed throughout the relevant periods. The pattern is very similar to the baseline results in Figure 1: prices of *asado de diez a trece costillas* fall sharply during the VAT-exemption period across all stages of the vertical supply chain.

Also, Figures B.2 and B.3 in Appendix B report the corresponding event-study estimates for the control product, *colita de cuadril*. These figures provide a benchmark for the evolution of prices of a non-treated beef cut over the same policy window, using both the full sample and the restricted sample of common units.

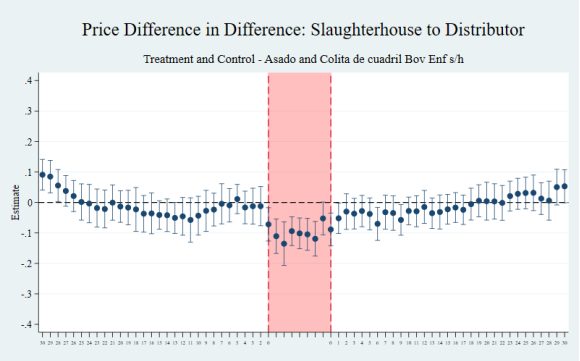
The event-study evidence above documents a sharp decline in the price of the treated cut during the VAT-exemption period. To distinguish this policy response from broader changes in beef prices, we next estimate a difference-in-differences specification comparing the treated cut with the control cut, *colita de cuadril*. This comparison allows us to net out common price movements affecting both products and provides a more direct estimate of the effect of the VAT exemption along the supply chain.

Figure 2 reports the difference-in-differences estimates for prices along the vertical supply chain. The estimates compare the evolution of the treated product, *asado de diez a trece costillas*, relative to the control product, *colita de cuadril*. Across the four

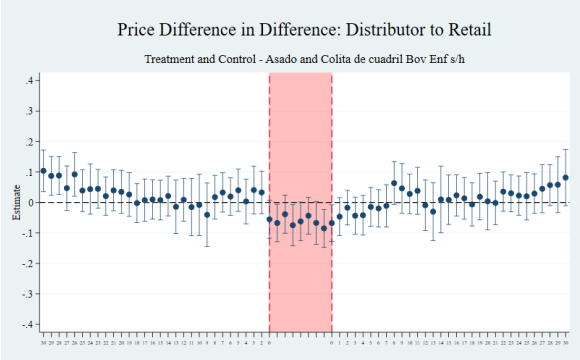
Figure 2: Price Difference-in-Differences Estimates



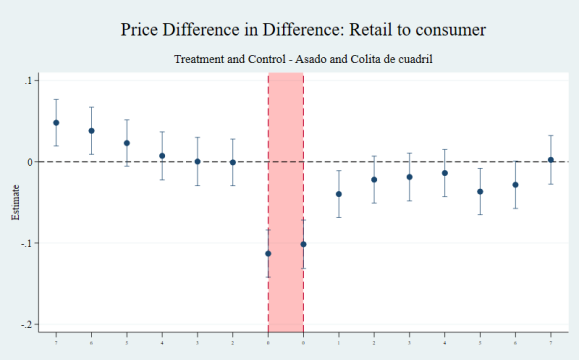
(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale



(d) Retail to Consumer

Notes: The figure reports difference-in-differences event-study estimates comparing the treated beef cut, *asado de diez a trece costillas*, with the control beef cut, *colita de cuadril*, along the vertical supply chain. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. Panel (d) shows retail prices charged to final consumers, as self-reported by retail outlets to INAC. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

stages, the coefficients fall sharply during the VAT-exemption period, indicating that the treated cut became cheaper relative to the control cut precisely when the tax cut was in place.

The decline is visible at the upstream stages, both from slaughterhouses to wholesale suppliers and from slaughterhouses to distributors, and it also appears in the intermediate stage from distributors to wholesale suppliers. This suggests that the price response was not confined to the final retail market, but emerged earlier in the supply chain.

The retail-to-consumer panel shows a comparable fall during the treatment period, consistent with at least partial pass-through of the VAT exemption to final consumers.

After the policy window, the estimates tend to move back toward zero, especially in the upstream and intermediate stages. This pattern is consistent with a temporary price response concentrated around the period in which the VAT exemption was active. The pre-treatment coefficients are generally close to zero, though not perfectly flat across all panels, so the event-study evidence should be read alongside the robustness exercises and the average treatment effects reported below.

As a robustness check, Appendix Figure B.4 repeats the difference-in-differences analysis restricting the sample to common units observed throughout the relevant periods.

To summarize the magnitude of the price response, we estimate a difference-in-differences specification that collapses the treatment window into a single post indicator. This specification corresponds to the average effect version of the event-study equation reported above. Specifically, we estimate the relative change in the price of the treated product, *asado de diez a trece costillas*, during the VAT-exemption period, using *colita de cuadril* as the control product. The coefficient of interest is the interaction between the treated-product indicator and the VAT-exemption-period indicator.

We estimate this specification separately for each stage of the vertical supply chain. For each stage, we report two specifications: one including product and event-time fixed effects, and another adding market-agent fixed effects. The dependent variable is the standardized real price. When interpreting the coefficient as tax pass-through, we compare the estimated price reduction with the mechanical reduction implied by the removal of the relevant VAT burden. Under the Uruguayan VAT regime for beef cuts, this burden combines the statutory 10 percent VAT with the VAT perception on a fictitious 20 percent retail margin, yielding a total tax wedge equivalent to 12 percent

of the upstream sale price. Therefore, full pass-through implies a reduction in the tax-inclusive price of $0.12/1.12 = 10.71$ percent. We report the implied pass-through rate obtained by dividing the estimated price reduction by this benchmark.

Table 4: VAT Exemption Pass-Through Along the Supply Chain

	Slaughterhouse to Wholesale		Slaughterhouse to Distributor		Distributor to Wholesale		Retail to Consumer	
Dependent Variable: Standardized Price	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment Effect	-0.088***	-0.086***	-0.094***	-0.097***	-0.106***	-0.099***	-0.107***	-0.105***
	(0.017)	(0.013)	(0.010)	(0.008)	(0.009)	(0.007)	(0.014)	(0.011)
Implied Pass-Through Rate	82.1%	80.3%	87.7%	90.5%	98.9%	92.4%	99.9%	98.0%
Cut FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Event-Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market-Agent FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,619	1,618	2,010	2,010	2,318	2,318	2,855	2,853
R^2	0.160	0.577	0.212	0.645	0.173	0.552	0.098	0.649
Within R^2	0.018	0.034	0.032	0.073	0.041	0.064	0.024	0.057

Notes: The table reports estimates of the average treatment effect during the VAT-exemption period from the difference-in-differences specification. The treatment effect corresponds to the coefficient on the interaction between the treated product, *asado de diez a trece costillas*, and the VAT-exemption period. The control product is *colita de cuadril*. The dependent variable is the standardized real price. The implied pass-through rate is computed as

$$-\hat{\beta}/(0.12/1.12),$$

where $0.12/1.12 = 0.1071$ is the mechanical percentage reduction in the tax-inclusive price implied by the removal of the relevant VAT burden under full pass-through. This benchmark reflects the Uruguayan VAT regime for beef cuts, under which the relevant tax wedge combines the statutory 10 percent VAT and the VAT perception on a fictitious 20 percent retail margin. Heteroskedasticity-robust standard errors are reported in parentheses. Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 4 reports the average treatment effects associated with the difference-in-differences specification introduced above. In this exercise, the coefficient of interest is the interaction between the treated product and the VAT-exemption period. Since the dependent variable is the standardized real price, the coefficient can be interpreted as the average price change of *asado de diez a trece costillas* relative to *colita de cuadril* during the policy window. We estimate the equation separately for each stage of the vertical supply chain and report two specifications per stage: one including cut and event-time fixed effects, and another adding market-agent fixed effects.

The estimates show a large and statistically significant reduction in the relative

price of the treated cut during the VAT-exemption period at every stage of the supply chain. The estimated effects range from 8.6 to 10.7 percent, depending on the stage and specification. These magnitudes are economically large and close to the mechanical price reduction implied by full pass-through once the specific VAT regime for beef products is taken into account. Under this regime, the relevant tax wedge for cuts such as the treated product is not simply the statutory 10 percent VAT. Instead, it combines the 10 percent VAT on the upstream sale price with the VAT perception on a fictitious 20 percent retail margin, yielding a total tax wedge equivalent to 12 percent of the upstream sale price. Removing this wedge implies a mechanical reduction in the tax-inclusive upstream price of $0.12/1.12 = 10.71$ percent under full pass-through.

Using this benchmark, the implied pass-through rates range from about 80 percent in sales from slaughterhouses to wholesale suppliers to about 100 percent at the distributor-to-wholesale and retail-to-consumer stages. More specifically, pass-through is incomplete but substantial in the first two stages of the chain, ranging from roughly 80 to 91 percent, while it is close to full in the distributor-to-wholesale and retail-to-consumer stages, ranging from roughly 92 to 100 percent. Overall, the results suggest that the VAT exemption was largely passed through to prices, with evidence of substantial upstream pass-through and nearly complete downstream pass-through.

Because the control product may also be affected by substitution spillovers, these estimates should be interpreted as conservative measures of the treated product's own-price effect. Appendix C shows formally that, under product substitutability and a weakly negative price spillover on the control product, the price difference-in-differences estimates are lower bounds in absolute value for the true own-price reduction and for the corresponding pass-through rate.

3.2 Quantity Responses Along the Supply Chain

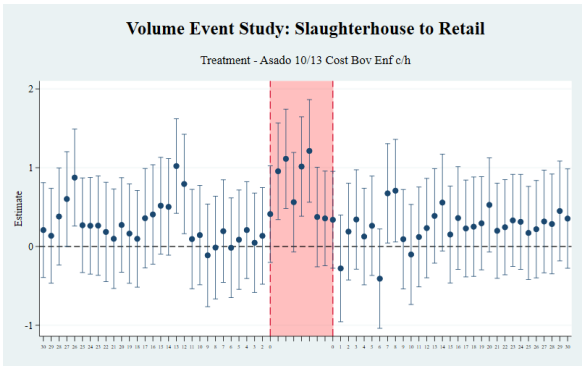
The price results indicate that the VAT exemption led to a sizable reduction in the relative price of the treated product T across the supply chain. We now examine whether this price reduction was accompanied by changes in traded quantities. This margin is important because the policy may have affected not only the prices paid at each stage, but also the allocation of beef cuts across the chain.

The quantity analysis is restricted to the upstream transaction datasets, where we observe both sales values and quantities sold in kilograms. The final-consumer dataset is not included in this part of the analysis because it contains only reported retail prices and does not include quantities sold. Therefore, the quantity results cover three stages of the supply chain: slaughterhouse to wholesale supplier, slaughterhouse to distributor, and distributor to wholesale supplier.

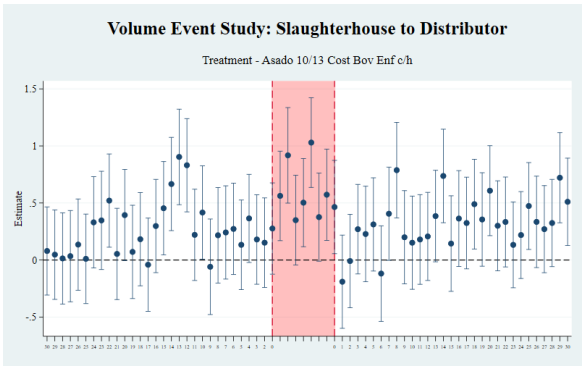
We estimate the same difference-in-differences specification used in the price analysis, replacing the dependent variable with traded quantities. The coefficient of interest is again the interaction between the treated product and the VAT-exemption period. It measures the change in quantities of the treated product T relative to the control product C during the policy window. Since T and C are related beef cuts, this comparison captures both the direct expansion in the traded volume of the treated product and any reallocation away from the control product.

Figure 3 reports the event-study estimates for traded volumes of the treated product T along the upstream stages of the supply chain. The evidence shows a clear increase in traded quantities during the VAT-exemption window. Across the three samples, the coefficients rise sharply during the treatment period and are positive in most treatment weeks. The response is particularly visible in the slaughterhouse–distributor and distributor–wholesale supplier samples, suggesting that the temporary reduction in the

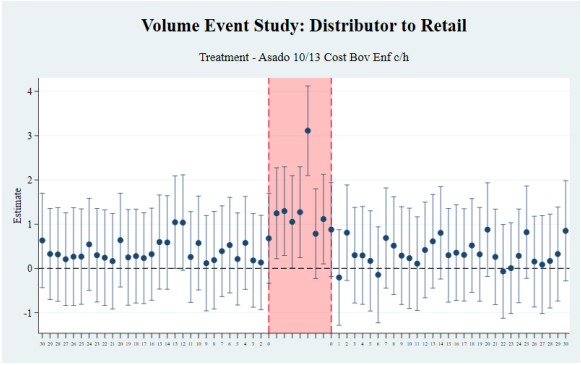
Figure 3: Volume Event Studies for the Treated Product



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale

Notes: The figure reports event-study estimates for traded volumes of the treated beef cut, *asado de diez a trece costillas*, along the upstream stages of the vertical supply chain. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals. The retail-to-consumer stage is not included because the final-consumer dataset contains reported retail prices but does not contain quantities sold.

tax-inclusive cost of the treated cut was accompanied by a substantial expansion in traded volumes along the chain.

The dynamic pattern is consistent with a demand response to the temporary price reduction documented above. In the weeks preceding the policy, the coefficients are somewhat noisy, but they do not display a comparable discrete increase exactly around the treatment window. During the exemption period, by contrast, the estimates become systematically positive and economically larger. After the policy expires, the coefficients decline relative to the treatment window, although some positive estimates remain in subsequent weeks. This persistence may reflect gradual adjustment in orders, inventories, or supply-chain relationships after the temporary tax exemption ended.

These quantity event studies should be interpreted as upstream traded-volume responses, not as final-consumer quantity responses. As discussed in the data section, the final-consumer dataset contains reported retail prices but does not include quantities sold. Therefore, the quantity evidence is restricted to the stages where transaction volumes are observed: slaughterhouse to wholesale supplier, slaughterhouse to distributor, and distributor to wholesale supplier.

Appendix B provides three additional sets of figures that help interpret these results. First, Figure B.5 shows that the increase in treated-product quantities is robust to restricting the sample to common units observed before, during, and after the policy period. Second, Figures B.6 and B.7 report the corresponding event studies for the control product C. These figures show that quantities of the control product do not increase during the VAT-exemption window and, in several stages, decline relative to the pre-treatment period. This pattern is consistent with substitution or reallocation away from the control cut and toward the treated cut during the policy window.

Taken together, the event-study evidence suggests that the VAT exemption affected not only prices but also quantities traded along the supply chain. The treated prod-

uct experienced a clear increase in trading volume, while the control product either remained flat or declined over the same period. This is important for interpreting the difference-in-differences estimates of quantities: the estimated relative effect combines an expansion in the treated product with a potential contraction in the control product. Therefore, the quantity estimates should be read as evidence of relative demand reallocation among related beef cuts, rather than as a pure own-quantity response of the treated product.

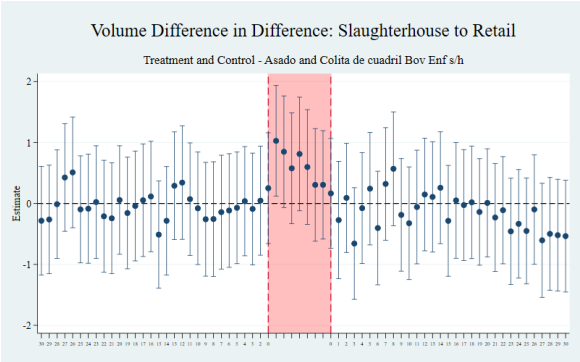
To examine the timing of the quantity response, we complement the average difference-in-differences estimates with a dynamic event-study specification. The estimates compare the evolution of traded volumes for the treated product T relative to the control product C, using the week immediately before the VAT exemption as the omitted reference period.

As in the quantity analysis above, this exercise is restricted to the upstream transaction datasets, where quantities sold in kilograms are observed. The retail-to-consumer stage is excluded because the final-consumer dataset reports prices but does not contain quantities. Figure 4 reports the dynamic difference-in-differences estimates for the three upstream stages of the supply chain.

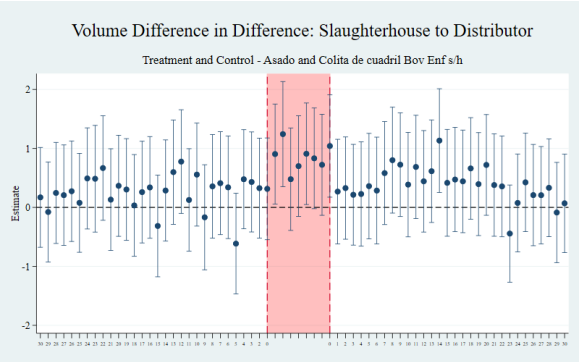
Figure 4 shows that traded volumes of the treated product increased relative to the control product during the VAT-exemption window. Across the three upstream stages, the coefficients become systematically positive during the treatment period, indicating that the reduction in the relative price of T was accompanied by a relative expansion in its traded quantities.

The effect is visible in all three segments of the chain. In sales from slaughterhouses to wholesale suppliers, the coefficients rise during the exemption window and then decline after the policy expires. In sales from slaughterhouses to distributors, the increase is more pronounced and remains positive throughout the treatment period. In sales

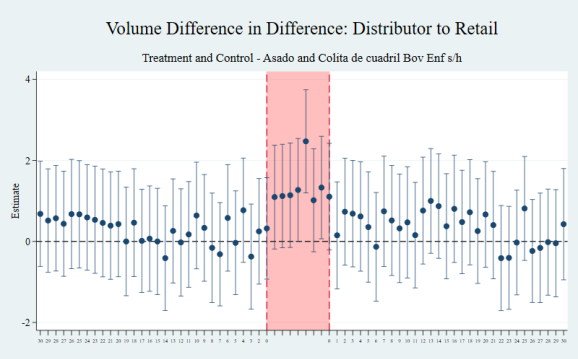
Figure 4: Volume Difference-in-Differences Event Studies



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale

Notes: The figure reports dynamic difference-in-differences estimates for traded volumes of the treated product relative to the control product along the upstream stages of the supply chain. The treated product is *asado de diez a trece costillas*, and the control product is *colita de cuadril*. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals. The retail-to-consumer stage is excluded because the final-consumer dataset reports prices but not quantities sold.

from distributors to wholesale suppliers, the dynamic response is also positive during the exemption window, consistent with downstream reallocation toward the treated cut.

The pre-treatment coefficients are somewhat noisy, reflecting the volatility of traded quantities in these markets. However, the treatment-period estimates display a clear discrete increase relative to the weeks immediately before the policy. This pattern supports the interpretation that the VAT exemption affected not only prices but also quantities traded along the supply chain.

These estimates should be interpreted as relative quantity effects. They combine an increase in the traded volume of the treated product with any simultaneous change in the traded volume of the control product. Therefore, the results are consistent with demand reallocation across related beef cuts: the temporary tax exemption lowered the relative price of T, increased its traded quantities, and reduced or weakened the relative performance of C.

The same substitution mechanism also affects the interpretation of the quantity estimates. Appendix C shows that, when the policy reallocates demand away from the control product, the quantity difference-in-differences coefficients should be interpreted as upper bounds for the true own-quantity response of the treated product.

Appendix B reports robustness exercises based on the same dynamic difference-in-differences specification but restricting the sample to common units observed before, during, and after the policy period. The results in Figure B.8 are qualitatively similar, indicating that the main quantity response is not driven by changes in sample composition across periods.

The event-study evidence suggests that the VAT exemption generated a visible increase in traded volumes of the treated product T relative to the control product C during the policy window. We now summarize this response using the average difference-

in-differences specification. As in the price analysis, the coefficient of interest is the interaction between the treated product and the VAT-exemption period.

The quantity analysis is restricted to the upstream transaction datasets, where quantities sold in kilograms are observed. The final-consumer stage is excluded because the retail dataset reports prices paid by consumers but does not include quantities sold. The dependent variable is standardized traded volume, defined relative to the pre-treatment average volume of each cut. Therefore, the estimated coefficients measure changes in traded volumes relative to pre-treatment average volumes, comparing the treated product T to the control product C.

Table 5 reports the estimated average effects on traded volumes along the upstream stages of the supply chain.

Table 5: Effect of the VAT Exemption on Traded Volumes Along the Supply Chain

	Slaughterhouse to Wholesale		Slaughterhouse to Distributor		Distributor to Wholesale	
Dependent Variable: Standardized Volume	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Effect	0.602*	0.631***	0.433***	0.477***	1.030***	0.891***
	(0.313)	(0.149)	(0.158)	(0.122)	(0.349)	(0.243)
Implied Volume Change	60.2%	63.1%	43.3%	47.7%	103.0%	89.1%
Cut FE	Yes	Yes	Yes	Yes	Yes	Yes
Event-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Market-Agent FE	No	Yes	No	Yes	No	Yes
Observations	1,619	1,618	2,010	2,010	2,318	2,318
R^2	0.022	0.776	0.045	0.420	0.036	0.595
Within R^2	0.004	0.018	0.005	0.009	0.008	0.014

Notes: The table reports estimates of the average treatment effect on traded volumes during the VAT-exemption period from the difference-in-differences specification. The treatment effect corresponds to the coefficient on the interaction between the treated product, *asado de diez a trece costillas*, and the VAT-exemption period. The control product is *colita de cuadril*. The dependent variable is standardized traded volume, defined relative to the pre-treatment average volume of each cut. Therefore, the treatment-effect coefficients can be interpreted as changes relative to pre-treatment average volumes. The analysis is restricted to upstream transaction datasets because quantities sold are not observed in the final-consumer price dataset. Heteroskedasticity-robust standard errors are reported in parentheses. Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

The results show a large and statistically significant increase in traded volumes of

the treated product relative to the control product during the VAT-exemption period. The estimated effects are positive across all stages of the upstream supply chain and across both specifications. In sales from slaughterhouses to wholesale suppliers, traded volumes increase by approximately 60 to 63 percent relative to pre-treatment average volumes. In sales from slaughterhouses to distributors, the estimated increase is between 43 and 48 percent. The largest response appears in sales from distributors to wholesale suppliers, where the estimated effect ranges from 89 to 103 percent.

The estimates remain positive and statistically significant after adding market-agent fixed effects. This is important because the specification with market-agent fixed effects compares changes within the same slaughterhouse or distributor over time, reducing concerns that the results are driven by changes in the composition of sellers active during the policy window. The magnitudes are somewhat smaller in the distributor-to-wholesale sample once these fixed effects are included, but the effect remains economically large.

Overall, the quantity results indicate that the VAT exemption affected not only prices but also traded volumes. The reduction in the relative price of T was accompanied by a sizable relative expansion in the quantities traded of the treated cut along the upstream supply chain. Since the estimates are obtained relative to the control product C, they should be interpreted as relative quantity effects: they capture both the increase in traded volumes of T and any contemporaneous weakening or decline in traded volumes of C. This pattern is consistent with an upstream traded-volume response and with reallocation across related beef cuts. Because the final-consumer dataset does not include quantities, these estimates should not be interpreted as direct evidence of final-consumer demand elasticities.

4 Conclusion

This paper studies the effects of a temporary VAT exemption in Uruguay's beef market. The policy created a short-lived, targeted tax shock on a specific beef cut, allowing us to trace price transmission along the vertical supply chain and study quantity responses in upstream transactions. Using INAC data, we compare the treated cut to a related untreated control cut across sales from slaughterhouses to wholesale suppliers, from slaughterhouses to distributors, from distributors to wholesale suppliers, and retail prices charged to final consumers.

The results show that the VAT exemption was largely passed through to prices. The relative price of the treated cut fell at every stage of the supply chain, with estimated effects ranging from 8.6 to 10.7 percent. Once the specific Uruguayan VAT regime for beef products is taken into account, these estimates imply pass-through rates of roughly 80 to 100 percent. Pass-through is substantial in the upstream stages and close to complete in the downstream stages.

We also find that the policy affected quantities traded along the upstream supply chain. Relative to the control cut, the treated product's traded volumes increased sharply during the exemption period. The estimated quantity effects range from 43 to 63 percent in sales from slaughterhouses to downstream buyers and from 89 to 103 percent in sales from distributors to wholesale suppliers. These responses indicate that the policy not only reduced prices but also changed the allocation of quantities across related beef cuts.

The dynamic evidence reinforces this interpretation. Price reductions and quantity increases are concentrated during the VAT-exemption window and partially revert after the tax returns to its original level. This pattern is consistent with a temporary policy shock that was transmitted through the chain but did not permanently alter relative

prices or quantities.

The findings contribute to the literature on tax pass-through in three ways. First, they provide evidence on both the introduction and expiration of a temporary tax cut. Second, they trace pass-through across several stages of a vertically linked market, rather than only at the consumer level. Third, they show that tax pass-through can generate sizable quantity reallocations across related products. This last point is important: when products are substitutes, the estimated effect on the treated product should be interpreted not only as a pure own-price response but also as part of a broader reallocation of demand within the product category.

The results also have policy implications. Temporary consumption tax cuts can reduce consumer prices when they are transmitted along the supply chain, but the extent of pass-through depends on the institutional details of the tax regime and on the structure of the market. In the Uruguayan beef market, the exemption was largely transmitted to prices and generated a strong quantity response. However, the policy was targeted to a specific product, so its effects should be interpreted as changes in relative prices and quantities within the beef market rather than as evidence of a broad reduction in inflation.

Finally, the analysis has two limitations. First, final-consumer data contain retail prices self-reported by retail outlets to INAC, but not quantities sold, so quantity responses can only be studied in upstream transactions. Second, the estimates compare the treated cut to a related control cut, which is useful for identification but also means that the quantity effects capture relative reallocation between products. Future work could extend this analysis by using household-level purchase data or scanner data to directly measure final-consumer substitution patterns.

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Supporting Information
(Online Appendix)

A Additional Tables

Table A.1: Outlier Removal by Product Group

Sample	Group	Product code	Original obs.	Clean obs.	Lost (%)
Slaughterhouse–Distributor	Treated	1127001	4,902	4,839	1.29
Slaughterhouse–Distributor	Control	1124012	4,702	4,647	1.17
Slaughterhouse–Wholesale supplier	Treated	1127001	2,841	2,740	3.56
Slaughterhouse–Wholesale supplier	Control	1124012	6,743	6,644	1.47
Distributor–Wholesale supplier	Treated	1127001	8,332	8,192	1.68
Distributor–Wholesale supplier	Control	1124012	9,333	9,209	1.33
Retail point–Consumer	Treated	1127001	1,437	1,421	1.11
Retail point–Consumer	Control	1124012	1,450	1,434	1.10

Notes: "Original obs." refers to the number of observations before outlier removal, and "Clean obs." refers to the number of observations after applying the outlier rule. The treated product is product code 1127001, *asado de diez a trece costillas*. The control product is product code 1124012, *colita de cuadril*. Outliers are removed separately by cut and sample using prices in levels.

Table A.2: Standard Deviations Used in the Outlier Rule

Sample	Treated product SD	Control product SD
Slaughterhouse–Distributor	29.37	40.75
Slaughterhouse–Wholesale supplier	54.55	46.00
Distributor–Wholesale supplier	37.79	49.23
Retail point–Consumer	46.26	53.42

Notes: The table reports the standard deviations used in the outlier rule. For each cut and sample, observations are removed when prices lie outside the median price in the corresponding period plus or minus three standard deviations of the full price series for that cut.

Table A.3: Effective Panel Observations by Period

Sample	Group	Pre-treatment	Treatment	Post-treatment	Total
Slaughterhouse–Distributor	Treated	381	121	400	902
Slaughterhouse–Distributor	Control	500	141	467	1,108
Slaughterhouse–Wholesale supplier	Treated	290	85	292	667
Slaughterhouse–Wholesale supplier	Control	425	121	406	952
Distributor–Wholesale supplier	Treated	393	138	370	901
Distributor–Wholesale supplier	Control	608	184	625	1,417
Retail point–Consumer	Treated	633	170	618	1,421
Retail point–Consumer	Control	632	174	628	1,434

Notes: For the weekly samples, the treatment period corresponds to event weeks 0 to 8. For the consumer sample, the treatment period corresponds to event months 0 and 1, April and May 2022. The table reports the effective panel observations used in the estimations after outlier removal and aggregation.

Table A.4: Number of Units by Period

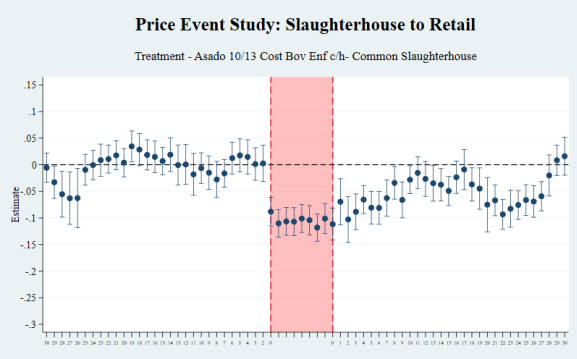
Sample	Group	Pre-treatment	Treatment	Post-treatment	Total
Slaughterhouse–Distributor	Treated	15	15	18	18
Slaughterhouse–Distributor	Control	20	19	21	21
Slaughterhouse–Distributor	Common units	14	14	17	13
Slaughterhouse–Wholesale supplier	Treated	14	11	15	17
Slaughterhouse–Wholesale supplier	Control	20	16	19	22
Slaughterhouse–Wholesale supplier	Common units	13	10	13	10
Distributor–Wholesale supplier	Treated	21	19	17	22
Distributor–Wholesale supplier	Control	26	24	25	29
Distributor–Wholesale supplier	Common units	19	17	17	15
Retail point–Consumer	Treated	130	98	123	143
Retail point–Consumer	Control	132	99	124	144
Retail point–Consumer	Common units	128	96	122	91

Notes: Units are slaughterhouses in the first two samples, distributors in the distributor–wholesale supplier sample, and points of sale in the consumer sample. The "Common units" row reports the number of units observed in each period and, in the final column, the number of units observed in all three periods.

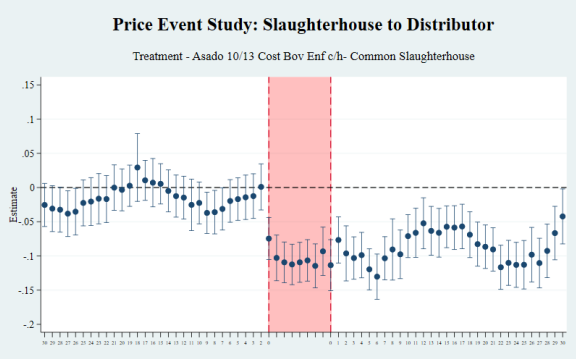
B Additional Figures

B.1 Price Event Studies

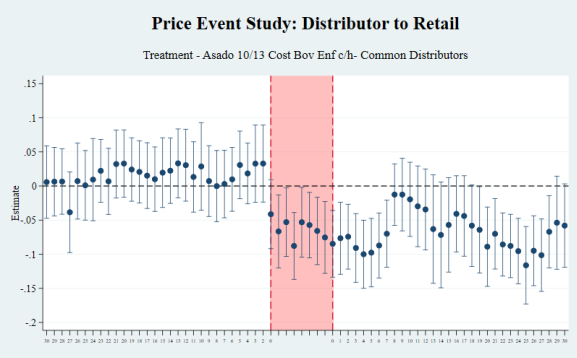
Figure B.1: Price Event Studies for the Treated Product: Common Units



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor

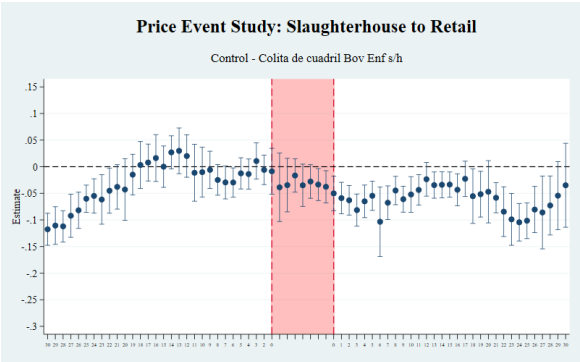


(c) Distributor to Wholesale

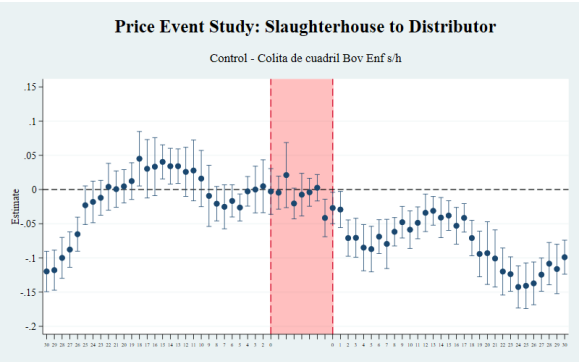
(d) Retail to Consumer

Notes: The figure reports event-study estimates for the treated beef cut, *asado de diez a trece costillas*, along the vertical supply chain, restricting the sample to common units observed throughout the relevant periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers using the sample of common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors using the sample of common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers using the sample of common distributors. Panel (d) shows prices charged to final consumers using the sample of retail points observed throughout the period. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

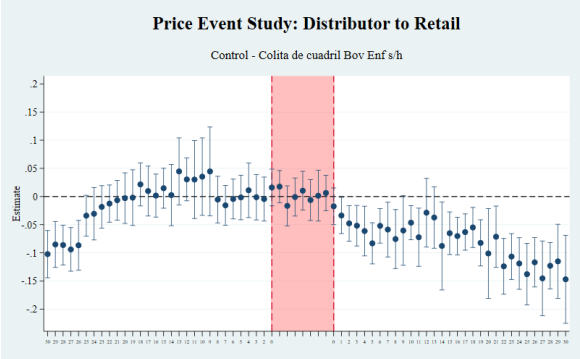
Figure B.2: Price Event Studies for the Control Product



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor

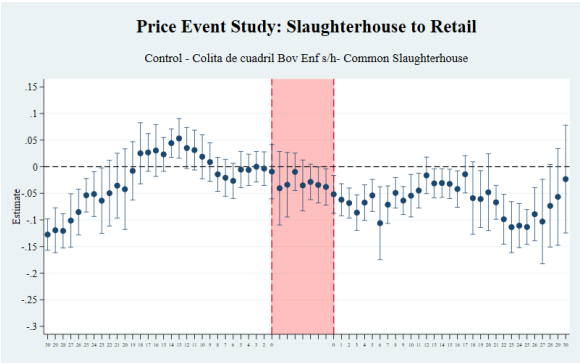


(c) Distributor to Wholesale

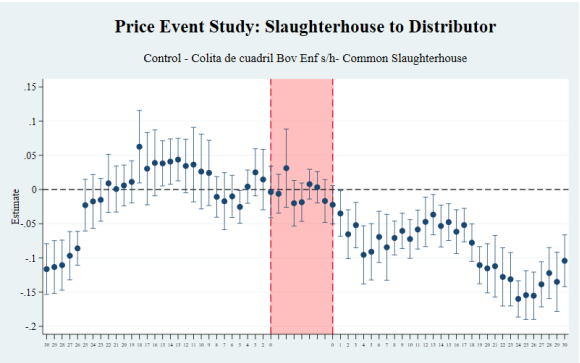
(d) Retail to Consumer

Notes: The figure reports event-study estimates for the control beef cut, *colita de cuadril*, along the vertical supply chain. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. Panel (d) shows retail prices charged to final consumers, as self-reported by retail outlets to INAC. The shaded area marks the VAT-exemption period for the treated product. Points represent estimated coefficients, and vertical lines report confidence intervals.

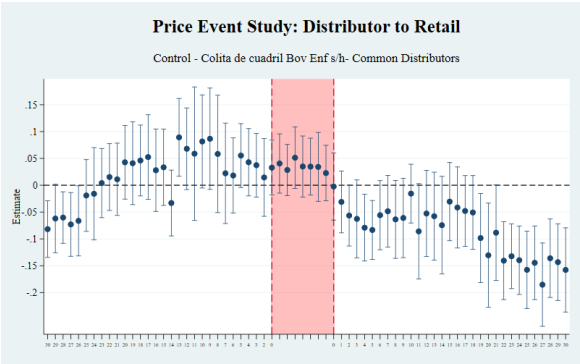
Figure B.3: Price Event Studies for the Control Product: Common Units



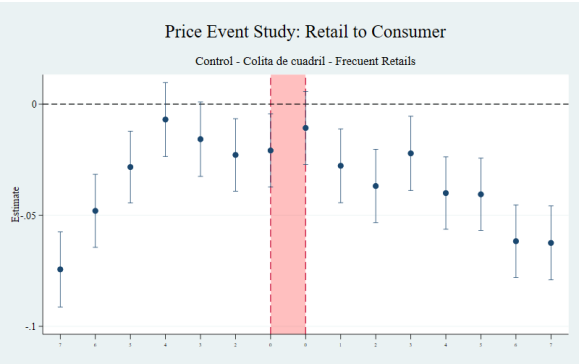
(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale

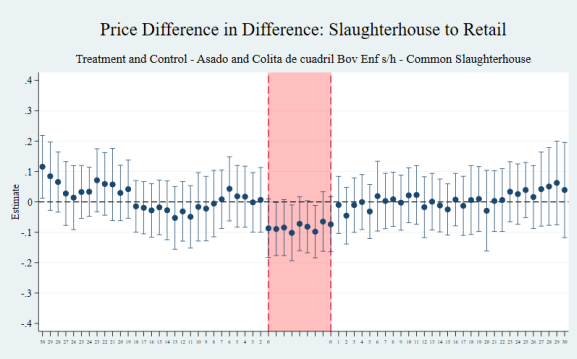


(d) Retail to Consumer

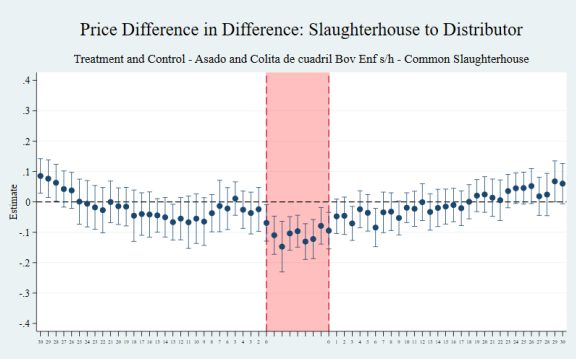
Notes: The figure reports event-study estimates for the control beef cut, *colita de cuadril*, along the vertical supply chain, restricting the sample to common units observed throughout the relevant periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers using the sample of common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors using the sample of common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers using the sample of common distributors. Panel (d) shows prices charged to final consumers using the sample of retail points observed throughout the period. The shaded area marks the VAT-exemption period for the treated product. Points represent estimated coefficients, and vertical lines report confidence intervals.

B.2 Price Difference-in-Differences Robustness

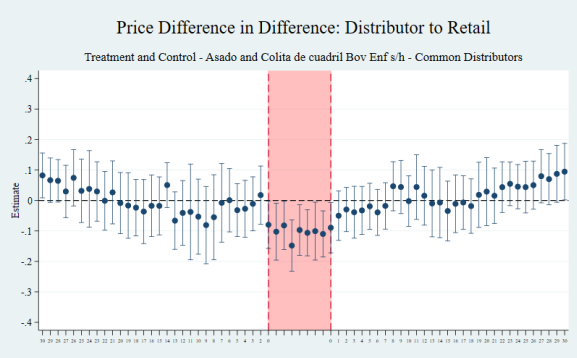
Figure B.4: Price Difference-in-Differences Estimates: Common Units



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



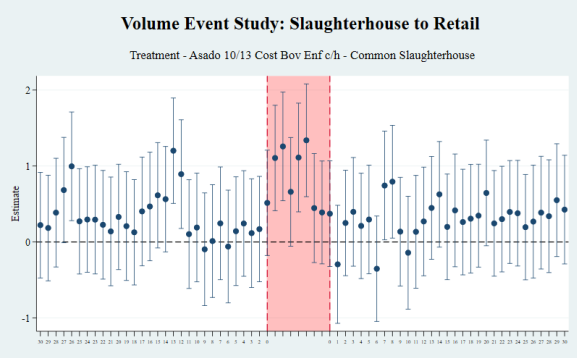
(c) Distributor to Wholesale

(d) Retail to Consumer

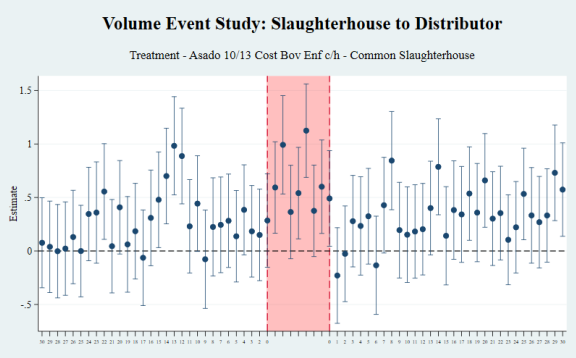
Notes: The figure reports difference-in-differences event-study estimates comparing the treated beef cut, *asado de diez a trece costillas*, with the control beef cut, *colita de cuadril*, along the vertical supply chain, restricting the sample to common units observed throughout the relevant periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers using the sample of common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors using the sample of common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers using the sample of common distributors. Panel (d) shows prices charged to final consumers using the sample of retail points observed throughout the period. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

B.3 Volume Event Studies

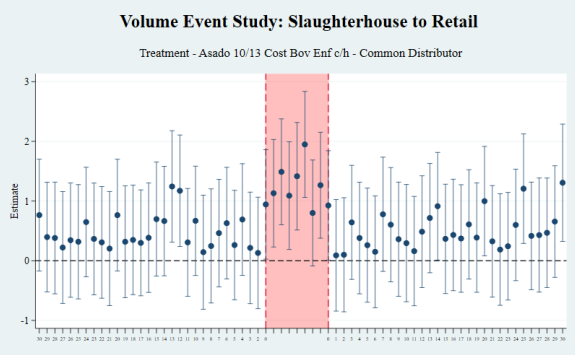
Figure B.5: Volume Event Studies for the Treated Product: Common Units



(a) Slaughterhouse to Wholesale



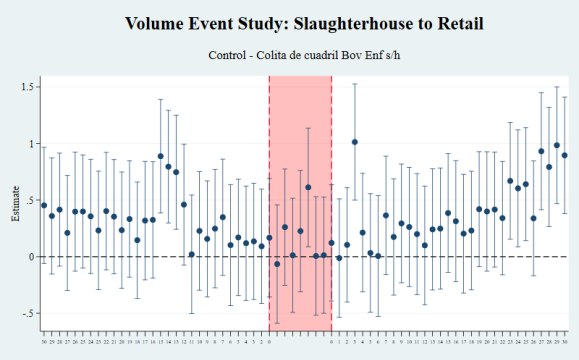
(b) Slaughterhouse to Distributor



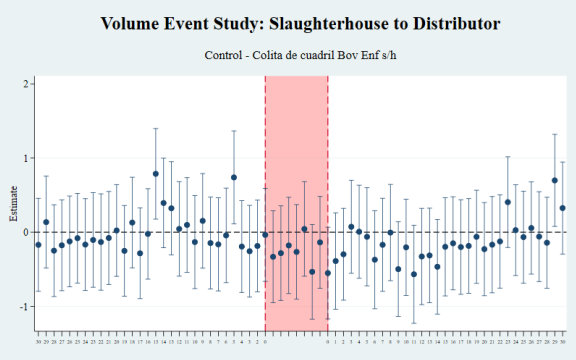
(c) Distributor to Wholesale

Notes: The figure reports event-study estimates for traded volumes of the treated beef cut, *asado de diez a trece costillas*, along the upstream stages of the vertical supply chain. The sample is restricted to common units, defined as units observed in the pre-treatment, treatment, and post-treatment periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers, restricting the sample to common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors, restricting the sample to common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers, restricting the sample to common distributors. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

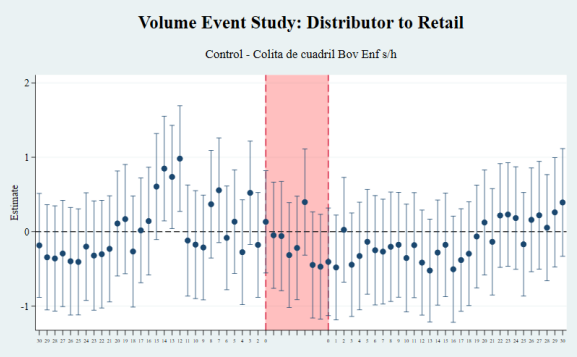
Figure B.6: Volume Event Studies for the Control Product



(a) Slaughterhouse to Wholesale



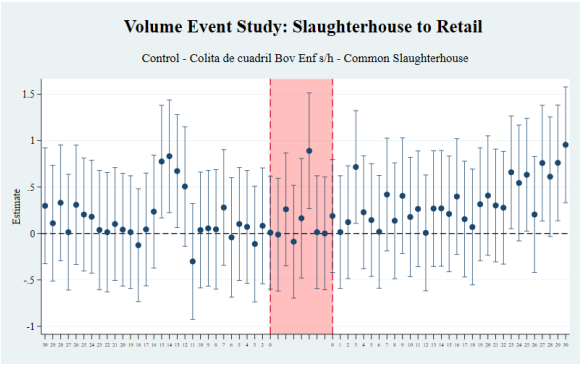
(b) Slaughterhouse to Distributor



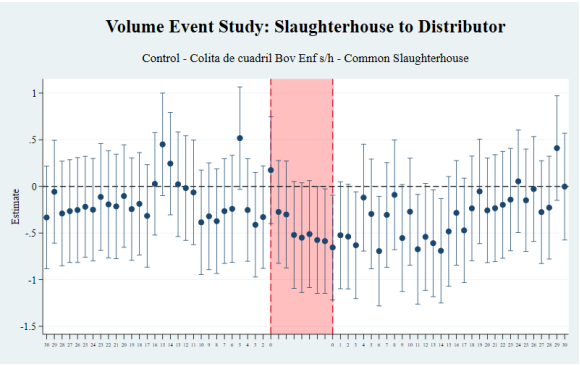
(c) Distributor to Wholesale

Notes: The figure reports event-study estimates for traded volumes of the control beef cut, *colita de cuadril*, along the upstream stages of the vertical supply chain. Panel (a) shows sales from slaughterhouses to wholesale suppliers. Panel (b) shows sales from slaughterhouses to distributors. Panel (c) shows sales from distributors to wholesale suppliers. The shaded area marks the VAT-exemption period for the treated product. Points represent estimated coefficients, and vertical lines report confidence intervals.

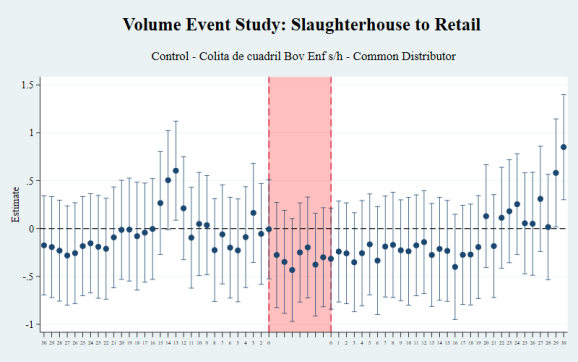
Figure B.7: Volume Event Studies for the Control Product: Common Units



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor

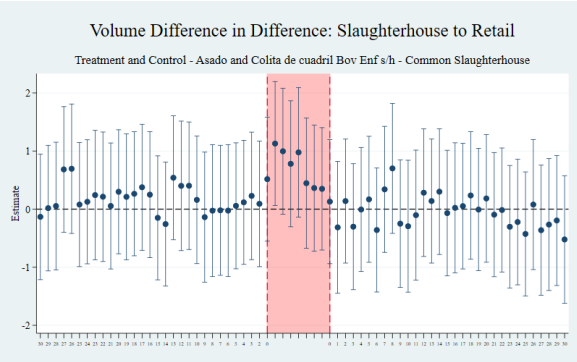


(c) Distributor to Wholesale

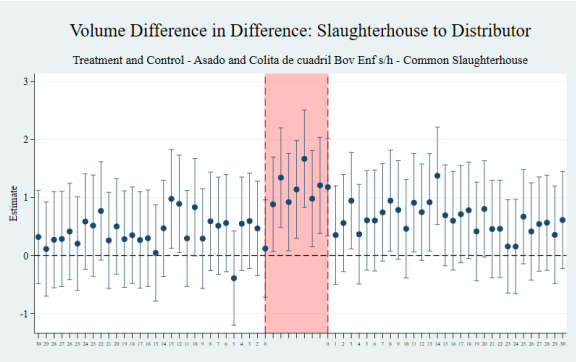
Notes: The figure reports event-study estimates for traded volumes of the control beef cut, *colita de cuadril*, along the upstream stages of the vertical supply chain. The sample is restricted to common units, defined as units observed in the pre-treatment, treatment, and post-treatment periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers, restricting the sample to common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors, restricting the sample to common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers, restricting the sample to common distributors. The shaded area marks the VAT-exemption period for the treated product. Points represent estimated coefficients, and vertical lines report confidence intervals.

B.4 Volume Difference-in-Differences Robustness

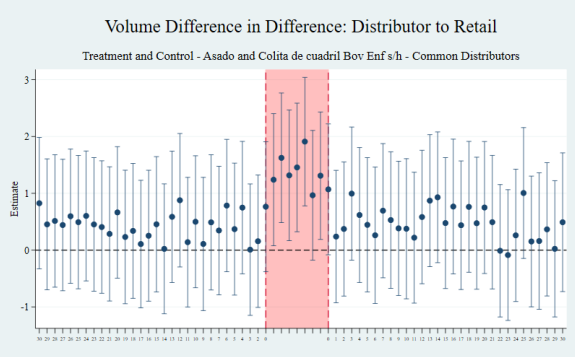
Figure B.8: Volume Difference-in-Differences Event Studies: Common Units



(a) Slaughterhouse to Wholesale



(b) Slaughterhouse to Distributor



(c) Distributor to Wholesale

Notes: The figure reports dynamic difference-in-differences estimates for traded volumes of the treated product relative to the control product along the upstream stages of the supply chain. The sample is restricted to common units, defined as units observed in the pre-treatment, treatment, and post-treatment periods. Panel (a) shows sales from slaughterhouses to wholesale suppliers, restricting the sample to common slaughterhouses. Panel (b) shows sales from slaughterhouses to distributors, restricting the sample to common slaughterhouses. Panel (c) shows sales from distributors to wholesale suppliers, restricting the sample to common distributors. The shaded area marks the VAT-exemption period. Points represent estimated coefficients, and vertical lines report confidence intervals.

C Interpreting Difference-in-Differences Estimates as Bounds

Our analysis is structured around two horizontally related products: the treated product, denoted by T, and the control product, denoted by C. Because these products are partial substitutes, a policy-induced change in the price of T may affect not only the quantity and price of T, but also the equilibrium quantity and price of C. This appendix shows how such spillovers affect the interpretation of the difference-in-differences estimates.

The representation below corresponds to specifications with market-agent fixed effects. If market-agent fixed effects are omitted, the same algebra applies after suppressing μ_i.

C.1 Quantity Effects as Upper Bounds

Let the observed outcome be traded quantity, denoted by Y_{ict}, for market-agent i, product $c \in \{T, C\}$, and period t. Consider the linear representation

$$Y_{ict} = \mu_i + \gamma_c + \delta_t + \varepsilon_{ict},$$

where μ_i captures time-invariant heterogeneity across market agents, γ_c denotes product fixed effects, δ_t captures period fixed effects, and ε_{ict} is an idiosyncratic component.

We analyze a policy intervention between periods 1 and 2 that induces an exogenous reduction in the price of the treated product T, such that

$$P_{T,1} > P_{T,2}.$$

The causal parameter of interest is the own-quantity effect of the policy on the treated

product:

$$\tau \equiv E[Y_{i,T,2} \mid P_{T,2}] - E[Y_{i,T,2} \mid P_{T,1}].$$

This compares the observed post-policy quantity of T under the lower treated-product price $P_{T,2}$ with the counterfactual quantity that would have been observed absent the policy, holding the treated-product price at $P_{T,1}$.

Identification and Bounding under Spillovers

The standard parallel-trends assumption in potential outcomes implies that, under the counterfactual price path $P_{T,1}$, the difference between the control and treated products would have remained stable over time:

$$E[Y_{i,C,1} - Y_{i,T,1} \mid P_{T,1}] = E[Y_{i,C,2} - Y_{i,T,2} \mid P_{T,1}].$$

Under this assumption, the unobserved counterfactual quantity of the treated product can be written as

$$E[Y_{i,T,2} \mid P_{T,1}] = E[Y_{i,T,1} \mid P_{T,1}] + E[Y_{i,C,2} \mid P_{T,1}] - E[Y_{i,C,1} \mid P_{T,1}]. \tag{C.1}$$

The first and third terms on the right-hand side are observed in the pre-treatment period. The problematic term is

$$E[Y_{i,C,2} \mid P_{T,1}],$$

the counterfactual post-treatment quantity of the control product in a world where the price of T had not changed.

Because T and C are substitutes, the price reduction of T reallocates demand away from C. Therefore, the observed post-treatment quantity of C under $P_{T,2}$ is below the

counterfactual quantity that would have prevailed under $P_{T,1}$:

$$E[Y_{i,C,2} \mid P_{T,1}] > E[Y_{i,C,2} \mid P_{T,2}].$$

This implies a lower bound for the unobserved counterfactual quantity of T:

$$E[Y_{i,T,2} \mid P_{T,1}] > E[Y_{i,T,1} \mid P_{T,1}] + E[Y_{i,C,2} \mid P_{T,2}] - E[Y_{i,C,1} \mid P_{T,1}]. \tag{C.2}$$

Using the definition of τ, this implies

$$\tau < E[Y_{i,T,2} \mid P_{T,2}] - E[Y_{i,T,1} \mid P_{T,1}] - E[Y_{i,C,2} \mid P_{T,2}] + E[Y_{i,C,1} \mid P_{T,1}]. \tag{C.3}$$

The expression on the right-hand side is the standard difference-in-differences estimand. Therefore, when the control product is negatively affected by substitution spillovers, the quantity difference-in-differences estimator is an upper bound for the true own-quantity effect of the policy on the treated product.

C.2 Exploiting the Linear Panel Data Representation

The same result can be seen directly using the linear panel representation. Under the counterfactual price vector $P_{T,1}$, impose parallel trends on the residual components:

$$E[\varepsilon_{i,T,2} \mid P_{T,1}] - E[\varepsilon_{i,T,1} \mid P_{T,1}] = E[\varepsilon_{i,C,2} \mid P_{T,1}] - E[\varepsilon_{i,C,1} \mid P_{T,1}]. \tag{C.4}$$

Let σ denote the equilibrium spillover shock on the control product under the realized policy price $P_{T,2}$:

$$\sigma \equiv E[\varepsilon_{i,C,2} \mid P_{T,2}] - E[\varepsilon_{i,C,2} \mid P_{T,1}].$$

For quantities, product substitutability implies

$$\sigma < 0,$$

because the price reduction of T shifts demand away from C.

Using

$$Y_{ict} = \mu_i + \gamma_c + \delta_t + \varepsilon_{ict},$$

the four observed conditional expectations can be written as

$$\begin{aligned}
E[Y_{i,T,2} \mid P_{T,2}] &= \mu_i + \gamma_T + \delta_2 + E[\varepsilon_{i,T,2} \mid P_{T,1}] + \tau, \\
E[Y_{i,T,1} \mid P_{T,1}] &= \mu_i + \gamma_T + \delta_1 + E[\varepsilon_{i,T,1} \mid P_{T,1}], \\
E[Y_{i,C,2} \mid P_{T,2}] &= \mu_i + \gamma_C + \delta_2 + E[\varepsilon_{i,C,2} \mid P_{T,1}] + \sigma, \\
E[Y_{i,C,1} \mid P_{T,1}] &= \mu_i + \gamma_C + \delta_1 + E[\varepsilon_{i,C,1} \mid P_{T,1}].
\end{aligned}$$

Substituting into the difference-in-differences estimand gives

$$\begin{aligned}
\text{DiD} &= (E[Y_{i,T,2} \mid P_{T,2}] - E[Y_{i,T,1} \mid P_{T,1}]) - (E[Y_{i,C,2} \mid P_{T,2}] - E[Y_{i,C,1} \mid P_{T,1}]) \\
&= \tau - \sigma. \qquad \text{(C.5)}
\end{aligned}$$

Since $\sigma < 0$, it follows that

$$\text{DiD} > \tau.$$

Thus, the empirical quantity difference-in-differences estimate is larger than the true own-quantity effect on the treated product. Equivalently,

$$\tau = \text{DiD} + \sigma < \text{DiD}\,.$$

C.3 Extension to the Event-Study Framework

The argument extends directly to the dynamic event-study specification. Let the VAT exemption begin at period t^*, and normalize the period immediately before the intervention, $t^* - 1$, as the reference period.

Under the counterfactual price path P_{T,t^*-1}, the parallel-trends condition for residual components is

$$E[\varepsilon_{i,T,t} \mid P_{T,t^*-1}] - E[\varepsilon_{i,T,t^*-1} \mid P_{T,t^*-1}] = E[\varepsilon_{i,C,t} \mid P_{T,t^*-1}] - E[\varepsilon_{i,C,t^*-1} \mid P_{T,t^*-1}] \tag{C.6}$$

for all periods t.

Let τ_t denote the period-specific true own-quantity effect on the treated product, and let σ_t denote the period-specific spillover shock on the control product:

$$\sigma_t \equiv E[\varepsilon_{i,C,t} \mid P_{T,t}] - E[\varepsilon_{i,C,t} \mid P_{T,t^*-1}].$$

For pre-treatment periods, $t < t^*$, there is no policy-induced spillover, so

$$\tau_t = 0 \qquad \text{and} \qquad \sigma_t = 0.$$

For post-treatment periods, $t \geq t^*$, the dynamic event-study coefficient can be written as

$$\begin{aligned} \beta_t &= (E[Y_{i,T,t} \mid P_{T,t}] - E[Y_{i,T,t^*-1} \mid P_{T,t^*-1}]) - (E[Y_{i,C,t} \mid P_{T,t}] - E[Y_{i,C,t^*-1} \mid P_{T,t^*-1}]) \\ &= \tau_t - \sigma_t. \end{aligned} \tag{C.7}$$

If substitution reallocates demand away from the control product during the policy

window, then

$$\sigma_t < 0 \qquad \forall t \geq t^*.$$

Therefore,

$$\beta_t > \tau_t \qquad \forall t \geq t^*.$$

The event-study coefficients for quantities should therefore be interpreted as upper bounds for the true own-quantity response of the treated product. For pre-treatment leads, the absence of policy spillovers implies

$$E[\beta_t] = 0,$$

which is the standard pre-trends implication.

C.4 Price Effects as Lower Bounds in Absolute Value

The previous derivation focuses on quantities. The same logic applies to prices, but the sign of the outcome reverses the interpretation. Let the outcome now be the standardized real price, denoted by P_{ict}^{std}. Define the true own-price effect of the VAT exemption on the treated product as

$$\tau^p \equiv E[P_{i,T,2}^{std} \mid P_{T,2}] - E[P_{i,T,2}^{std} \mid P_{T,1}].$$

Because the policy reduces the tax-inclusive price of the treated product, we expect

$$\tau^p < 0.$$

The observed price difference-in-differences estimand is

$$\mathrm{DiD}^p = \left(E[P^{std}_{i,T,2} \mid P_{T,2}] - E[P^{std}_{i,T,1} \mid P_{T,1}]\right) - \left(E[P^{std}_{i,C,2} \mid P_{T,2}] - E[P^{std}_{i,C,1} \mid P_{T,1}]\right).$$

Let the price spillover on the control product be

$$\sigma^p \equiv E[\varepsilon^p_{i,C,2} \mid P_{T,2}] - E[\varepsilon^p_{i,C,2} \mid P_{T,1}],$$

where ε^p_{ict} denotes the residual component of the standardized price equation. Under parallel trends in the counterfactual price path, the same algebra as above gives

$$\mathrm{DiD}^p = \tau^p - \sigma^p.$$

Because T and C are substitutes, a reduction in the price of T shifts demand away from C. If this reduction in demand for C weakly lowers the equilibrium price of the control product relative to its counterfactual path, then

$$\sigma^p \leq 0.$$

Therefore,

$$\mathrm{DiD}^p = \tau^p - \sigma^p \geq \tau^p.$$

When the estimated price effect is negative, as in the empirical application, this means that the estimated difference-in-differences coefficient is less negative than the true own-price effect on the treated product. Equivalently,

$$-\mathrm{DiD}^p \leq -\tau^p.$$

Thus, the estimated price reduction in absolute value is a lower bound for the true own-price reduction of the treated product. The same implication applies to the implied pass-through rate. Let

$$m \equiv \frac{0.12}{1.12}$$

be the mechanical tax-inclusive price reduction implied by full pass-through of the VAT burden under the Uruguayan VAT regime for beef products. The estimated pass-through rate is

$$\widehat{PT}^{p} = \frac{-\,\mathrm{DiD}^{p}}{m},$$

whereas the true own-price pass-through is

$$PT^{p,true} = \frac{-\tau^{p}}{m}.$$

Since

$$-\,\mathrm{DiD}^{p} \leq -\tau^{p},$$

it follows that

$$\widehat{PT}^{p} \leq PT^{p,true}.$$

Therefore, when the control product is affected by substitution spillovers, the price difference-in-differences estimates should be interpreted as lower bounds on the absolute price reduction and on the true pass-through rate. This strengthens the interpretation of the empirical results: the estimates in the main text already indicate substantial pass-through, and any downward spillover in the control product's price implies that the true own-price pass-through for the treated product is weakly larger than the reported estimate.