From protection to retaliation: The trade war effect

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This paper explores the welfare cost of trade impediments during the trade war period, highlighting the crucial role of accurately measuring trade elasticities—the import demand elasticity and the inverse export supply elasticity. I propose a novel instrument: retaliatory tariffs imposed on sectors different from those targeted by the trade partner. Under WTO rules, countries must match the tariff rate imposed by the trade partner but can choose which products to target. By focusing on price-elastic goods, countries maximize punishment by driving away demand from foreign competitors. Using Canadian retaliation against the U.S., I estimate an inverse export supply elasticity of zero and an import demand elasticity of 5.2, significantly higher than the commonly reported value of around 2.5. This suggests that trade policies tend to target extremes of the elasticity distribution: revenue-raising tariffs on inelastic goods and retaliatory tariffs on elastic goods. By constructing an interval for the average demand elasticity between 2.5 and 5.2, I estimate the U.S. welfare costs to range between \$11 and \$22 billion, doubling prior estimates. THIS IS A TEST

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I Introduction

Trade elasticities play a crucial role in international economics, with renewed interest sparked by recent trade wars. These elasticities are key drivers of welfare costs associated with trade shocks. In many models, these costs depend on two factors: the demand elasticity for imports and the inverse supply elasticity for exports (e.g., Arkolakis et al. (2012); Costinot and Rodríguez-Clare (2014)). Together, these determine the price and quantity equilibrium in the market for imported varieties.

Economists have employed various methods to measure these elasticities. Recent state-of-the-art literature has utilized tariffs to identify elasticities and quantify the welfare cost of the trade war in the United States (Fajgelbaum et al. (2020); Amiti et al. (2019)).

However, this approach faces two challenges. First, tariff implementation timing is not random; tariffs often respond to negative economic shocks, creating a reverse causality problem that can bias elasticity estimates (e.g., Bown and Crowley (2013, 2014)). Second, and often overlooked, the selection of tariff-targeted products is also non-random. These issues complicate the identification of trade elasticities.

This paper proposes a novel instrument to address these issues: retaliatory tariffs on sectors not targeted by the trading partner. This serves as an exogenous variation to identify trade elasticities. I find a significantly larger demand elasticity than previously estimated in the literature, which translates to higher welfare costs of tariffs.

State-of-the-art literature using tariffs to identify elasticities has found relatively low trade elasticities—typically with an import demand elasticity around 2 and an inverse export supply elasticity close to zero. I find an export elasticity consistent with these findings, but the elasticity of demand is twice as large, resulting in doubled welfare costs. This discrepancy is explained by the heterogeneity of goods subject to tariffs: revenue-raising tariffs target low-elasticity industries, while retaliatory tariffs focus on more elastic goods.

Countries that need to raise revenue target inelastic goods, as this minimizes the deadweight loss of tariffs. On the other hand, those facing these tariffs aim to maximize the probability that the trade partner will withdraw them. They retaliate by maximizing the punishment they could inflict on the trade partner, choosing products with a high demand elasticity. This drives away demand from foreign producers, reducing their profits and ultimately hurting the government's counterpart.

Under WTO rules, retaliation is reciprocal and aims to restore trade through tit-for-tat tariffs. Countries must match the tariff rate imposed by the trade partner. However, they can choose which goods to target while keeping the average tariff in line with their counterpart. Selecting varieties with a high elasticity would maximize the probability that the trade partner withdraws their tariffs.

The identification strategy rests on this requirement. Tariff rates reflect differences in productivity and demand shocks of the varieties on which they are imposed[1]. When the retaliating country imposes these tariffs on a different sector, the tariff rate becomes orthogonal to idiosyncratic shocks of the sector in which it is imposed.

The instrument, cross-sector retaliation, provides exogenous variation in prices and quantities. Additionally, I employ a discrete choice model to account for the systematic selection of elastic varieties in the estimation. The results yields a demand elasticity of 5.2, representing an upper bound of the elasticity distribution.

Trade policy targets the extremes of the elasticity distribution. Papers using Trump tariffs, motivated by revenue considerations, identify the lower bound. Retaliation, on the other hand, identifies an upper bound. As average welfare costs depend on elasticities across the distribution, I use these results to construct an interval for the average elasticity.

The contribution to the literature is twofold: (i) I propose a novel instrument to identify trade elasticities and (ii) I construct an interval for the average elasticity. The average demand elasticity is bounded between 2.5 and 5.2, implying the welfare costs are between \$11 and \$22 billion.

For the estimation, I use administrative data from the Canadian International Trade

[1]For example, US tariffs on steel and aluminum in 2018 were set to increase capacity utilization to at least 80%. The capital utilization in 2017 was 72.3% and 39% in the steel and aluminum sectors, respectively.

Division, covering the universe of imports from all Canadian trade partners. These are recorded at a monthly frequency and at the Harmonized System (HS) 10-digit level, providing rich and detailed disaggregation. The estimation window is during the trade war period, specifically between 2018 and 2019, as this is where most papers studying the trade war focus.

Canada is one of the many countries that retaliated against the tariffs imposed by the US. Trade between these two countries is significant: around two-thirds of Canada's total trade is with the US, while about 25% of US exports go to Canada.

In May 2018, the US imposed tariffs of 25% on steel and 10% on aluminum imports, affecting \$12.4 billion of Canadian exports and raising the average tariff rate by 16%[2]. Canada retaliated within a month, imposing similar tariffs on \$12.7 billion of US exports, increasing the average rate by 15%. Half of Canada's retaliatory tariffs targeted the metal industry, while the other half applied to final goods[3].

The identification strategy relies on retaliation targeting these different set of goods. If US tariffs on steel and aluminum correlate with productivity differences between US and foreign competitors, retaliation on those goods would face similar endogeneity issues. However, Canada's tariffs on final goods are exogenous to the US steel and aluminum industries, and controlling for various factors ensures that idiosyncratic shocks in these sectors are orthogonal to those in steel and aluminum.

This condition is crucial for the instrument's validity. Regressing changes in quantity demanded on the duty-inclusive price of imports yields the demand elasticity. The instrument—retaliatory tariffs on final goods—correlates with the duty-inclusive price while being orthogonal to idiosyncratic shocks. If the exogeneity condition is satisfied, it provides a consistent estimator for demand elasticity and an upper bound, estimated at 5.2.

The lower bound can be estimated using Canadian retaliatory tariffs on steel and alu-

[2]US tariffs on steel and aluminum in 2018, were set to increase the capacity utilization to at least 80%. The capital utilization in 2017 was of 72.3% and 39% in the steel and aluminum sector, respectively.

[3]Data based on 2017 annual import values, representing the pre-trade war period.

minum, despite potential correlation with shocks in these varieties. The estimate is 1.9, close to the 2.5 reported in studies of US tariffs under Trump, suggesting similar results can be replicated with Canadian data. The inverse export supply elasticity is zero in both cases, consistent with US findings.

The panel data structure controls for a rich set of fixed effects. Time fixed effects isolate variation from aggregate shocks, accounting for the countercyclical profile of tariffs. Without these controls, negative correlations between tariffs and aggregate shocks would bias estimates toward zero. A similar bias would occur with negative correlations between tariffs and idiosyncratic shocks. However, the instrument provides a plausible source of exogenous variation.

The inclusion of fixed effects at the industry level accounts for the likelihood of targeting relatively more demand-elastic varieties during retaliation. The discrete choice model allows this probability to be expressed in terms of elasticities at the sector level. Therefore, industry fixed effects can capture these variations in the estimation.

Since the inverse export supply elasticity is zero, the pass-through of tariffs into duty-inclusive prices is complete. This implies that the deadweight loss from the tariff scales linearly with the demand elasticity. Using the US as a baseline, this means that the welfare cost of the tariffs ranges between \$11 billion and \$22 billion.

The exact magnitude depends on the position of the average elasticity within the distribution of demand elasticities. Since trade policy is not applied across the entire range, it is not possible to draw definitive conclusions about this. This question becomes particularly relevant when assessing the broader effects of tariffs.

To rationalize these findings, I use a political economy two-country model to illustrate the dynamics of protection and retaliation. The foreign country imposes discretionary tariffs on a particular set of goods, while the home country retaliates by maintaining the tariff level but shifting its application to different goods.

The foreign country has stronger incentives to impose discretionary tariffs during recessions, as this increases the government's marginal utility from tariffs. The effect is even greater if the home country is experiencing a boom, as more resources can be extracted from its firms through tariffs.

The tariff also generates a positive effect for domestic producers in the foreign country, allowing them to raise prices without affecting markups. These groups lobby for protection in the industries they represent. The imposed tariff reflects a combination of how inelastic the demand for the good is and the lobbying strength of the industry.

The home country commits to a state contingent plan to retaliate if the foreign country imposes tariffs, acting as a mechanism of dissuasion. In effect, the tit-for-tat strategy aims towards returning to the free trade equilibrium in the long run.

If the foreign economy is facing adverse aggregate shocks, the profits of domestic firms are relatively low, and the retaliation effect is diminished. Although the punishment is less effective during bad times, the home economy must still retaliate; otherwise, the foreign economy would not give up tariffs during normal times.

When the foreign economy transitions to this state, the impact of retaliation becomes more significant. In this scenario, the marginal utility of government revenue is lower, meaning that targeting demand-elastic goods in industries sensitive to the foreign country maximizes the punishment.

Retaliation affects the probability that the trade partner will withdraw its tariffs. As this decision follows a stochastic choice model, retaliation lowers the threshold for tariff withdrawal. As a result, it becomes more likely that the foreign country will give up its tariffs in this economic state. This represents the subgame perfect Nash equilibrium of the game.

Related literature

Historically, tariffs often target intermediate inputs, which are harder to substitute in the short run and therefore have relatively inelastic demand Barattieri et al. (2021). In Canada, approximately 90% of tariffs have been imposed on intermediate goods, suggesting a deliberate strategy to minimize distortions by focusing on demand inelastic industries.

Empirical studies support this notion. Barattieri and Cacciatore (2023) find that U.S. tariffs on intermediate inputs do not lead to significant employment gains in protected industries. Similarly, Bown et al. (2021) show that protectionist measures fail to boost domestic production, reinforcing the idea that intermediate goods are price inelastic in the short run.

In the context of the trade war, Fajgelbaum et al. (2020) use U.S. import data at the HS-10 level to estimate trade elasticities. Using steel and aluminum tariffs as instruments for the duty-inclusive price, they find a demand elasticity of 2.5, which reflects the elasticity of substitution across imported varieties.

Another paper estimating the impact of the 2018 US tariffs is Amiti et al. (2019). In their analysis, they regress quantities directly on the tariff measure to arrive at a demand elasticity of 1.3. This result is closer to Fajgelbaum et al. (2020) OLS results.

A recent paper by Boehm et al. (2023), though not in the context of the trade war, finds short-run trade elasticities as low as -0.76, rising to -2 in the long run, using panel data from 183 economies. Their use of Most Favored Nation (MFN) tariffs, which are non-discriminatory, may explain the lower estimates compared to studies focusing on discriminatory tariffs during trade wars.

Most studies find that the export supply elasticity is close to zero, implying a flat supply curve and the complete pass-through of tariffs to consumer prices. These findings are supported by Amiti et al. (2019), Fajgelbaum et al. (2020), Flaaen et al. (2020), and Cavallo et al. (2021).

Retaliatory measures against the U.S. targeted consumption goods, automobiles, and agricultural commodities, with China focusing heavily on the latter. Waugh (2019) shows that these tariffs were imposed on counties with high exposure, reducing U.S. export capacity.

Estimating the elasticity of retaliatory tariffs is challenging because most studies focus on China's retaliation against the U.S., and the available data is limited to the HS 6-digit level, which lacks granularity. This aggregated data groups diverse products together, obscuring important variations in trade flows and making it difficult to precisely assess how export quantities respond to retaliatory tariffs.

A study estimating the demand elasticity to retaliatory tariffs is Amiti et al. (2019). They find that the elasticity of U.S. export quantities to foreign retaliatory tariffs is 1.2, contributing to a decline in employment in the sector. The inverse export supply elasticity is positive but marginal, implying an almost complete pass-through of tariffs to prices.

Similarly, Fajgelbaum et al. (2020) estimates the elasticity of U.S. export quantities to foreign retaliatory tariffs as -1.04, indicating significant sensitivity to tariff increases. Full pass-through to prices is observed, meaning U.S. exporters bear the full cost with little price adjustment by foreign producers.

The modest magnitude contrasts sharply with the 5.2 estimate in this paper, which is closer to estimates from gravity equation models. In these models, trade elasticity represents the sensitivity of trade flows to changes in trade costs. Trade elasticities typically range between 4 and 6 (see, e.g., Eaton and Kortum (2002), Simonovska and Waugh (2014), and Head and Mayer (2014)).

This paper reconciles two strands of the literature. Ex-post trade war studies report low elasticities due to the heterogeneity of tariffs, which often target low-elasticity varieties. In contrast, this paper shows that when the upper tail of the elasticity distribution is targeted, the estimates align more closely with those from gravity models.

The rest of the paper is organized as follows: Section II shows the data and conducts an event study to analyze the behavior of quantities and prices in response to tariffs. It also portrays some empirical facts regarding trade policy features that are useful for the model. Section III introduces the model. Section IV describes the identification the identification strategy. Section V presents the results of the estimations, to finally conclude.

II Model

A. Environment

The model involves two countries: Home (H) and Foreign (F). The Home country is characterized as a continuum of small open economies (SOEs), which collectively form the domestic economy but individually lack market power. In contrast, Foreign is a large country with significant market power, capable of influencing international prices and trade flows.

The economy operates within a multi-industry framework. Each industry is indexed by $s = 1, \ldots, S$, and within each industry, there are multiple varieties of tradable goods, indexed by $j = 1, \ldots, J$. These tradable varieties form the basis of both inter-industry and intra-industry trade between the Home and Foreign countries.

Labor markets in both countries consist of L_s units of labor. Workers supply labor to the industries and earn after-tax wages, with the governments in both Home and Foreign imposing taxes on labor income. Labor is mobile within industries but immobile across countries.

The Foreign government, leveraging its market power as a large country, imposes uniform tariffs at the industry level to manipulate the terms of trade in its favor. This policy effectively maximizes welfare at the sector level.

B. Basic setup

The utility function of the representative consumer in each country depends on consumption, government spending, and the disutility from labor. Specifically, the utility function is given by:

$$U = \prod_s (C_s)^{\beta_s} + u(G) - v(L)$$

Consumption follows a Cobb-Douglas utility function across industry-specific consumption levels C_s. The parameters β_s represent the Cobb–Douglas industry expenditure weights, satisfying $\sum_s \beta_s = 1$. The consumer's budget constraint is given by $PC = \Pi + wL(1-\tau_n) + T$, where P is the aggregate price level, C is total consumption, w is the wage rate, L is labor supply, τ_n denotes the labor income tax rate, Π represents domestic firms' profits, and T is the government's lump-sum transfer to the representative agent.

The term $u(G) = \ln(G - \bar{G}_m)$ represents a Stone–Geary utility function for government expenditure G, where $\bar{G}_m$ denotes the minimum subsistence level of government spending. The disutility of labor is specified as a Constant Relative Risk Aversion (CRRA) function $v(L) = L^{1+\frac{1}{\kappa}}/(1+\frac{1}{\kappa})$, exhibiting a constant labor supply elasticity κ.

Consumption at the industry level follows a two tier Nested Constant Elasticity of Substitution (CES). At the top tier, expenditures in 4-digit NAICS sectors are allocated between domestically produced goods and foreign imports. The bottom tier is a CES bundle over imported varieties across products at the HS10 digit level. This tier can be further disaggregated across trading partners in a multi-country framework, something explored in the empirical section[4]. Both tiers are:

The model is governed by two key sets of variables: state variables and policy variables. The state variables are $Z = \{Z_H, Z_F\}$, where $Z_H = \{\varepsilon_{A_{Hsj}}, \varepsilon_{d_{Hsj}}\}$ and $Z_F = \{\varepsilon_{A_{Fsj}}, \varepsilon_{d_{Fsj}}\}$. Here, $\varepsilon_{A_{Hsj}}$ and $\varepsilon_{d_{Hsj}}$ denote the productivity and demand shocks, respectively, in industry s and variety j in Home, while $\varepsilon_{A_{Fsj}}$ and $\varepsilon_{d_{Fsj}}$ represent the corresponding shocks in Foreign.

On the policy side, the governments of both Home and Foreign impose tariffs on traded goods. The tariff structure is represented by $\tau = \{\tau_{sj}, \tau^*_{sj}\}$, where τ_{sj} and τ^*_{sj} denote the tariffs imposed by Home and Foreign, respectively, on variety j in industry s.

[4] For simplicity, I am assuming that the elasticity of substitution between the two bundles is the same. In effect, that the elasticity of substitution across imported products is the same as the one between imported varieties (the elasticity of substitution between products across different trading partners)

This structure provides the foundation for analyzing trade dynamics between the two countries, considering productivity fluctuations, demand shocks, and government policy interventions.

$\{\varepsilon_{A_{sj}}, \varepsilon^*_{A_{sj}}\}$, represent productivity shocks in each industry and variety. Here, $\varepsilon_{A_{sj}}$ denotes the productivity in industry s and variety j in Small, while $\varepsilon^*_{A_{sj}}$ represents the corresponding productivity in Big.

On the policy side, the governments of both Small and Big impose tariffs on traded goods. The tariff structure is represented by $\tau = \{\tau_{sj}, \tau^*_{sj}\}$, where τ_{sj} and τ^*_{sj} denote the tariffs imposed by Small and Big, respectively, on variety j in industry s.

This structure provides the foundation for analyzing trade dynamics between the two countries, considering both productivity fluctuations and government policy interventions.

III ModelB

Consider a three-tier Nested Constant Elasticity of Substitution (CES) demand structure within the tradable sector.

At the top tier, expenditures in 4-digit NAICS sectors are allocated between domestically produced goods and foreign imports. The middle tier employs a CES technology to aggregate imported varieties across products and trading partners within each sector.

The bottom tier defines demand functions for varieties at the HS10 digit level. On the supply side, monopolistically competitive intermediaries produce these varieties using a technology with decreasing returns to scale in labor. The resulting demand and supply equations are as follows:

$$
\begin{aligned}
Y_{Fsjit} &= \xi_{\mu_{sjit}} \left(\frac{(1+\tau_{sjit})P^*_{Fsjit}}{P_{Fsjt}} \right)^{-\lambda_s} Y_{Fsjt} \\
P^*_{Fsjit} &= \mu^*_s \left(\frac{W^*_{sit}}{A^*_{Fsjit}} \right) \left(\frac{Y_{Fsjit}}{A^*_{Fsjit}} \right)^{\omega^*_s}
\end{aligned}
$$

On the demand side, let Y_{Fsjit} denote the quantity of product j, supplied by trading partner i (i.e., variety pair 'ji') at time t, to the home country. The asterisk superscript in Y^*_{Fsjit} represents the trading partner's counterpart of the supplied variety in foreign markets. The sum of these two quantities equals total production Y^*_{sjit}. Variety-specific taste shocks, orthogonal between varieties, are captured by $\xi_{\mu_{sjit}}$, while λ_s represents the import demand elasticity.

The price set by foreign producers, P^*_{Fsjit}, equals a constant markup over marginal costs, adjusted for the concavity of the production function. Marginal costs depend on A^*_{sjit}, the firm-specific productivity shock (orthogonal between varieties); ω^*_s, the inverse elasticity of export supply; and W^*_{sit}, labor costs[5].

Two key assumptions implicit in the above equations are: (i) tariffs are paid at the border, generating a wedge between the price the home country faces and the one the producer receives, and (ii) there is heterogeneity between sector elasticities[6].

This distribution can be characterized by the following set $\Omega_s = \{\lambda_s, \omega^*_s\}$ where $\lambda_s \in \{\lambda_L, ..., \lambda_H$ and $\omega^*_s \in \{\omega_L, ..., \omega_H\}$. Taking this into consideration, express the model in log-differences:

$$\widetilde{y}_{Fsjit} = \widetilde{\phi}_{sjt} - \lambda_s[\widetilde{(1+\tau_{sjit})} + \widetilde{p}^*_{Fsjit}] + \xi_{\mu_{sjit}} \tag{1}$$

$$\widetilde{p}^*_{Fsjit} = \widetilde{\phi}^*_{sit} + \omega^*_s \widetilde{y}^*_{sjit} - (1+\omega^*_s)\xi^*_{A_{sjit}} \tag{2}$$

$$\widetilde{p}_{Fsjit} = \widetilde{(1+\tau_{sjit})} + \widetilde{p}^*_{Fsjit} \tag{3}$$

where $\tilde{x}$ denotes variables in log-deviations, and $\tilde{\phi}$ represents terms at higher aggregation levels, which are captured by fixed effects during the estimation stage.

[5]Workers are assumed to move freely between firms producing varieties in a given sector. Therefore, wages are the same within a sector for any given trading partner at a particular point in time.

[6]In other words, elasticities are assumed to be constant across varieties within a given sector, but they differ between sectors.

A. System of equations

Given the system of equations, express the reduced form model as a function of the import tariff:

$$\widetilde{y}_{Fsjit} = \widetilde{\phi}_{y_{Fsjit}} - \underbrace{\left[\frac{\lambda_s}{1+\omega_s^*\lambda_s}\right]}_{\varepsilon_{y_{Fsjit}}} (\widetilde{1+\tau_{sjit}}) + \xi_{y_{Fsjit}} \tag{4}$$

$$\widetilde{p}_{Fsjit} = \widetilde{\phi}_{p_{Fsjit}} + \underbrace{\left[\frac{1}{1+\omega_s^*\lambda_s}\right]}_{\varepsilon_{p_{Fsjit}}} (\widetilde{1+\tau_{sjit}}) + \xi_{p_{Fsjit}} \tag{5}$$

$$\widetilde{p}^*_{Fsjit} = \widetilde{\phi}_{p^*_{Fsjit}} - \underbrace{\left[\frac{\omega_s^*\lambda_s}{1+\omega_s^*\lambda_s}\right]}_{\varepsilon_{p^*_{Fsjit}}} (\widetilde{1+\tau_{sjit}}) + \xi_{p^*_{Fsjit}} \tag{6}$$

where terms $\widetilde{\phi}_{y_{Fsjit}}$ and $\widetilde{\phi}_{p_{Fsjit}}$, are a linear combination of fixed effects of the demand and supply equation, respectively.

To identify the price elasticity of imports, take the ratio of equation (4) with equation (5). In effect, this is equivalent to instrument the duty inclusive prices using import tariffs, in the estimation for the demand equation. Hence, the import demand elasticity can be computed as, $\hat{\lambda}_s = -\left(\frac{\varepsilon_{y_{Fsjit}}}{\varepsilon_{p_{Fsjit}}}\right)$.

Similarly, the export supply elasticity can be identified through the ratio of equation (6) with equation (4). The IV estimation uses import tariffs as an instrument for the duty-exclusive price in the supply equation. The inverse export supply elasticity is then, $\hat{\omega}_s^* = -\left(\frac{\varepsilon_{P^*_{Fsjit}}}{\varepsilon_{y_{Fsjit}}}\right)$.

The estimation requires random assignment in the instrument. This is, (i) tariffs do not react to other shocks in the economy and, (ii) varieties are not targeted systematically. This critically depends on the stage of the trade policy in which the government is in.

B. Foreign revenue tariffs

Assume that the foreign country imposes tariffs to generate revenue. Under such policies, governments tend to select varieties in sectors characterized by low import demand elasticity and high export supply elasticity. To demonstrate this, we can express the government's tariff revenue as:

$$\widetilde{r}^*_{s'j'it} = \widetilde{\phi}_{r^*_{s'j'it}} + \widetilde{\tau}^*_{s'j'it} - \left[\frac{\lambda'_s(1+\omega^*_{s'}))}{1+\omega^*_{s'}\lambda_{s'}}\right](\widetilde{1+\tau^*_{s'j'it}}) + \xi_{r^*_{s'j'it}}$$

Higher import tariffs raises government revenue, at the expense of a dead-weight loss. This distortion, depends on the elasticities:

$$\left.\frac{\partial\widetilde{r}^*_{s'j'it}}{\lambda^*_{s'}}\right|_{\widetilde{\tau}^*_{s'j'it}} = \lambda^*_L, \quad \left.\frac{\partial\widetilde{r}^*_{s'j'it}}{\partial\omega_{s'}}\right|_{\widetilde{\tau}^*_{s'j'it}} = \omega^*_H$$

Varieties with low import demand and high inverse export supply elasticities, minimize the size of the distortion. This forces the trading partner to bear the tariff cost.

The magnitude of the tariff is assumed to be proportional to the price difference between the good produced in the foreign country and the home counterpart. As countries are required to prove injury to the local industry when imposing tariffs, this creates a correlation between these policies and variety-specific shocks.[7]

Denote this difference as $\widetilde{d}^*_{s'j'it} = \widetilde{p}^*_{Fs'j'it} - \widetilde{p}^*_{Hs'j'it}$, and rewrite the tariff as:

$$(\widetilde{1+\tau^*_{s'j'it}}) = \widetilde{d}^*_{s'j'it} = \widetilde{\phi}_{d^*_{s'j'it}} + \psi_{s'}(\xi_{As'j'it} - \xi^*_{As'j'it}) + \Sigma_{s'}(\xi_{\mu^*_{s'j'it}} - \xi_{\mu_{s'j'it}})$$

Governments impose tariffs on varieties exhibiting large differentials in productivity or demand shocks. This implies a countercyclical relationship between tariffs and productivity

[7]Under WTO norms, when countries impose antidumping duties, they are required to demonstrate injury to the local industry, in addition to providing evidence of dumping. This requirement also applies when implementing safeguard measures. These tools are commonly used by countries to unilaterally raise tariffs against specific competitors.

shocks.

C. Home retaliatory tariffs

The Home governments facing these revenue tariffs, are entitled to impose retaliatory measures. Under reciprocity, countries apply symmetric tariff rates with respect to the ones they faced[8]. The decision then rests on the battery of goods that will be subject to these policies.

The choice is based on maximizing the conditional probability that the trading partner withdraws their tariffs. Assume this depends on the differences between both government revenues:

$$P\left((1-\rho_s)\widetilde{g}_{s'j'it} - \rho_s \widetilde{g}^*_{sjit} | \widetilde{\tau}^*_{s'j'it}\right) = P\left((1-\rho_s)\left[\widetilde{r}_{s'j'it} + \widetilde{\pi}_{s'j'it}\right] - \rho_s\left[\widetilde{r}^*_{sjit} + \widetilde{\pi}^*_{sjit}\right] | \widetilde{\tau}^*_{s'j'it}\right)$$

where $P(\cdot)$ is a convex probability combination of the government revenue terms. They are the sum of their own tariff's revenue, and the corporate tax rate that is lost when the home competitors are targeted by foreign tariffs.

Taking foreign protection in sector s' as given, the home country maximizes this probability by choosing symmetric retaliation on industry s:

$$\begin{aligned}
&\max_{\Omega_s} P\left((1-\rho_s)\left[\widetilde{r}_{s'j'it} + \widetilde{\pi}_{s'j'it}\right] - \rho_s\left[\widetilde{r}^*_{sjit} + \widetilde{\pi}^*_{sjit}\right] | \widetilde{\tau}^*_{s'j'it}\right) \\
&\quad \text{s.t.} \;\; \widetilde{\tau}_{s'j'it} = \widetilde{\tau}^*_{s'j'it}, \;\; \widetilde{\tau}_{sjit} = \widetilde{\tau}^*_{s'j'it}, \;\; P(\cdot) \in [0,1] \\
&\quad \text{FOC}: (1-\rho_s)P'_g\left(\frac{\partial \widetilde{r}_{s'j'it}}{\partial \Omega_{s'}}\right) + \rho_s P'_{g^*}\left(-\frac{\partial \widetilde{\pi}^*_{sjit}}{\partial \Omega_s}\right) = 0
\end{aligned}$$

The first order condition implies it is optimal to slump foreign profits, hurting the trading partner to ultimately, force the tariff's withdrawal. In doing so, governments sacrifice tariff revenue, but these losses are buffered by carrying out retaliation in the protected sectors (i.e. protectionism).

[8] WTO mandates that retaliation is used as a tool to restore trade. Therefore, it's not punitive

Using the model equations, express foreign profits as:

$$\widetilde{\pi}^*_{sjit} = \widetilde{\phi}^*_{sjit} - \left[\frac{\lambda_s}{1+\omega^*_s\lambda_s}\right](\widetilde{1+\tau_{sjit}}) + \xi_{\pi^*_{sjit}}$$

The derivatives with respect to each of the elements of Ω_s, are:

$$\left.\frac{\partial - \widetilde{\pi}^*_{sjit}}{\partial \lambda_s}\right|_{\widetilde{\tau}^*_{s'j'it}} = \lambda_H, \quad \left.\frac{\partial - \widetilde{\pi}^*_{sjit}}{\partial \omega^*_s}\right|_{\widetilde{\tau}^*_{s'j'it}} = \omega_L$$

The optimal strategy is to impose tariffs on industries characterized by high import demand elasticity and low export supply elasticity. High values of λ_s significantly reduce demand for foreign competitors' products, diminishing their profits. When combined with low values of ω^*_s, this prevents adjustments in the duty-exclusive price that might otherwise attract additional resources.

This reduction in foreign producers' profits leads to decreased resources available to the foreign government, counteracting the tariff revenue gained from protectionism. Consequently, this increases the likelihood of tariff removal and a return to the free trade equilibrium.

The two stages of government trade policy-protection and retaliation—differ in their approach to these elasticities: Protection: $\lambda^*_{\mathbf{L}}, \; \omega_H$

Retaliation: $\lambda_{\mathbf{H}}, \; \omega^*_{\mathbf{L}}$

D. Selection process

Governments carrying out retaliation do not target systematically the most elastic good. Instead, they focus on a basket of goods with different elasticities, but on the elastic region of the elasticity distribution.

To smooth this decision, assume a discrete choice model for the selection of the industry in which to retaliate:

$$\left[(\widetilde{1+\tau_{sjit})}|\widetilde{\tau}^{*}_{s'j'it})\right] = (D_{sjit}|D^{*}_{s'j'it} = 1)(\widetilde{1+\tau^{*}_{s'j'it}})$$

where term $(D_{sjit}|D^{*}_{s'j'it} = 1)$ captures the retaliation decision. This is driven by a latent process described by $U_{sjit} > U_{s'j'it}$.

Assume the utility function is given by $U_{sjit} = \mathbb{E}(\widetilde{r}_{sjit}|\widetilde{\tau}^{*}_{s'j'it}) + u_{st}$, where u_{st} represents random taste shocks from the government for specific sectors. Defining Δ^{s} as the difference between sector s and s', express the process as: $-\Delta^{s} u_{st} < \Delta^{s'} E(\widetilde{r}_{sjit}|\widetilde{\tau}^{*}_{s'j'it})$.

Using the model's equations, write this as:

$$\begin{aligned}
\Delta^{s} E(\widetilde{r}_{sjit}|\widetilde{\tau}^{*}_{s'j'it}) &= \left[\Delta^{s}\varepsilon_{p_{Fsjit}} + \Delta^{s}\varepsilon_{y_{Fsjit}}\right](\widetilde{1+\tau^{*}_{s'j'it}}) \\
\Delta^{s} E(\widetilde{r}_{sjit}|\widetilde{\tau}^{*}_{s'j'it}) &= -\left[\frac{(1+\omega^{*}_{s})}{(1+\omega^{*}_{s'}\lambda_{s'})(1+\omega^{*}_{s}\lambda_{s})}\right]\Delta^{s}\lambda_{s}(\widetilde{1+\tau^{*}_{s'j'it}}) \\
&\quad -\left[\frac{\lambda_{s'}(\lambda_{s}-1)}{(1+\omega^{*}_{s'}\lambda_{'s})(1+\omega^{*}_{s'}\lambda_{s})}\right]\Delta^{s}\omega^{*}_{s}(\widetilde{1+\tau^{*}_{s'j'it}}) \\
\Delta^{s} E(\widetilde{r}_{sjit}|\widetilde{\tau}^{*}_{s'j'it}) &= \left[-\gamma_{ss'}\Delta^{s}\lambda_{s'}{}_{-}\delta_{ss'}\Delta^{s}\omega^{*}_{s'}\right](\widetilde{1+\tau^{*}_{s'j'it}})
\end{aligned}$$

Intuitively, governments carrying out retaliation are willing to sacrifice revenue to harm foreign firms, forcing the tariff withdrawal.

Further, characterize the conditional probability assuming $\{u_{st}, u_{s't}\}$ follows a Type-I Extreme Value distribution:

$$Pr(D_{s} = 1|D^{*}_{s'j'it} = 1) = \left(1 + \exp\left(\left[-\gamma_{ss'}\Delta^{s}\lambda_{s'} + \delta_{ss'}\Delta^{s}\omega^{*}_{s'}\right](\widetilde{1+\tau^{*}_{s'j'it})}\right)\right)^{-1}$$

Given the selection process is characterized by observables, i.e. industries characteristics, this can be controlled for sector-specific fixed effects in the regressions. These controls account for the likelihood that sectors with relatively higher elasticity are targeted during retaliation.

IV Identification strategy

To identify the demand elasticity, take the demand function for a foreign variety:

$$\widetilde{y}_{Fsjit} = \widetilde{\phi}_{sjit} - \lambda_s[\widetilde{(1+\tau_{sjit})} + \widetilde{p}^*_{Fsjit}] + \xi_{sjit}, \quad \xi_{sjit} \perp \xi_{s'j'it} \;\; \forall sj \neq s'j'$$

It is important to note that while the error term is allowed to be correlated within products in the same sector and between products across different countries, the shocks are assumed to be uncorrelated across different industries.

The term $\widetilde{\phi}_{sjit}$ represents a collection of fixed effects that account for aggregate influences and sector-specific characteristics. This includes controlling for factors such as overall economic shocks, exchange rate fluctuations, wages, sector-level disturbances, and foreign tariffs, among others. The only variation not captured by these fixed effects is at the detailed product level, classified at the 10-digit Harmonized System (HS) code.

To identify the demand elasticity, we use retaliatory tariffs across industries. These tariffs are imposed in sector s' in response to foreign tariffs imposed in sector s. This approach allows us to identify $\lambda_{s'}$ through instrumental variable (IV) estimations:

$$\mathbb{E}\left[\widetilde{(1+\tau^*_{sjit})} \times \widetilde{y}_{Fs'j'it}\right] = -\lambda_{s'}\mathbb{E}[\widetilde{(1+\tau^*_{sjit})} \times \widetilde{p}_{Fs'j'it}] + \mathbb{E}\left[\widetilde{(1+\tau^*_{sjit})} \times \xi_{s'j'it}\right]$$

A consistent estimator requires $\mathbb{E}\left[\widetilde{(1+\tau^*_{sjit})} \times \xi_{s'j'it}\right] = 0$ to hold. As the foreign tariffs are correlated with idiosyncratic shocks in sector s, we can express this as $\widetilde{(1+\tau^*_{sjit})} = -\psi_s \xi_{sjit}$. This implies that when imposed on sector s', $\mathbb{E}\left(\xi_{sj}\xi_{s'j'}\right) = 0$.

The estimation requires to control for selection $P(D_{s'} = 1 | D^*_s = 1)$.

V Estimation

The estimation for the import demand and export supply equations is as follows:

$$\widetilde{y}_{Fsjit} = \tilde{\phi}_{jt} + \tilde{\phi}_{it} + \tilde{\phi}_{is} - \lambda_s \widetilde{p}_{Fsjit} + \xi^d_{sjit} \tag{7}$$

$$\widetilde{p}^*_{Fsjit} = \tilde{\phi}_{jt} + \tilde{\phi}_{it} + \tilde{\phi}_{is} - \omega^*_s \widetilde{y}_{Fsjit} + \xi^s_{sjit} \tag{8}$$

This is subject to two sources of bias, endogeneity and selection. If tariffs are countercyclical, a negative correlation with varieties' productivity or demand shocks downward bias the estimates. Similarly, selection of inelastic products into treatment results in bias towards zero.

To deal with these, decompose tariffs into a protective and retaliatory component:

$$(\widetilde{1+\tau_{sjit}}) \in \{[(\widetilde{1+\tau_{s'j'it}})|\widetilde{\tau}^*_{s'j'it}], [(\widetilde{1+\tau_{sjit}})|\widetilde{\tau}^*_{s'j'it}]\}$$

Protective tariffs employed as instrument correlate with differences in productivity and demand shocks in sector s:

$$\mathbb{E}\left((\widetilde{1+\tau_{sjit}}) \times \{(\xi_{Asjit} - \xi^*_{Asjit}), (\xi^*_{\mu_{Hsjit}} - \xi_{\mu_{Fsjit}})\}\right) \neq 0$$

Similarly, protective tariffs also violates this condition, as these are placed in the same protected industries by the trade partner. In contrast, retaliation does not, as varieties' specific shocks are orthogonal across sectors. Therefore:

$$\mathbb{E}\left(\left[(\widetilde{1+\tau_{sjit}})|\widetilde{\tau^*_{s'j'it}}\right] \times \{(\xi_{As'j'it} - \xi^*_{As'j'it}), (\xi^*_{\mu_{Hs'j'it}} - \xi_{\mu_{Fs'j'it}})\}\right) = 0$$

Selection on the other hand depends on sector characteristics, i.e. on how elastic the products involved are. When inelastic products are selected into treatment, the estimates are downward biased.

This magnitude depends on the probability of these events. This, at the industry level, depends on price elasticity differentials and the average tariff rate faced. Industry and time fixed effects are employed to account for this.

Regardless of these controls, using trade policy as an instrument cannot recover the estimate for the average price elasticity. As it targets the two extremes of the elasticity distribution systematically, this can be used to set bounds of the average effect.

Protective tariffs can be used as an estimate for the lower bound. However, this is a conservative estimate as, due to endogeneity bias, the true value should be higher. On the other hand, retaliation estimates the upper bound. Having met the exogeneity condition, a consistent estimate for this is obtained.

VI Data

The dataset includes administrative records from the Canadian International Trade Division, comprising monthly data from 1988 to 2020 on Canadian imports at the HS-10 level. Each observation represents the import of an HS-10 good in a given month from a specific trade partner. The data include information on prices, quantities, and import duties collected at the border.

The advantage of this database lies in its detailed information on imported products. HS-10 imports represent the most disaggregated level at which trade data are reported, which is crucial for analysis since tariffs are applied at this specific tariff line. This granularity allows for a more precise examination of how prices and quantities respond to tariff changes.

This database offers a significant advantage over others by providing more detailed information. For instance, the TRAINS and the UN Comtrade databases generally offer data at the HS-6 digit level. In contrast, this database is more comparable to the USA counterpart (USA TRADE Online), which is frequently used in research analyzing the impact of the trade war in the United States.

For estimation purposes, data from 2017 to 2019 will be used. This period is particularly relevant as it captures Canada's retaliation against U.S. tariffs on steel and aluminum. The following section presents stylized facts that align with the key features discussed in the model section.

Stylized facts

This section tackles thee empirical facts present in the literature: (i) tariffs have a countercyclical profile, (ii) these are predominantly imposed on intermediate inputs, (iii) retaliation matches the tariff rates imposed by the counterpart, but shifts towards consumption goods.

To show some of these facts, I will also employ historic data of Canadian temporary trade barriers[9]. The tariffs in this database are expressed as a percentage of prices rather than values, as is typically reported.[10]

I will decompose these tariffs into protective and retaliatory components, using the definitions employed in Feinberg and Reynolds (2006, 2018), where retaliation is defined as a short-run response to a trading partner's protective measure.[11] This decomposition will allow me to show the different behaviors of these two components.

First, to address the countercyclical profile, focus on Canada's two most recent recessions. During these periods, I will analyze the timing of tariffs from the quarter at the peak, and two quarters around that period. Figure 1 shows this relationship:

[9] This information is taken from Bown (2016).This comprises information of Canada´s antidumping and countervailing duties between 1985 and 2016.

[10] The most common tool of temporary trade barriers is antidumping policies. These are measured in terms of the dumping margin, which is defined as the difference between the normal value and the export price, expressed as a percentage of the export price. This margin is applied to specific products to counteract dumping practices by a trade partner.

[11] Retaliation is defined as an action taken no more than a year after the original tariff increase by a trading partner.

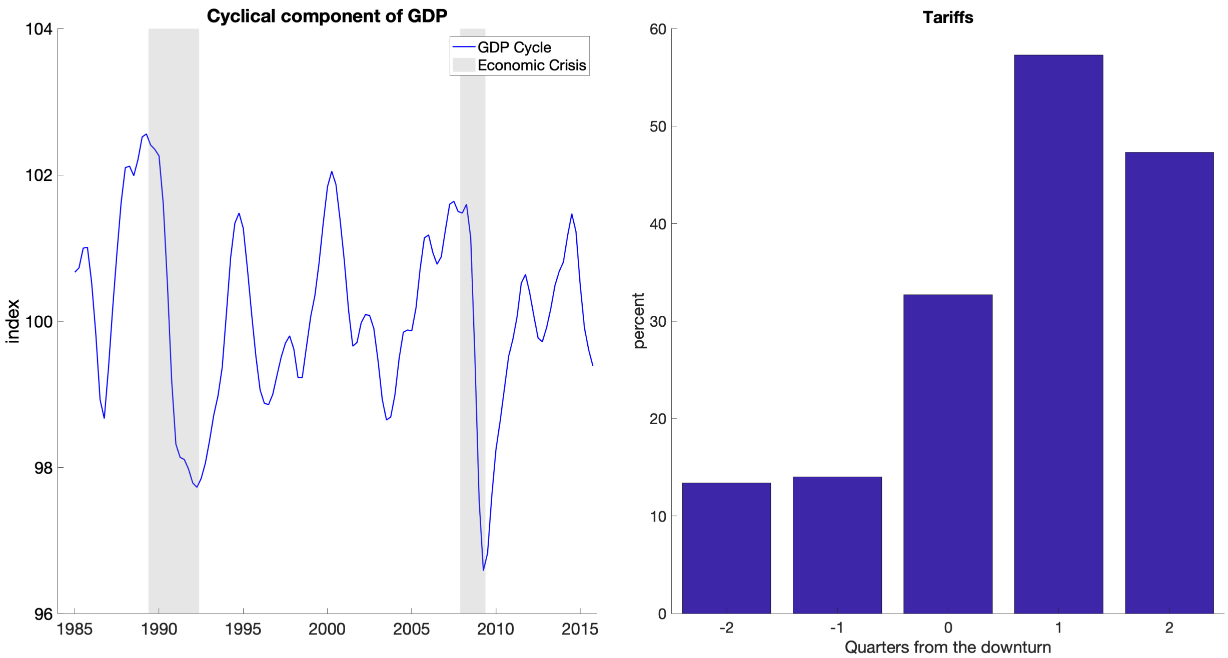

Figure 1: Endogenous tariffs

It is important to note that, in this graph, During economic downturns, countries tend to impose higher import tariffs against competitors. This indicates that tariffs are used as a discretionary tool to, for example, raise revenue during recessions.

Table Appendix A.I explores the relationship between the intensive and extensive margins. To do this, I classify periods as expansions or contractions, following the OECD's definition based on the cyclical component of quarterly GDP.[12]

The results of regressing tariffs on the contraction dummy indicator, both through OLS and a probit model, show that protective tariffs are about 10 percentage points higher during recessions and 20% more likely to be imposed. However, no significant effect is observed for the retaliatory component. This supports the conventional wisdom that protective tariffs are used as a stabilizing tool.

Second, import tariffs are predominantly imposed on intermediate inputs. Figure 2 shows that 84% of the cases involving temporary trade barriers are concentrated in these kind of

[12]The OECD defines contractions and expansions using the cyclical component of quarterly GDP.

goods:

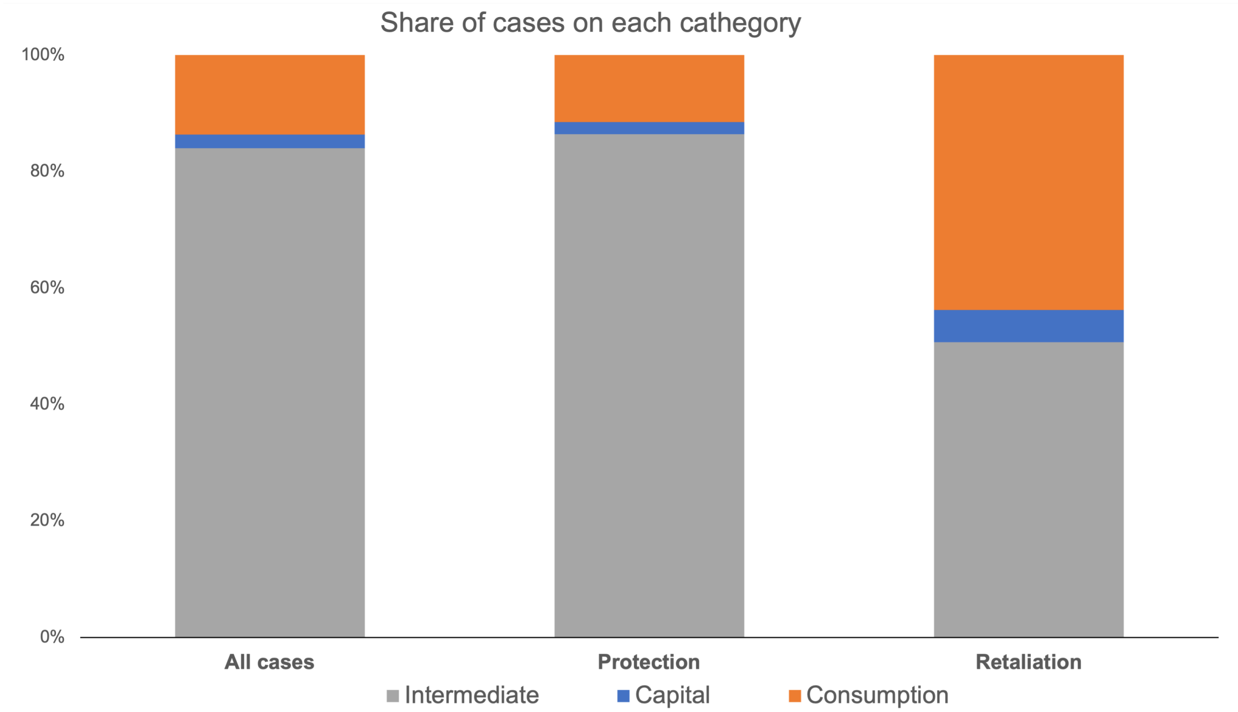

Figure 2: Composition of tariff's cases in Canada

Protective episodes focus heavily on intermediates, and more precisely, in the metal industry. this is the same behavior observed in the aggregate as protections accounts for a little more than 90% of cases in the sample. However, this sharply contrasts with those of retaliation, as half of the cases concentrate on consumption goods.

Relative to these, intermediate goods are harder to substitute in the short run, as they are used as inputs for others industries. Long terms supply contracts between firms delays the adjustment of these factors. Protecting relatively inelastic industries implies higher sources of government's revenue, or alternatively, for a given amount of revenue, the distortion is minimized in these sectors. These are some of the decisions when government maximizes revenue.

Third, during retaliation, tariff rates are matched with those of the counterpart. As the retaliatory response is regulated by the WTO, tariffs are set reciprocally to those imposed by the trading partner. For example, during the trade war, Canada mirrored the 25% and 10% tariffs imposed by the US, while keeping the average rate at a similar level—16% in the US and 15% in Canada. The left panel of Figure 3 illustrates this.

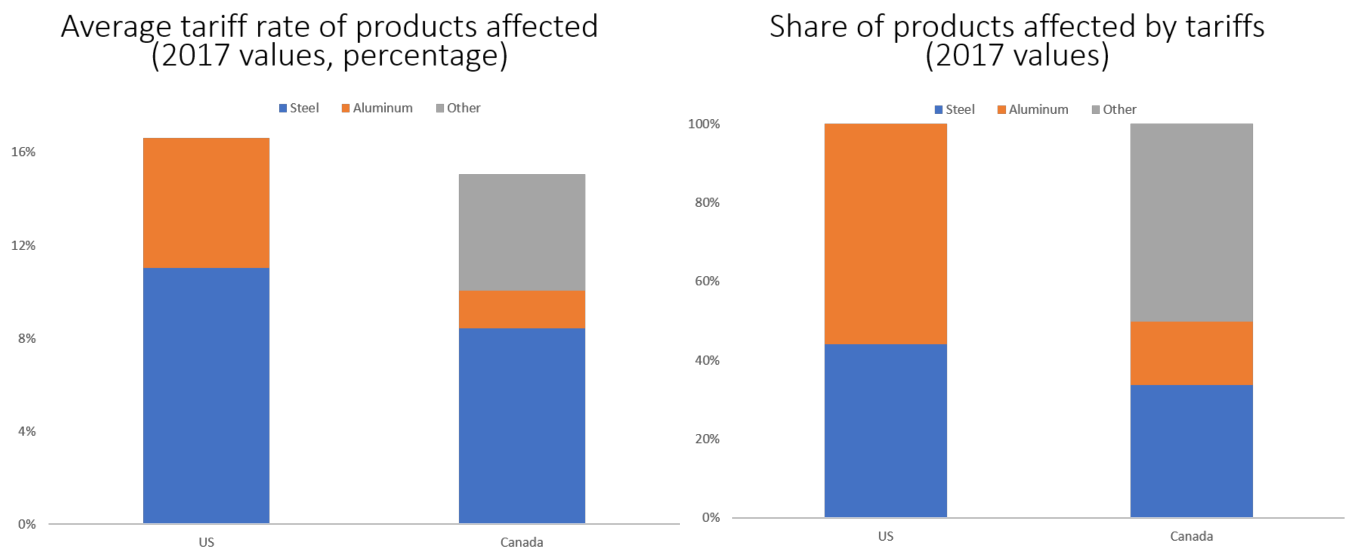

Figure 3: Canadian retaliation against US protective tariffs

Each bar also reflects the contribution to the average tariff by type of good, weighted by the 2017 import share value. The right panel portrays the share of goods targeted by Canadian retaliation. The basket of goods is equivalent in 2017 values to the products covered by US protectionism. However, half of the retaliation was directed at sectors different from those protected. This leads to the fourth and final empirical fact.

Finally, the retaliatory response shifted towards consumption goods. As shown in Table 1, which organizes the products subject to this policy by economic activity using the BEC indicator, tariffs on steel and aluminum were set at 25% and 10%, respectively. These are the products protected by the US that were also targeted by Canada.

Industries outside these sectors were subject to 10% tariffs, primarily targeting final consumption goods, which represent around 40% of the value share. These include foods and beverages, as well as durable and non-durable goods. Appendix A.II provides a detailed breakdown of these goods.

Table 1: Retaliatory tariffs by activity sectors

Type of good (BEC Indicator)	Products (units)	Value (2017 BUS$)	Value share (percent)	Tariff (percent)	Av. Tariff rate (weighted, %)
Steel	329	4,326	34	25	8.5
Aluminum	41	2,048	16	10	1.6
Food and beverages	46	2,397	19	10	1.9
Consumer goods, durables	59	1,239	10	10	1.0
Consumer goods, non-durables	25	1,337	10	10	1.0
Transport equipment, non-industrial	19	511	4	10	0.4
Capital goods (except transport)	4	536	4	10	0.4
Other Industrial supplies	23	368	3	10	0.3
	546	12,763			15.1

This behavior, as also highlighted in the second empirical fact, suggests that it is optimal for the government to target goods with different characteristics. More importantly, compared to protectionist measures, these goods tend to have higher elasticity. The rationale behind the government's objective function is to target goods from competitors that are strategically significant to the foreign government. This strategy aims to decrease demand, thereby harming both competitors and the trade partner. Consequently, this approach increases the likelihood of tariff withdrawal, a feature that is incorporated into the model.

Event study

This section conducts an event study to examine the presence of pre-trends between targeted and untargeted varieties. Taking period zero as the point when Canada implemented the retaliation (July 2018), I analyze the evolution of the data six months before and after this event. Periods earlier than six months before (-6) are excluded, while those beyond six months after (+6) are grouped together. The regression specification is as follows:

$$\ln(y_{sjit}) = \phi_{ji} + \phi_{jt} + \phi_{it} + \sum_{h=-6}^{6} \beta_{0h} \mathbb{1}\{\text{event}_{sji} = 1\} \\ + \sum_{h=-6}^{6} \beta_{1h} \mathbb{1}\{\text{event}_{sji} = 1\} \times \text{target}_{sji} + \epsilon_{sjit}$$

where the first three terms on the right-hand side represent product-country, product-time, and country-time fixed effects. This setup ensures that β_{1h} is identified using variation between target and untargeted varieties. Dummy variable "target_{sji}" captures those varieties affected by tariffs, while "event_{sji}" is the tariff enactment date. The dependent variables, all in logs, include import values, quantities, duty-inclusive prices, and duty-exclusive prices. Figure 4 illustrates these results:

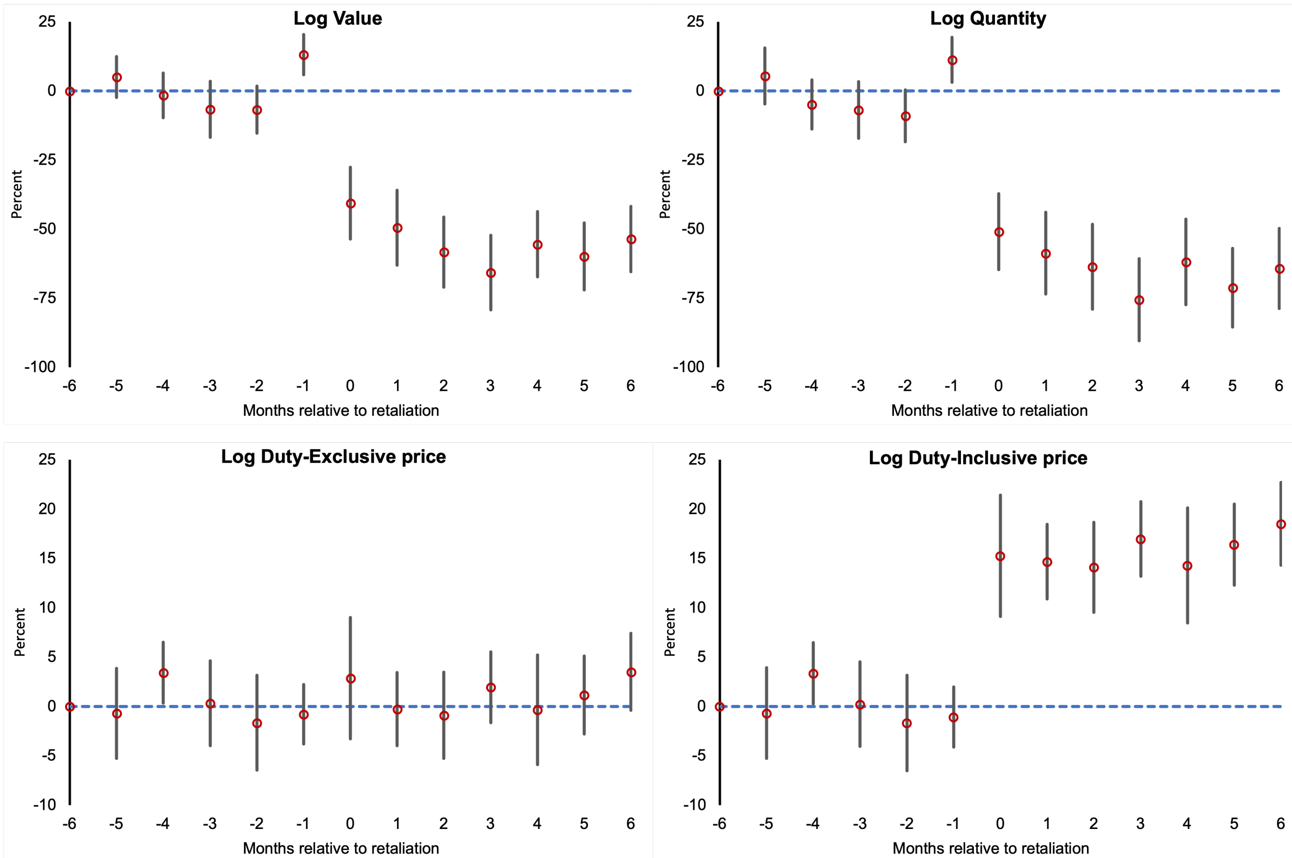

Figure 4: Event study

The results show a significant drop in values at the time of retaliation, approximately 50%, which is primarily explained by a similar decrease in quantities. The duty-exclusive price remains unchanged, indicating full pass-through from tariffs to duty-inclusive prices, as foreign producers do not absorb the tariffs by reducing markups. This outcome also suggests a flat supply curve, consistent with the insignificant foreign export supply elasticities reported in the literature.

Another important observation is the absence of significant pre-trend dynamics in any of the cases. However, mild anticipation effects are noted in the month preceding the tariff's enactment, particularly visible in the graphs for import values and quantities. This behavior is largely driven by the steel sector. Appendix A.III decomposes the dynamics of these variables into protective and retaliatory tariffs.

From this analysis, it is evident that the anticipation effect is entirely explained by the protective component, as the same behavior is observed in both values and quantities during period -1. Retaliatory tariffs do not exhibit this issue, and therefore, this is not a concern when using them as an instrument.

VII Results

This section presents the baseline results for the estimation of the elasticity, and it's organized as follows. First, estimating using all tariff changes as an instrument. Second, the decomposition between protective and retaliatory tariffs, and finally, the welfare costs of tariffs.

The estimations controls for a series of fixed effects at the product-time, country-time and country-sector level. The first controls for seasonal patterns or other product-specific dynamics, the second for aggregate variables, such as exchange rates. The last one accounts for sector characteristics at the country level, such as the necessary ones for selection. All variables are expressed in log differences, while the duty-inclusive price is instrumented using tariff changes. Table 2 shows the baseline estimation:

Table 2: OLS and IV estimation using all tariff changes

	OLS		IV - All Tariffs	
	λ_s	ω_s^*	λ_s	ω_s^*
$\hat{\beta}$	-0.76	-0.22	-2.37	-0.05
se($\hat{\beta}$)	(0.02)	(0.00)	(0.33)	(0.03)
Product x time FE	Yes	Yes	Yes	Yes
Country x time FE	Yes	Yes	Yes	Yes
Country x sector FE	Yes	Yes	Yes	Yes
1st-stage F			165	65
R2	0.27	0.27	.	.
N	2,409,339	2,409,339	2,409,339	2,409,339

The OLS coefficient is -0.76, heavily biased due to endogeneity. When using tariffs as instrument, the coefficient is -2.37, higher (in absolute terms) than the OLS counterpart. Regarding the supply elasticity this is negative and marginal in both cases, and not significant in the case of IV. This implies and elastic supply curve and therefore, the pass-through of tariffs into duty inclusive prices is complete.

Using the model's result, express the average effect on trade values as:

$$\left(\widetilde{p}^*_{Fsjit} + \widetilde{y}_{Fsjit}\right) = -\left[\frac{\lambda_s(1+\omega_s^*)}{1+\omega_s^*\lambda_s}\right] (\widetilde{1+\tau_{sjit}}) \approx -33\%$$

Employing the Canadian average tariff increase, along with the estimates from the table above, leads to an average drop of 33%. This is driven by the demand side, as the supply elasticity is zero.

Compared to Fajgelbaum et al. (2020) OLS estimate of -1.01, this is close to what they obtained. In their case, the coefficient is -2.5, similar to the estimate obtained in this paper. With regard to the supply elasticity, they also find a negative but insignificant result. Taken together, they imply a drop in trade values of approximately 32%, close to this paper's finding.

Tariff changes mask the effect of the retaliatory component. To see this, use the decomposition to run the same regressions. Table 3 show the results:

Table 3: IV estimation for tariff decomposition

	IV within-sector		IV cross-sector	
	λ_s	ω_s^*	λ_s	ω_s^*
$\hat{\beta}$	-1.87	-0.12	-5.23	0.10
se($\hat{\beta}$)	(0.28)	(0.04)	(1.45)	(0.05)
Product x time FE	Yes	Yes	Yes	Yes
Country x time FE	Yes	Yes	Yes	Yes
Country x sector FE	Yes	Yes	Yes	Yes
1st-stage F	163	46	21	24
R2	.	.	.	.
N	2,409,339	2,409,339	2,409,339	2,409,339

The -2.37 result is driven by the elasticity of the protective component, which is -1.87. In effect, the downward-bias dominates the aggregate outcome. This however, can be used as a conservative lower bound ($\hat{\lambda}_L$) for the average effect.

However, retaliatory tariffs consistently estimate the upper bound ($\hat{\lambda}_H$). The estimated elasticity is -5.2, more than double the magnitude of the lower bound. To discard the possibility that lower and upper bounds are equal, I run the following test:

$$H_0 : \hat{\lambda}_L = \hat{\lambda}_H$$

$$\mathrm{F} = 5.2, \quad \mathrm{P}_v = 2.4\%$$

At 5% confidence level, the test rejects the null hypothesis that both bounds are equal. This creates a meaningful set for the average elasticity.

On the supply side, protective tariffs delivers a negative estimation for this elasticity. This is an indication that, when these are used as an instrument, endogeneity concerns are potentially still present. However, retaliatory tariffs yield a positive estimate, but small. This implies supply factors are not key to explain average trade effects.

To illustrate the results, Figure 6 portrays a visual representation of them:

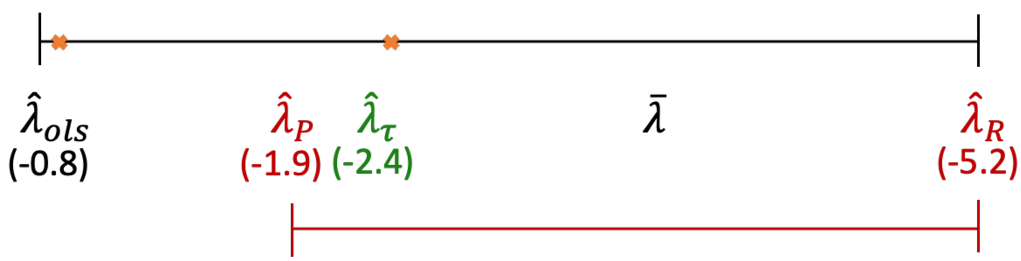

Figure 5: Average elasticity bounds

The average elasticity lies in the interval of -1.9 to -5.2, marked in red. Within these bounds is the elasticity estimated using all tariff changes, which is closer to the lower end of the interval. The location of the average elasticity depends on the distribution, which is unknown. The OLS estimate, heavily downward biased, is outside these bounds. Finally, the orange dots represent the estimates from Fajgelbaum et al. (2020), with the OLS on the left and the IV on the right, which are -1 and -2.5 respectively.

Robustness checks

The result remain robust to several specifications. One of them is that if these effects are driven by trade between Canada and the US. Certainly, tariff rates were raised towards this trade partner, keeping the remaining ones unchanged. To isolate this, interact the variables with a US dummy indicator and re-run the regressions:

Table 4: Robustness - Estimation using US tariffs

	IV within-sector		IV cross-sector	
	λ_s	ω_s^*	λ_s	ω_s^*
$\hat{\beta}$	-1.69	-0.11	-5.6	0.10
se($\hat{\beta}$)	(0.22)	(0.04)	(1.67)	(0.04)
Product x time FE	Yes	Yes	Yes	Yes
Country x time FE	Yes	Yes	Yes	Yes
Country x sector FE	Yes	Yes	Yes	Yes
1st-stage F	217	55	24	26
R2	.	.	.	.
N	2,409,339	2,409,339	2,409,339	2,409,339

Table 4 shows that the estimates are very close to the ones obtained in the result. Moreover, the null hypothesis $H_0 : \hat{\lambda}_L = \hat{\lambda}_H$ is rejected: F = 5.3 (P_v = 2.2%).

This suggests that the estimations using the whole sample are driven by the retaliation against the US. Tariffs against other trading partners remained unchanged during the trade war, and tariffs on targeted HS-10 products increased only for the US. This explains why the results are entirely driven by this counterpart.

To explore if tariffs against the rest of the world play a role in the results, I will run the regressions using these and controls. Table 5 illustrates this:

Table 5: Robustness - Estimation using US tariffs with controls

	IV - Protective		IV - Retaliatory	
	λ_s	ω_s^*	λ_s	ω_s^*
$\hat{\beta}$	-1.76	-0.13	-5.5	0.10
se($\hat{\beta}$)	(0.23)	(0.04)	(1.62)	(0.04)
Product x time FE	Yes	Yes	Yes	Yes
Country x time FE	Yes	Yes	Yes	Yes
Country x sector FE	Yes	Yes	Yes	Yes
1st-stage F	216	55	24	26
R2	.	.	.	.
N	2,409,339	2,409,339	2,409,339	2,409,339

The estimation for the elasticities remains roughly the same with respect to the previous results. The standard error however, are improved marginally. Tariffs against the rest of competitors are therefore not relevant for explaining the elasticity estimations. This is in line with the argument made before, as the dynamics are entirely explained by Canada and the US.

Welfare Effects

Welfare implications are a nonlinear function of trade elasticities. Taking averages between the two bounds could over-predict or under-predict the welfare consequences of tariffs.

The deadweight loss resulting from the tariff can be quantified using the Harberger triangles formula. As the export supply elasticity approaches zero, the average deadweight loss exhibits a linear relationship with the import demand elasticity. Figure 7 illustrates this:

This calculation incorporates the model's equations and estimated elasticities of demand and supply. Given that the export supply elasticity approaches zero, the average deadweight loss exhibits a linear relationship with the import demand elasticity. Figure 7 illustrates this:

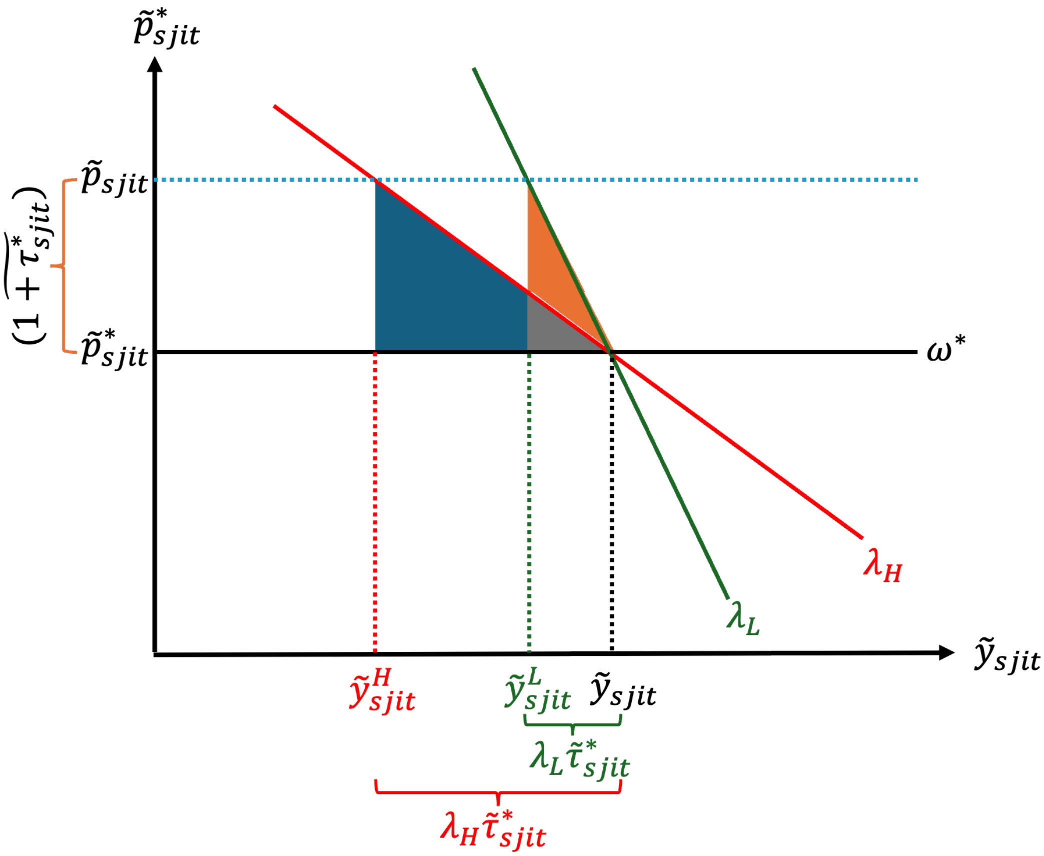

Figure 6: Welfare cost of tariffs

The deadweight loss (DWL) in the case with a low demand elasticity (λ_L) is the sum of the gray and orange areas. In the case of an elastic demand elasticity (λ_H), it's the gray and blue areas. As λ_H is twice as large as λ_L, the welfare cost is doubled.

To calculate this, use the model's equations and estimated elasticities of demand and supply. The DWL can be expressed as:

$$\widetilde{DWL} = \frac{1}{2}\left(p^*_{sjit} \times y_{Fsjit}\right)\left(\widetilde{\tau}_{sjit} \times \widetilde{y}_{Fsjit}\right) = -\frac{1}{2}\lambda_s \left(p^*_{sjit} \times y_{Fsjit}\right)\left[\widetilde{\tau_{sjit}} \times \left(\widetilde{1+\tau_{sjit}}\right)\right]$$

Since the estimate for elasticity is approximately three times higher during retaliation compared to protection, keeping other factors constant, the welfare cost is proportional to this difference. Consequently, if tariff rates are the same in both cases, the deadweight loss is \$7.6 billion compared to \$2.7 billion.

However, in this particular case, Canada applied an average tariff rate of 20% on the protected industries and 10% on the remaining ones. Taking into account these differences, the deadweight loss remained the same between the two scenarios. Table 6 summarizes these findings:

Table 6: Tariff's welfare costs

Imports	$\hat{\lambda}$	$\Delta\tau$	DWL
12.4b	-2.5	16.6	11b
12.4b	-5.2	16.6	22b

Regarding the United States, the value of imports affected by tariffs, based on 2017 figures (prior to the trade war), totaled \$12.4 billion. The Trump administration's tariff policies resulted in an average tariff rate increase of 16.6%. To assess the impact, we employ the estimated demand elasticity for both the lower and upper bounds

These findings suggest that the welfare losses in the United States resulting from the Trump administration's tariffs may be significantly larger than previously reported in the literature—potentially twice as high. Using a lower bound elasticity of -2.5, as reported by Fajgelbaum et al. (2020), and an upper bound elasticity of 5.2, we find that the estimated deadweight loss increases from \$11 billion to \$22 billion.

While the estimated welfare losses show a substantial increase, they remain relatively modest at the aggregate level. In the context of total U.S. imports for 2017, the impact reflects an increase from 0.4% to 0.8% of total import value. However, at the industry level, these changes can be quite significant. For instance, in the metal industry, the impact escalates from 20% to 40% of the sector's output.

VIII Conclusion

This paper analyzes the effects of tariffs on Canada's trade volumes and prices. A key driver of these effects is the price elasticity of import demand, which is why the identification strategy plays a crucial role.

Using tariffs an exogenous variation to estimate the demand equation raises endogeneity concerns. Protective tariffs are correlated with differences in productivity and demand shocks between home and foreign variety producers. This results in a downward bias of the estimate.

Retaliatory tariffs on industries distinct from those protected by the trading partner, are used as an exogenous variation instead. A key aspect of the identification strategy, is that when countries retaliate, they apply the same tariffs magnitudes the trading partner imposed on them.

An important aspect to take into account is that there is selection in the instrument. Retaliatory tariffs are applied systematically on relatively elastic goods. This depends on sector characteristics, and therefore, is controlled by industry fixed effects in the estimations.

The results show that the elasticity is -5.2. This is twice as large as other reports in the literature. As there is selection in the policy design of tariffs, this constitutes a local treatment effect and an upper bound of the elasticity distribution.

As trade policy is unable to point identify the average elasticity, I put forward an approach to set bounds on it. Differentiate Canadian cross-sector retaliatory tariffs from those imposed in the protected industries. Use the latter as a proxy for protectionism to estimate the lower bound.

Together, the average elasticity ranges from -1.9 to -5.2. If the goal is to study the average effect of an exogenous trade shock, it will be within the boundaries implied by this interval.

Another important implication, is that papers using Trump tariffs to identify trade elasticities, are estimating the lower bound (in absolute value) of the interval defined above. Nevertheless, the average elasticity is probably much higher than that.

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Appendix

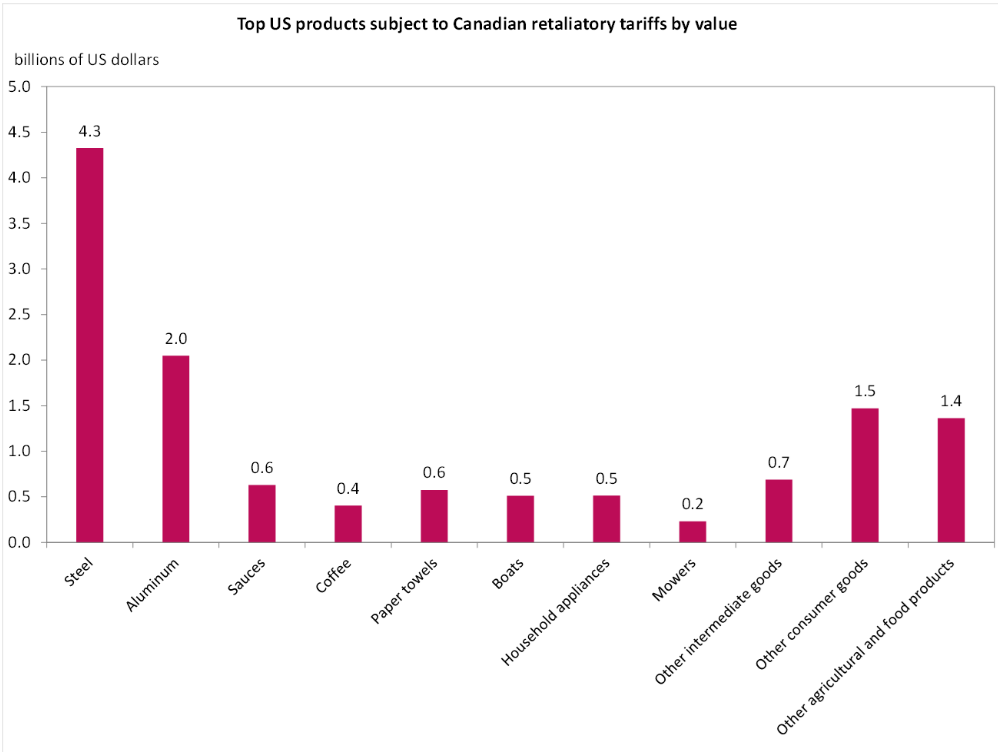
A.I Extensive and Intensive margin of Import tariffs

Table 7: Protective and Retaliatory tariff's business cycle behavior

Series	Indicator	Coefficient	SE
Import tariffs	Contraction (levels)	6.1 (*)	3.49
	Contraction (probability)	0.09	0.08
Protective tariffs	Contraction (levels)	9.7 (***)	3.72
	Contraction (probability)	0.18 (**)	0.08
Retaliatory tariffs	Contraction (levels)	-2.6	2.66
	Contraction (probability)	-0.12	0.08

Notes: (***): $p < 0.01$, (**): $p < 0.05$, (*): $p < 0.1$. Standard errors are calculated using Newey West estimator with four lags. For efficiency reasons, time dummies are used to control for the tariffs of the top 5% upper tail. Results remain robust to their inclusion.

A.II Retaliation decomposition by products



A.III Event study decomposition