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Abstract

With rising barriers to trade with the United States, it is important to understand how Canadian firms adjust to tariffs. To provide insight, this paper examines the effects of U.S. tariffs imposed on Canadian steel and aluminum products from June 1, 2018, to May 20, 2019. Over the months tariffs were imposed, the value of tariffed steel and aluminum exports fell by about 50%, with U.S. importers paying the full cost of tariffs through higher prices. Exports of steel declined as exporters affected by tariffs responded by exiting the U.S. market and halting operations. Exports of aluminum declined as exporters affected by tariffs adjusted by reducing their exports, rather than severing supply chains by exiting the U.S. market. Across the 2017 cohort of steel and aluminum exporters affected by tariffs, gross output and employment levels were at least maintained from 2017 to 2019. Moreover, steel and aluminum producers affected by tariffs that continued to export to the United States increased investment by about 60%, which far outpaced firms that exited the U.S. market (-36% and +37% for steel and aluminum producers, respectively). Lastly, firms that left the U.S. market tended to have higher debt levels relative to those that continued, suggesting a link between the health of balance sheets and firms' ability to continue as exporters. In the face of higher tariffs, declining trade (in value and volume) is expected. The resilience of steel and aluminum exporters is a more surprising outcome, and the lessons learned from this are more tentative given that current tariffs are higher, more uncertain and potentially more persistent.

Keywords: tariffs, prices, employment, investment, firm survival

Authors

Mark Brown, Wulong Gu and Jesse Tweedle are with the Economic and Social Analysis and Modelling Division, Analytical Studies and Modelling Branch, at Statistics Canada.

Introduction

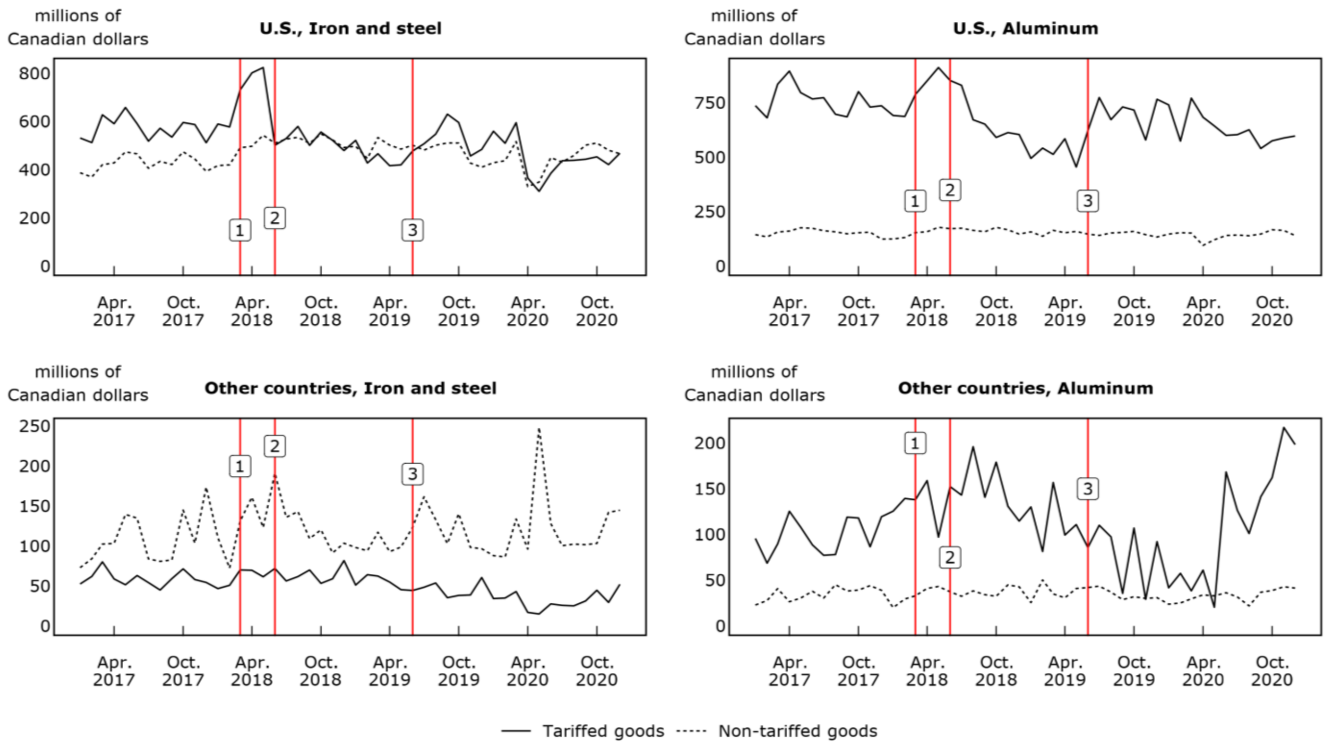
It will take some time to fully determine the degree and scope of U.S. tariffs, let alone their impact on the Canadian economy. Nevertheless, some insight into these latest tariffs can be gained by examining the effects of tariffs imposed in the recent past, namely, the 25% tariffs on Canadian steel and 10% tariffs on Canadian aluminum imports imposed from June 2018 to May 2019.[1] These steel and aluminum tariffs are especially relevant because the United States has once again imposed them, this time at an initial rate of 25% and rising to 50% at the time of writing. With this in mind, the magnitude, uncertainty and possibly longer duration of current tariffs may affect a firm's decision making differently than those imposed from 2018 to 2019. Hence, while previous experience provides some perspective, it should be treated with some caution.

To set the scene, Figure 1 reports monthly Canadian exports to the United States and other countries of tariffed[2] and non-tariffed steel and aluminum products from January 2016 to December 2020 (see also Statistics Canada, 2019). The first vertical red line indicates the month the tariffs were announced (March 2018), the second vertical line indicates the month they were imposed (June 2018) and the third vertical line indicates the month they were removed (May 2019).[3] In current dollar terms, exports to the United States of tariffed and non-tariffed steel and aluminum goods followed a relatively steady path until March 2018, after which there was a brief spike in (to-be) tariffed exports, with exports of aluminum increasing by 33% and steel by 43% from February to May 2018. These increases likely resulted from the buildup of U.S. inventories to avoid impending tariffs. This was followed by a decline in tariffed exports of about 50% for aluminum and steel from May 2018 to May 2019. From February 2018 to May 2019, a span that encompasses the announcement and tariff periods, exports of tariffed aluminum and steel products fell by 34% and 27%, respectively. Non-tariffed exports to the United States remained largely unchanged over the tariff period.

Exports to countries other than the United States of the same set of aluminum and steel products tariffed by the United States did not compensate for the fall in U.S. exports. Indeed, their nominal value also declined over the tariff period. Why this occurred is open to question. However, this pattern would be consistent with increased international competition, as the United States imposed steel and aluminum tariffs on other countries, forcing their producers to seek alternative markets at home and abroad. Exports of non-tariffed steel and aluminum products to countries other than the United States show no consistent pattern.

1. Statistics Canada (2019) provides an initial analysis of the response to the imposition of U.S. and Canadian tariffs on aluminum and steel from 2018 to 2019. The present analysis builds on this work by implementing models to test the influence of tariffs on the value, quantity and price of tariffed steel and aluminum exports to the United States and by examining how aluminum and steel firms affected by tariffs adjusted over the period they were in place. The effective tariff rate may be lower than the statutory rate because of firm-level exemptions given by the U.S. government.
2. The United States imposes tariffs at the 10-digit Harmonized System (HS) level, but exports to the United States are reported at the more aggregate 8-digit HS level (HS8). In one case involving aluminum products, tariffs vary within an HS8 category. For the Canadian international merchandise trade data plotted in Figure 1, this HS8 category is classified as untariffed.
3 In terms of precise dates, the tariffs were announced on March 1, 2018, implemented on June 1, 2018 and removed on May 20, 2019.

Figure 1
Export value of aluminum and steel products by destination, tariffed and non-tariffed goods, January 2016 to December 2020



Note: 1: U.S. tariffs start (excluding Canada, Mexico and the European Union). 2: U.S. tariffs start on Canada, Mexico and the European Union. 3: U.S. tariffs on Canada stop.
Source: Statistics Canada, Canadian International Merchandise Trade.

The apparent impact of tariffs on Canadian exports of aluminum and steel to the United States raises questions regarding the true magnitude of these tariffs' effects on the value and volume of trade and, importantly, how producers adapted:

- **How much did the value and volume of tariffed Canadian exports of steel and aluminum fall because of the tariffs, and did they recover after the tariffs were removed? Were tariffs fully passed through to U.S. buyers, or did exporters reduce export prices?**

  Figure 1 provides a picture of the trends in exports in the run up to and through the imposition of tariffs, but more analysis is needed to better identify their impact on the value and volume of trade and export prices. There is strong U.S. evidence that tariffs affected the value of U.S. imports from abroad, with imports falling 25% to 30% (Amiti et al., 2019). Regarding prices, recent evidence on U.S. imports (Amiti et al., 2019 Fajgelbaum et al., 2020; Cavallo et al., 2021) indicates tariffs were almost completely passed through to importers—that is, exporters did not reduce their prices in compensation for the tariffs paid by importers.

- **How did firms adapt to the tariffs? Did all firms continue to export to the United States but export less (adaptation through the intensive margin), or did some exit the U.S. market altogether (adaptation through the extensive margin)?**

  As supply chains are costly to establish (Bernard and Moxnes, 2018), recovering from the tariffs is expected to be less costly if firms can maintain supply chain links by adjusting through the intensive margin.

- **How did firms perform in the face of rising tariffs? Did firms affected by tariffs experience falling output, employment and investment?**

  While it would be reasonable to expect firms with falling exports to the United States to reduce output, lay off employees and curtail investment plans, this may not be the case, because they may seek out alternative domestic and overseas markets and pursue efficiency gains to compensate for falling competitiveness in the U.S. market.

- **Were firms with higher debt-to-asset ratios and lower profits more likely to exit the U.S. market or to cease operations over the period the tariffs were in place? In other words, is financial strain associated with firms selecting out of the U.S. market and shuttering operations?**

To answer these questions, trade and longitudinal firm-level data are used. The next section briefly discusses the key data sources. These data include both Canadian and U.S. trade data and, most importantly, linked firm and trade data that allow tariffed exporting firms to be identified and tracked through time. This is followed by a discussion of the findings, organized around these four topics of investigation. The paper finishes with a brief conclusion.

Data

The analysis uses several different data sources. Trade flow data are derived from Statistics Canada's Canadian International Merchandise Trade Database and the U.S. Census Bureau's USA Trade Online dataset. The latter provides the 10-digit Harmonized System (HS) commodity detail necessary to fully distinguish between tariffed and non-tariffed U.S. steel and aluminum imports. It also provides measures of the quantity of goods exported and therefore a means to measure prices.

Firm-level data are from the National Accounts Longitudinal Microdata File, which is linked to Trade by Exporter Characteristics data. Exporters are defined as firms within the top 10th percentile of U.S. export value among all firms that exported tariffed goods to the U.S. market. Firms below this threshold—those with minimal export activity—are classified as non-exporters. Notably, this top decile of firms accounts for approximately 99% of total Canadian exports to the U.S. market, making it a representative and meaningful definition of exporters. This classification approach is consistent with common practices used in the construction of extended supply and use tables, where firms are similarly divided into exporters and non-exporters based on export intensity. Only exporters of tariffed goods as defined at the eight-digit HS level are included.

Exporters affected by tariffs (hereafter "tariffed exporters") are followed through the period from 2017 to 2019. They include firms that entered and exited the U.S. market. Among firms that exited the U.S. market, those that ceased operations are also identified. Hence, both the intensive margin (adjustment to export levels by continuing exporters) and the extensive margin (adjustment to export levels by entering and exiting exporters) can be measured, as well as the financial characteristics of these firms (e.g., debt-to-asset ratios and gross margins). Furthermore, the performance (i.e., output, employment and investment) of the 2017 cohort of tariffed exporters is measured from 2017 to 2019. Since tariffs were lifted on May 20, 2019, performance measures partially capture the degree that tariffed exporters were able to recover in the latter half of 2019.

Results

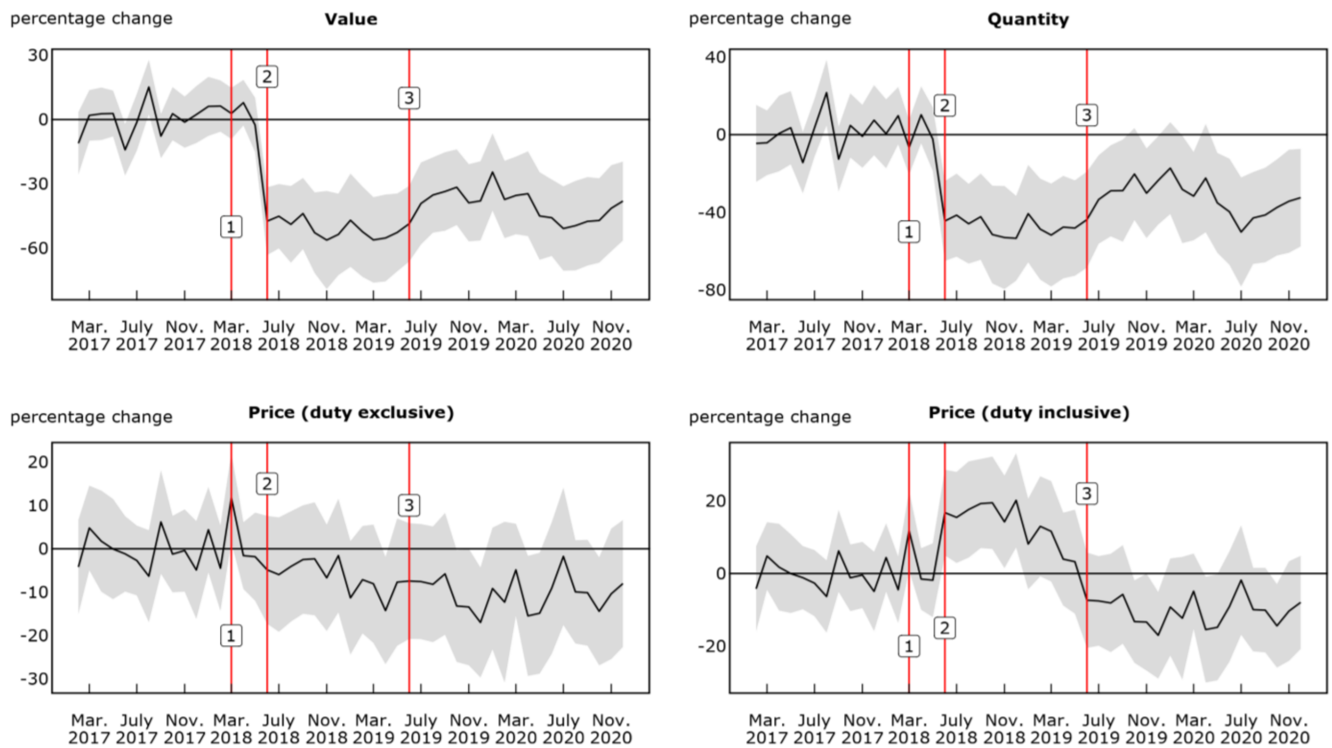
The key questions are how tariffed steel and aluminum producers responded over the nearly 12-month period that tariffs were imposed and what the consequences of these decisions were. Firms can decide to continue or exit the U.S. market. If they remain in the export market, they must decide whether to compensate for the tariffs by reducing their prices. If firms exit the U.S. market, do they continue and rely on domestic and other foreign markets or do they decide to shut their operations? Lastly, what are the consequences for firms in terms of revenues, employment and investment, and what are the financial characteristics of tariffed exporters that continue to export to the United States compared with those that exit?

Price and quantity response to tariff changes

At issue is whether the value of trade dropped because the price of steel and aluminum fell and/or because the volume of trade fell. As noted above, recent evidence suggests tariffs were almost completely passed through to U.S. importers (Fajgelbaum et al., 2020; Cavallo et al., 2021). Figure 2 presents the modelled effect of tariffs on the value, volume and price (duties excluded and included) of steel and aluminum combined (see the Methodology appendix for more details on the estimation). The influence (treatment effect) of tariffs is identified by comparing the export trends of the tariffed and non-tariffed steel and aluminum products before and after the tariffs were imposed.[4] If the tariffs had an impact, those trends would be expected to diverge—this is indeed the case. Relative to non-tariffed steel and aluminum exports from Canada, the value and volume of steel and aluminum exports fell by about half after tariffs were introduced. This result is similar in magnitude to Bennett and Hernandez's (2024) analysis of the effect of Canadian tariffs imposed on imports of steel and aluminum from the United States over roughly the same period. There was no statistically significant change in the price (before adding duties) during this time. Consistent with this finding, the price plus duties increased by a statistically significant amount, approximately matching what would be expected based on the tariff rate. The evidence points to tariffs being fully passed through to importers in the form of higher prices (see Table 3). While there was some recovery in the volume of trade after the tariffs were removed in May 2019 and prices plus tariffs returned to pre-tariff levels, the volume of trade did not fully recover and remained significantly below pre-tariff levels.

4. The effect of tariffs on steel and aluminum is based on an event study framework, where trends in the value, volume and prices of tariffed goods (treated) are compared with those of goods that have not been tariffed (untreated). The non-tariffed steel and aluminum products include those exported to the United States from Canada, where non-tariffed Canadian exports are used as a basis of comparison. Tariffed goods at the 10-digit HS level that experienced zero trade during one or more months over the study period were excluded from the analysis. They accounted for over half of trade by value, raising concern that the estimates in Figure 2 are biased toward zero. However, when exports were measured at a more aggregate level (the four-digit HS level), including a larger portion of tariffed exports, the results were qualitatively unchanged when examining the value of trade (see the Methodology appendix). The volume and price effects cannot be measured at the four-digit level.

Figure 2
Estimated effect of tariffs on the monthly value, volume (quantity) and export price (with tariffs excluded and included) of steel and aluminum, February 2017 to December 2020



Note: 1: U.S. tariffs start (excluding Canada, Mexico and the European Union). 2: U.S. tariffs start on Canada, Mexico and the European Union. 3: U.S. tariffs on Canada stop. The black line displays the point estimate of the effect for each month, and the grey area displays the 95% C.I. for each point estimate.
Source: Authors' calculations; United States Trade Online.

Intensive and extensive margins of adjustment

Of course, these aggregate trends reflect the decisions of individual firms in the face of rising tariffs and the consequent fall in the volume of exported steel and aluminum. Firms can choose to maintain their presence in the U.S. market but reduce their export levels (intensive margin), or they may choose to exit the U.S. market (extensive margin). The latter may have longer-term effects—it may take time to re-establish buyer–supplier relationships (Bernard and Moxnes, 2018) if tariffs are lifted, and exiting the U.S. market may also coincide with plant closures.

To illustrate the potential impacts of tariffs at the firm level, Table 1 decomposes the decline in exports to the United States from 2017 (the year before the tariffs were imposed) to 2019 (the year tariffs were removed after five months) for the top decile of both steel and aluminum producers in 2017 that faced tariffs on their exports. Over this period, Canadian steel producer exports to the U.S. market declined by 8.2%. Note that this decline in exports is relatively small compared with what the monthly data would suggest (see Figure 1). However, steel exports at least partially recovered after tariffs were lifted in 2019, and this would have muted some of the decline measured on an annual basis. Most of the 8.2% decline (27.7 percentage points) was attributable to exporters exiting the U.S. market. A smaller portion of the decrease resulted from the decline among continuing exporters (5.5 percentage points).

There was a high exit rate among Canadian exporters. By 2019, 29.6% of firms that had exported to the United States in 2017 had ceased exporting to the country, either by exiting production entirely or by shifting their focus to other export markets or to the domestic market. The exit rate from the U.S. market was much higher than the exit rate in the pre-tariff period from 2015 to 2017.

Table 1
Changes in Canadian steel and aluminium exports to the United States and non-U.S. markets among tariffed exporters, 2017 to 2019

	Steel			Aluminum		
	Entry/exit rate	U.S. exports	Non-U.S. exports	Entry/exit rate	U.S. exports	Non-U.S. exports
			percent			
Growth in exports	…	-8.2	-17.5	…	-15.9	-3.3
Contribution from:						
Continuing exporters	…	-5.5	-18.2	…	-15.5	-3.2
Net turnover: Entrants and exiters	…	-2.7	0.7	…	-0.4	-0.2
Entrants to U.S. export market	26.2	25.0	9.5	31.3	3.2	0.1
Exiters from U.S. export market	29.6	-27.7	-8.8	36.1	-3.6	-0.3
Exiter continuers	25.9	-5.8	0.0	31.9	-1.5	-0.3
Exiter exits	3.7	-21.8	-8.8	4.2	-2.1	0.0

… not applicable

Note: Exiter continuers are firms that exited the U.S. market but continued operating.

Source: Statistics Canada, authors' calculations.

As shown in Table 1, Canadian exports of aluminum to the U.S. market declined 15.9% from 2017 to 2019. Again, the annual firm-level data mute the more substantial decline derived from monthly data. Almost all of that decline is attributable to continuing aluminum exporters (15.5 percentage points). The net effect of firms entering and exiting the U.S. market was quite small (-0.4 percentage points). Firms that exited the U.S. market accounted for 36.1% of Canadian tariffed exporters, while entrants accounted for 31.3%. However, unlike steel producers, these firms accounted for only a small proportion of export growth (see Table 1). A small share of firms that exited the U.S. market closed down (4.2% of tariffed exporters).

Steel and aluminum exports to non-U.S. markets also declined from 2017 to 2019. This was driven by reduced exports among continuing exporters. As noted above, declining exports to countries other than the United States would be consistent with more competitive non-U.S. export markets resulting from U.S. tariffed imports from other countries.

There was a large turnover of steel and aluminum firms entering and exiting the U.S. export market from 2017 to 2019. Turnover was also high in the pre-tariff period from 2015 to 2017. However, with the imposition of tariffs, the entry rate decreased, while the exit rate increased. The tariffs reduced the incentive for firms to enter the U.S. market and increased the incentive for them to exit.

Overall, the decline in aluminum exports was attributable to continuing exporters, whereas for steel exports, exiting firms accounted for the drop. Depending on the industry, adjustment occurred through the intensive and extensive margins.

Exporter growth and survival

This section examines the output, employment and investment performance of Canadian tariffed steel and aluminum exporters active in 2017 by tracking their performance over the subsequent two years.[5] Furthermore, it decomposes the cohort's performance into contributions from continuing exporters and firms that exited the U.S. market, divided among those that remained active by redirecting their output to the domestic market (exiter continuers) or non-U.S. export markets and those that ceased production entirely (hereafter referred to as exits).

From 2017 to 2019, steel and aluminum producers experienced current dollar gross output and employment growth, although steel producers experienced only marginal employment growth (see Table 2). Declining U.S. exports did not coincide with overall falling output or employment. Among steel producers, continuing exporters experienced stronger output and employment growth than firms that exited U.S. markets. These continuing exporters drove employment and output growth, compensating for exits. By contrast, aluminum producers that continued in the U.S. market experienced declining employment and output. Aluminum producers that exited the U.S. market but continued to operate experienced positive gross output and accounted for the overall rise of aluminum output and employment.

The most striking finding is the growth in investment among the 2017 cohort of tariffed steel and aluminum producers—investment increased by just over 50% (see Table 2). Moreover, the primary source of this growth was firms that continued to export to the United States. They accounted for all the investment growth among steel producers and about two-thirds of investment growth for aluminum producers. This stronger investment growth among continuing exporters is open to interpretation. These investments may have been induced by higher tariffs as firms sought out efficiency gains to remain competitive in the U.S. market. However, it may be that their ability to serve the U.S. market in the face of tariffs also underlay the expectation that these investments would provide a sufficient long-run return. Finally, these investments may be related to the effect of government supports for steel and aluminum producers.[6]

5. The analysis excludes 2020 and beyond, as these years were significantly affected by the COVID-19 pandemic, which could confound the effects of U.S. import tariffs.
6. The estimates in tables 1 and 2 on the sources of changes in exports, as well as the growth and turnover of steel and aluminum producers, are based on this paper's definition of exporters as the top 10% of exporters. If instead all firms that exported to the U.S. market were defined as exporters, the turnover in the U.S. export market would be higher. However, the sources of the decline in exports—whether from continuing exporters or from exiters—are similar. This is not surprising, as the top 10% of exporters accounted for 99% of total exports in a given year.

Table 2
Growth of the 2017 steel and aluminum exporter cohort, 2017 to 2019

	Gross output	Employment	Investment
		percent	
Panel A: Steel exporters			
Growth of 2017 exporters	3.0	0.1	52.3
Contribution from:			
Continuing exporters	9.5	4.8	56.8
Exiters from U.S. export market			
Exiter continuers	0.1	0.4	-0.8
Exiter exits	-6.6	-5.1	-3.7
Addendum: Growth rates			
Continuing exporters	11.0	5.5	60.4
Exiter continuers	1.6	5.3	-36.0
Panel B: Aluminum exporters			
Growth of 2017 exporters	2.3	4.7	51.5
Contribution from:			
Continuing exporters	-1.1	-1.0	34.2
Exiters from U.S. export market			
Exiter continuers	3.5	6.0	17.3
Exiter exits	-0.1	-0.3	0.0
Addendum: Growth rates			
Continuing exporters	-3.4	-2.7	63.8
Exiter continuers	5.2	9.6	37.3

Notes: Gross output and investment are measured in current dollars. Exiter continuers are firms that exited the U.S. market but continued operating.
Source: Statistics Canada, authors' calculations.

Financial characteristics of tariffed exporters

Table 3 compares the financial characteristics of Canadian firms that continued exporting to the U.S. market with those that entered or exited the U.S. export market from 2017 to 2019, for both the steel and aluminum sectors. The analysis reveals several noteworthy findings. First, there is more financial leverage among exiters. Firms that exited the U.S. market tended to have a higher debt-to-asset ratio compared with continuing exporters, suggesting greater financial vulnerability. This pattern holds for both steel and aluminum exporters. Second, there is little difference in profitability between continuing and exiting exporters, indicating that profitability alone may not fully explain exit behaviour. Last, there is a nonlinear relationship with export intensity. Exporters with very high or very low export intensity (ratio of U.S. exports to gross output) were more likely to exit the U.S. market, while firms with moderate export intensity were more likely to continue exporting. The firms exiting the U.S. market with high export intensity were also firms that exited altogether. By contrast, firms exiting the U.S. market with low export intensity tended to continue serving other markets, including the domestic market. This suggests a U-shaped relationship between export intensity and market survival. Firms that entered the U.S. market had the lowest average export intensity and by implication had less at stake than continuing exporters.

Table 3
Characteristics of Canadian steel and aluminium producers in 2017 that continued in the U.S. market, entered it or exited it (continued or closed down) the U.S. market, 2017 to 2019

	U.S. export status from 2017 to 2019			
			Exiter	
	Continuer	Entrant	Continuing firm	Exiting firm
Panel A: Steel producers				
Current ratio	2.19	2.38	1.76	1.03
Debt-to-asset ratio	0.89	0.89	0.93	0.97
Gross margin (proportion)	0.17	0.19	0.19	0.16
Ratio of U.S. exports to gross output	0.12	0.03	0.06	0.28
Average firm characteristics				
Gross output ($'000)	74,948	62,564	43,508	1,081,124
Employment	154	94	80	311
Gross investment ($'000)	57	66	40	12,405
Panel B: Aluminium producers				
Current ratio	1.75	2.32	2.29	3.80
Debt-to-asset ratio	0.67	1.10	0.69	59.68
Gross margin (proportion)	0.20	0.27	0.25	0.42
Ratio of U.S. exports to gross output	0.25	0.03	0.05	1.00
Average firm characteristics				
Gross output ($'000)	64,646	42,767	44,103	15,707
Employment	134	106	109	33
Gross investment ($'000)	105	86	79	7

Note: The current ratio, or working capital ratio, is calculated as (total current assets)/(total current liabilities).
Source: Statistics Canada, authors' calculations.

Conclusion

Overall, the findings both confirm and challenge expectations. That tariffs were fully passed through in the form of higher prices is to be expected (see Fajgelbaum et al., 2020; Cavallo et al., 2021). The declining value and volume of trade are also to be expected, although the 50% decline compared with non-tariffed steel and aluminum products suggests a high responsiveness to tariffs. Despite declining exports, the 2017 cohort of tariffed exporters was able to maintain employment and output levels and, indeed, increase investment from 2017 to 2019. So, while there was a heterogeneous response across firms, this was not an aluminum and steel industry in retreat. Still, some caution is due when interpreting these results, because they paint a picture of industry- and firm-level responses to a relatively short period of tariffs. Over a longer time or with higher tariff levels, firms may be forced to make different decisions. The point to be taken is that declining output, employment and investment in industries affected by tariffs are not a foregone conclusion.

Methodology appendix

To estimate the price and quantity response to tariff change, we use an event study design similar to that of Fajgelbaum et al. (2020) that compares goods targeted by tariffs with goods not targeted by tariffs. However, we focus only on steel and aluminum exports from Canada to the United States. This necessitates an empirical design that accommodates staggered treatment and treatment effect heterogeneity to differentiate Canada from the rest of the world (ROW).

To prepare the data, we download all monthly steel and aluminum product exports at the 10-digit level of the Harmonized Tariff Schedule (HTS10) from the USA Trade Online service for Canada and the world. Then, to create the ROW category, we subtract Canadian exports to the United States from the world's exports to the United States for each product-month. In the specification used in the paper, all steel and aluminum products are pooled together to get an overall effect of tariffs on exports. This approach produces headline estimates that summarize the effect at the expense of conflating the two tariff levels (25% on steel and 10% on aluminum), along with possible heterogeneity in effects because of differences in overall economic conditions for the two metals. Specifications using steel alone produce similar estimates, but specifications using aluminum alone suffer more from the data limitations explained below. Therefore, we report the pooled estimates alone as an initial study of the data.

Adopting and adapting the notation of Baker et al. (2025) and Sun and Abraham (2021), we estimate the following specification:

$$Y_{cpt} = \theta_{ct} + \eta_{cp} + \sum_{g \neq \infty} \sum_{e=-16}^{30} \beta_{g,e} 1\left\{G_{cp} = g\right\} 1\left\{G_{cp} + e = t\right\} + \varepsilon_{cpt},$$

where Y_{cpt} is the log of value, quantity or price of U.S. imports of product *p* (HTS10 level) from country *c* (Canada or ROW) in month *t* (from January 2017 to December 2020); G_{cp} denotes the treatment time of product *p* and country *c* ($G_{cp} = 18$ for tariffed Canadian products and $G_{cp} = 15$ for the tariffed ROW products, while $G_{cp} = \infty$ for products that are never tariffed); and ε_{cpt} is an error term.

Figure 2 plots the estimated percentage effect $\left|100 * \left[\exp\left(\widehat{\beta_{g,e}}\right) - 1\right]\right.$ for $G_{cp} = 18$ (Canada, tariffed products) and *e* = {-16, -15, ..., -2, -1, 0, 1, ..., 29, 30}, indexing the months before and after the imposition of tariffs on Canadian steel and aluminum imports. Fajgelbaum et al. (2020) estimate a similar equation except without any treatment effect heterogeneity by country group, which allows them to add product-month fixed effects as well. However, since we want to estimate the treatment effect for Canada specifically (e.g., we want to estimate $\beta_{g,e}$ instead of only β_e), we can only use country-month and country-product fixed effects. This approach allows us to estimate the effect of the tariffs on steel and aluminum for Canadian exports to the United States specifically instead of an overall effect of tariffs on all products for all U.S. imports.

We use the "never-treated" specification of staggered treatment design, partly because the stagger is so short that we do not gain very much from using the not-yet-treated comparison groups for just March, April and May 2018, in addition to the fact that Canada never sees a not-yet-treated comparison group, and Canada is the group we are most interested in. Formally, the parallel trends assumption based on never-treated groups is the following: for every eventually treated group *g* and post-treatment period $t \geq g$,

$$E_w\left[\ Y_{i,t}(\infty)-Y_{i,t-1}(\infty)\middle|X_i,G_i=g\ \right]=E_w\left[\ Y_{i,t}(\infty)-Y_{i,t-1}(\infty)\middle|X_i,G_i=\infty\right].$$

In words (remember the group notation G_i denotes treatment time and $Y_{it}(\infty)$ is the potential outcome of country-product *i* at time *t* if *i* were never treated), the potential trend of country-product *i* (if *i* were never treated) conditional on being in the group (and having covariates X_i) that is treated at time *g* is the same as the potential outcomes of the group with covariates X_i that is never treated $G_i=\infty$.

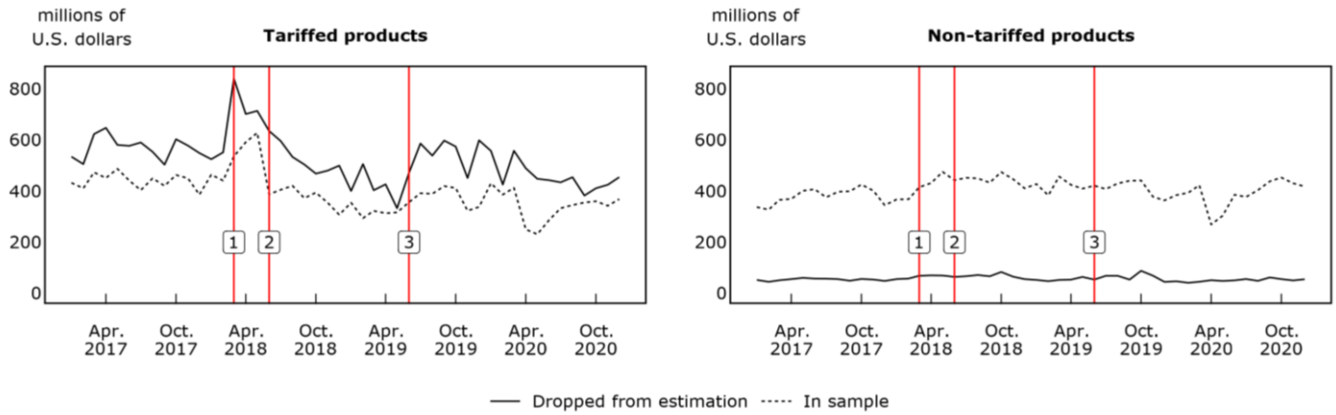
In short, we are using all untargeted Canadian products as a comparison group to see how the outcomes of targeted Canadian products change after the U.S. tariff introduction. Using country-month fixed effects is important to ensure we are comparing Canadian exports to the United States across targeted and untargeted products. Changing country-month fixed effects to month fixed effects would add untargeted products imported from the ROW to the comparison group. Finally, we cluster standard errors at the individual (country-product) level.

There is one major methodological issue to raise. Since we use the log of values, quantities and prices, any month in which a country-product observation is zero (for value or quantity) or missing (for price) will be dropped from the estimation sample. An economist would expect imports of targeted products to decrease, and if the decrease is extreme enough to push imports of that product to zero, then these imports would be dropped from the estimation. This would bias the estimates of the effect of tariffs toward zero, since the observations with the largest effects would be removed from the estimation.

To quantify the problem here, we compare the input data with the data actually used by the estimation in Figure A1. We divide products into tariffed and untariffed categories and into “in sample” and “dropped from estimation” based on whether or not an observation is used in the difference-in-difference estimation. Then we plot the total value of each category over time. The issue is apparent: more than half the value of tariffed products is dropped from the estimation (especially compared with the relatively small value of untariffed products that is dropped from the estimation). In addition, the total value of tariffed products dropped from the estimation decreases over the Canadian tariff period relative to the total value of in-sample tariffed products.

This is a clear sample-selection issue that is important to rectify in future work. For now, we support the initial results by aggregating the U.S. import data to the four-digit Harmonized System (HS) level (HS4). While this approach has several problems, the tradeoffs are appropriate for our purposes. First, the price and quantity information is lost when moving from the detailed HTS10 tariff categories to the aggregate HS4 categories. Second, if a tariff is applied at the six-digit HS, eight-digit HS or HTS10 level, the HS4 category would include tariffed and untariffed products. For the few steel and aluminum products that are tariffed at a level lower than HS4, we drop these categories from this test for simplicity.

Figure A.1
Value of in-sample and out-of-sample tariffed and non-tariffed products, January 2017 to December 2020



Note: 1: U.S. tariffs start (excluding Canada, Mexico and the European Union). 2: U.S. tariffs start on Canada, Mexico and the European Union. 3: U.S. tariffs on Canada stop.
Source: Authors' calculations; United States Trade Online.

Figures A2 and A3 show the sample selection and event study estimates when using the HS4 sample only. The total value of observations that are dropped from the sample (not including the observations dropped because the tariffs were applied at a level lower than HS4) is essentially zero (see Figure A2)—that is, the total value of tariffed observations in the sample is close to the total value tariffed observations available. Most importantly, the results support the analysis in the text: the general sign and magnitude of the event study coefficients are similar to the main analysis (although less precise because of the aggregation) (see Figure A3).

There are several other methodological and data issues that may be considered in future work.

First, we choose to use data from the United States to add the perspective of duty paid on U.S. imports, which Canadian export sources do not publish. Future work may also include the Canadian export performance relative to the ROW using the Canadian International Merchandise Trade Database.

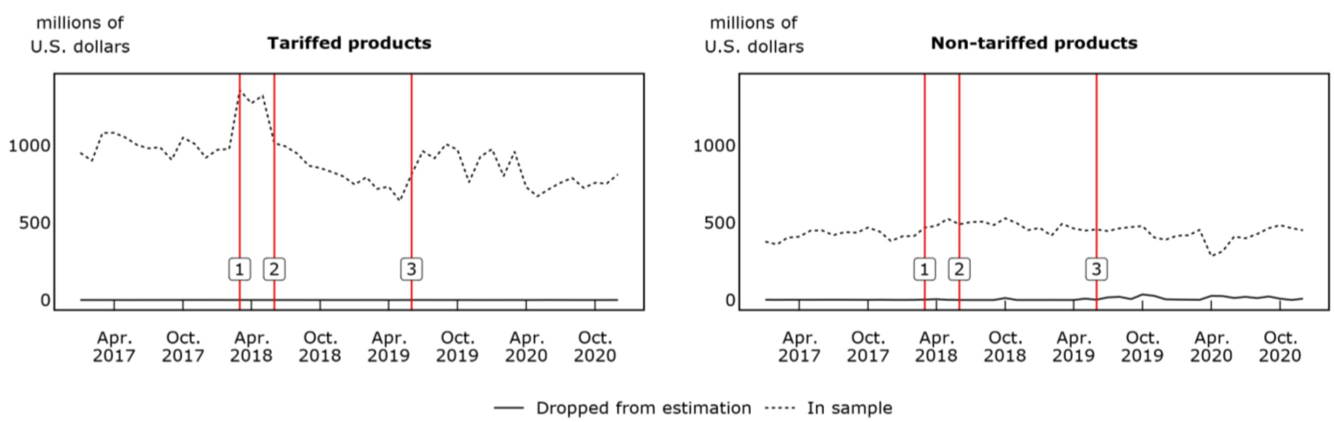
Second, the raw import data spiking just after the tariff announcement shows the possibility that U.S. importers were front-running the tariffs on Canada and substituting non-tariffed Canadian imports for tariffed imports from the ROW. If front-running is an issue, we should expect these estimates to be biased downward (negative coefficients are **more** negative than the true coefficient). The coefficient estimates do not suggest there was any treatment anticipation across the board, but further work should investigate the anticipation and leakage effects of tariffs more completely.

Third, large companies may employ lawyers and specialists to strategically change their products to reclassify them into non-tariffed HTS10 codes, as well as apply for tariff exemptions from the Bureau of Industry and Security. If reclassification is an issue, the bias could be either negative or positive. Consider a product that is partially reclassified from a tariffed product to an untariffed product at the time of treatment—now the control group (Canadian products that are never treated) is artificially high after the treatment, while the treatment group (Canadian products that are tariffed) is artificially low. The difference between them is **more** negative than it should be, suggesting a negative bias. However, suppose a product is completely reclassified so that there is no trade in the tariffed product after the treatment; then, the tariffed product is dropped from the estimation completely. This is an instance of the first issue raised above—products with zero trade are dropped, and if those products are dropped because of the treatment, the estimate is positively biased toward zero. This possibility is also left to future work.

Fourth, Mexico and the European Union (EU) are also treated at the same time as Canada (month 18), but we treat them as if they are part of the ROW (treated at month 15). Breaking out Mexican and EU steel and aluminum imports to the United States would be a more appropriate specification, but we would lose even more observations if Mexico and the EU had any more zero exports to the United States in any HTS10 categories, in addition to the HTS10 categories that are dropped because of missing Canadian exports to the United States. This mainly affects the estimates of tariffs on imports from the ROW, although we have tested a specification that studies Canadian products only, and the Canadian estimates are similar across both specifications. We omit specifying the results for each subsample and specification because of space constraints, but further research should investigate specification possibilities more thoroughly.

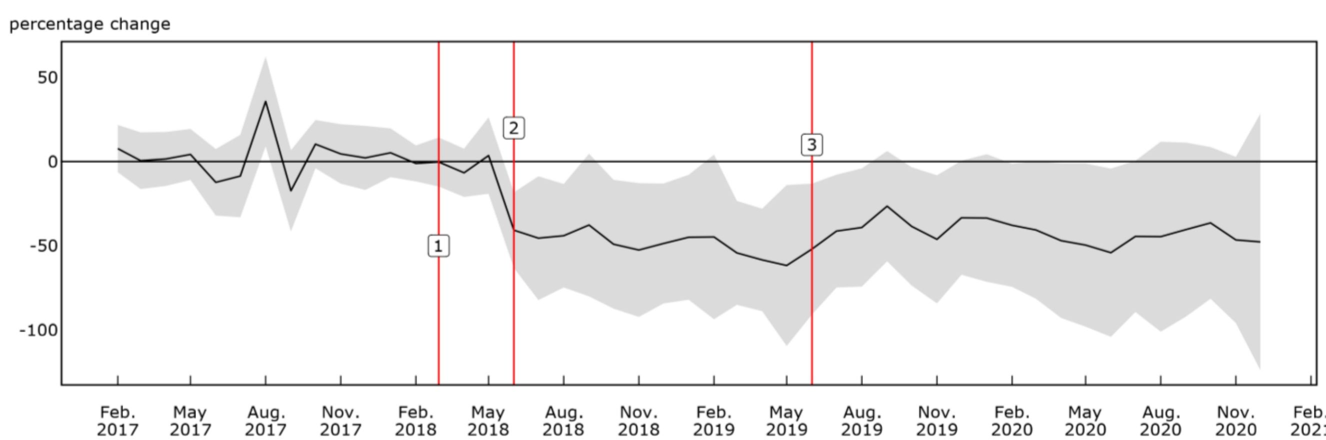
Finally, the typical difference-in-difference empirical design does not allow for turning treatment "off," but technically the tariffs on Canada were removed in 2019. We view the empirical design as testing whether the tariffs had any lasting effects even after they were removed.

Figure A.2
In-sample and out-of-sample tariffed and non-tariffed products at the four-digit Harmonized System level, January 2017 to December 2020



Note: 1: U.S. tariffs start (excluding Canada, Mexico and the European Union). 2: U.S. tariffs start on Canada, Mexico and the European Union. 3: U.S. tariffs on Canada stop.
Source: Authors' calculations; United States Trade Online.

Figure A.3
Estimated effect of tariffs on the monthly value ofexports of steel and aluminum, February 2017 to December 2020



Note: 1: U.S. tariffs start (excluding Canada, Mexico and the European Union). 2: U.S. tariffs start on Canada, Mexico and the European Union. 3: U.S. tariffs on Canada stop. The black line displays the point estimate of the effect for each month, and the grey area displays the 95% C.I. for each point estimate.
Source: Authors' calculations; United States Trade Online.

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