The Long-Term Impact of Steel Tariffs on U.S. Manufacturing

Lydia Cox*
Harvard University

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Abstract

In this paper, I study the long-term effects that temporary upstream tariffs have on downstream industries. Even temporary tariffs can have cascading effects through production networks when placed on upstream products, but to date, little is known about the long-term behavior of these spillovers. Using a new method for mapping downstream industries to specific steel inputs, I estimate the effect of steel tariffs enacted by President Bush in 2002 and 2003 on downstream industry outcomes. I find that upstream steel tariffs have highly persistent negative impacts on the competitiveness of U.S. downstream industry exports. Persistence in the response of exports is driven by a restructuring of global trade flows that does not revert once the tariffs are lifted. I use a dynamic model of trade to show that the presence of relationship-specific sunk costs of trade can generate persistence of the magnitude that I find in the data. Finally, I show that taking both the contemporaneous and persistent downstream impacts into account substantially alters the welfare implications of upstream tariffs.

Keywords: Trade policy, tariff, global value chains, gains from trade, sunk cost, welfare.

JEL Codes: F10, F12, F13, F14

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1 Introduction

U.S. trade policy under the Trump administration sparked renewed attention to the fact that globally integrated supply chains complicate the traditional cost-benefit analysis of tariffs. Tariffs and other emergency safeguards are often justified as temporary measures designed to relieve struggling domestic industries. When placed on upstream products, however, this protection comes at a cost: tariffs on upstream products raise input costs for downstream manufacturers, making them more vulnerable to foreign competition. While the tariffs themselves are temporary, little is known about the long-term behavior of these spillover effects. This is the primary focus of my paper.

While the breadth and scale of the Trump administration's protectionist efforts was unprecedented in recent history, protectionist policy for certain U.S. industries is not a new phenomenon.[1] In this paper, I use a case study of the steel tariffs levied by George W. Bush in 2002 and 2003 to provide new empirical evidence on the long-term effects that temporary upstream tariffs have on downstream industries. Because steel is a broadly used input—Cox and Russ (2020), for example, find that the number of jobs in industries that use steel as an input outnumber the number of jobs that produce steel by about 80 to 1—tariffs on steel are particularly prone to having broad downstream effects. This feature, along with the fact that the Bush tariffs were a sizable but temporary shock to steel tariff rates, makes the episode useful for studying both the contemporaneous and long-term downstream impacts of temporary upstream tariffs. To generalize my empirical findings outside of this context and understand the underlying mechanisms, I calibrate a dynamic model of trade, consistent with my findings.

A key empirical challenge in estimating the causal impacts of upstream tariffs through supply chains is linking protected upstream inputs to the downstream industries that use them. Tariffs are placed on highly disaggregated products, rendering publicly available input-output tables too coarse to provide the required mapping. A key innovation in this paper is the creation of a highly detailed, steel-specific input-output table that links disaggregated steel products to specific downstream industries. I create this new table using exclusion requests for steel products that were submitted by firms in response to the Trump steel tariffs. I take advantage of the fact that, by definition, exclusion requesting firms are downstream users of very specific upstream products. With these data, I create a detailed mapping that allows me to leverage the variation in tariff rates imposed by Bush in 2002 and 2003 to causally estimate the impacts of higher tariff rates on downstream industry outcomes.

[1] Upstream products—like steel, aluminum, lumber, and sugar—that are central inputs to many U.S. manufacturing industries have enjoyed spurts of protectionist policy since this nation's founding, according to Irwin (2017).

My primary empirical findings are threefold. First, I find that upstream steel tariffs have persistent negative impacts on the competitiveness of U.S. downstream industry exports. A 1 percentage point increase in an industry's upstream steel tariff rate causes a relative decline in the U.S. share of that industry's world exports—or the industry's global market share—of 0.1 percentage points at its peak (0.2 percentage points for steel-intensive industries). To put the magnitude of the impact into perspective, shifting an industry from the 25th to the 75th percentile of the tariff burden distribution (an increase of 13.5 percentage points) results in a decline in global market share of 1 percentage point relative to pre-tariff levels (2 percentage points for steel-intensive industries). Declines in the competitiveness of U.S. exports due to the tariffs are highly persistent—global market share remains depressed relative to pre-tariff levels for at least 8 years after the tariffs are lifted. Using district-level U.S. export data, I show that the persistent response of downstream exports appears to be driven by changes on the extensive margin. Industries that face higher steel tariffs suffer persistent relative declines in the number of trading partners. Likely a result of this loss in market share, I also find that steel-intensive industries suffered persistent declines in employment in response to relatively high steel tariff rates.

Second, I find that the steel tariffs induced a restructuring of global trade flows away from downstream producers in the United States toward the United States' top competitors. Specifically, I find that in downstream industries that faced higher steel tariffs, the combined world export share of the top five non-U.S. exporters of downstream products in 2001—Germany, Japan, France, Italy, and Canada—increase by the same magnitude as the decline in export share in the United States. As was the case for the United States, the change in foreign market share is persistent. This finding suggests that the U.S. steel tariffs induced a shift in sourcing patterns for foreign buyers in downstream industries that did not revert when the tariffs were removed.

Lastly, I find that the impact of the steel tariffs on downstream domestic production is more transitory than the impact on exports. U.S. imports of downstream products that faced a 1 percentage point higher steel tariff increased by 0.65 percent relative to pre-tariff levels in the average industry and 1 percent in steel-intensive industries during the 2002-03 period in which the tariffs were in place. This suggests that U.S. consumers shifted consumption toward foreign sources when the tariffs were in place. Imports revert to pre-tariff levels immediately after the tariffs are removed, however, indicating that domestic producers were able to regain lost domestic market share much more easily than they were able to regain foreign market share.

To make sense of the theoretical mechanisms driving my empirical findings, I next present a dynamic model of trade and show that the presence of relationship-specific sunk costs of trade can generate a persistent response of downstream exports to a temporary input tariff that is consistent with the patterns I find in the data. The partial equilibrium model features two asymmetric countries in which downstream manufacturing producers use a composite of home and foreign steel to produce differentiated, tradable consumption goods. The focus of the model is on the dynamic decision that consumers face about where to source downstream goods. Consumers choose to purchase each good from the cheapest possible source. However, they face a sunk cost of forming relationships with new foreign suppliers. A consumer purchasing from a domestic source in period $t-1$ must pay a fixed cost to purchase from the foreign source in period t. The presence of these relationship-specific sunk costs drives the persistent response of downstream exports to a temporary input tariff shock. Intuitively, because it is costly for consumers to switch suppliers, if an input tariff induces a change in sourcing patterns, those patterns will not immediately revert when the tariffs are lifted. Model-simulated regressions of exports, export shares, and imports lie squarely within the confidence intervals estimated in the data. Counterfactual simulations show the importance of the fixed costs and trade policy expectations in generating responses that align with the data.

In the last part of the paper, I use my reduced form results to calculate partial equilibrium estimates of the overall welfare effects of the Bush steel tariffs. Taking into account both the contemporaneous and persistent impact of the tariffs on downstream industry producer surplus, I find that the tariffs induced average annual welfare losses of 2.8 percent of exports. Losses continue to accrue for 6 years after the tariffs were removed, something that conventional methods for evaluating the impacts of such a policy traditionally miss.

My paper contributes to the growing empirical literature on the many channels through which trade policy can affect the domestic economy. Among others, this literature includes the work of Amiti et al. (2019), Cavallo et al. (2019), and Fajgelbaum et al. (2020), who estimate the impacts of the Trump tariffs on prices and welfare; and Flaaen et al. (2020) who examine the price production relocation effects of anti-dumping duties on washing machines. A subset of this literature focuses, as I do, on the effect of tariffs through supply chains. Handley et al. (2020), for example, find that downstream industries that were more exposed to increases in tariffs imposed by the Trump administration experienced a relative slow-down in export growth. Flaaen and Pierce (2019) find that industries more exposed to upstream tariff increases experience relative reductions in employment, driven by rising input costs and retaliatory tariffs. Blonigen (2016) focuses on the steel industry in particular, leveraging variation across countries to show that the presence of steel-sector industrial policy has a negative impact on the export competitiveness of downstream manufacturing sectors. Bown et al. (2020) find that tariffs and anti-dumping duties against China since the 1980s have led to job-losses in downstream industries. Also related is work on the impact of input tariff liberalization on the economy—Amiti and Konings (2007), Goldberg et al. (2010), Topalova and Khandelwal (2011), Blaum et al. (2018)—and the role of input linkages in the transmission of shocks—Boehm et al. (2019) and Auer et al. (2019), to name a few—illustrating that tariffs on inputs can have potent effects.

My findings are broadly consistent with these results, but my work departs from existing studies in several ways. First and foremost, the aforementioned studies of the Trump tariffs are, by nature, only able to provide evidence of short-term effects.[2] By focusing on an earlier period of temporary tariff implementation, I provide new evidence on the persistence of these effects. In addition, due to the complexity of the trade war induced by Trump's policies, the Bush tariffs provide a cleaner setting to isolate the impact of upstream tariffs on downstream industries. Second, because many of the Trump tariff rates were uniform across product types (e.g., 25 percent for all types of protected steel), studies with similar empirical setups like Handley et al. (2020) and Flaaen and Pierce (2019) use estimates of downstream industry *exposure* to tariffs as the primary source of variation. The Bush tariffs were varied across steel products, meaning that different downstream industries faced different taxes on their inputs depending on which inputs they use. This feature combined with my newly constructed steel-specific input-output table allows me to leverage variation in tariff rates themselves for causal inference. Third, with the exception of Handley et al. (2020) and Blonigen (2016), recent work focuses primarily on the impact of tariffs on domestic outcomes. In contrast, I place more emphasis on the broader impacts of upstream tariffs on the export margin, and provide new evidence of their effects on downstream global sourcing patterns.

The study most closely related to this one is that of Lake and Liu (2021), who also implement a case study of the Bush steel tariffs to study long-term effects on local employment. The authors find that the tariffs led to a persistent depression in employment in local labor markets that relied on steel more heavily as an intermediate input. My findings on employment are consistent with theirs. In addition to employment, I focus on a broader set of results, including U.S. and foreign exports and domestic production, and my results focus on industry-level outcomes rather than local effects. Finally, I provide a theoretical motivation for the persistence found in the data, and an estimate of the welfare implications.

My findings also contribute to our knowledge of the hysteretic effects of temporary shocks. There is very little direct empirical evidence of hysteresis in response to temporary shocks. One of the few papers that provides causal evidence from an exogenous shock is Xu (2021), who studies the 1866 London banking crisis to show that temporary financial shocks have a persistent impact on exports. On the theoretical side, seminal work by Baldwin (1988),

[2] Amiti et al. (2019), Cavallo et al. (2019), Fajgelbaum et al. (2020), Flaaen and Pierce (2019).

Baldwin and Krugman (1989), and Dixit (1989) showed that the presence of sunk costs of exporting can generate hysteresis in trade flows in response to temporary shocks. Earlier work by Roberts and Tybout (1997) and Bernard and Jensen (2004) has shown that the presence of sunk costs is an important determinant of firm entry into exporting. More recent papers, for example Das et al. (2007), Burstein and Melitz (2013), Atkeson and Burstein (2010), and Alessandria and Choi (2014), have embedded sunk costs of exporting into both partial- and general-equilibrium dynamic models to show how they impact trade dynamics. I rely on features of this existing theory to build a model that fits my setting and allows me to simulate the dynamic impacts of temporary upstream tariffs on the economy.

Overall, my findings highlight the complicated nature of tariff policy in a world with global production networks. Even temporary tariffs on a small subset of imports can have vast, persistent effects on a broad swath of the economy. The rest of the paper will proceed as follows: In Section 2, I provide a brief background on the policy setting. In Section 3, I describe a key innovation of this paper—the creation of a highly detailed, steel-specific input-output table. In Sections 4 and 5, I present my empirical strategy and results. In Section 6 I present a theoretical framework, simulations, and counterfactuals to shed light on the theoretical mechanisms potentially driving my empirical findings. Lastly, in Section 7, I present reduced-form estimates of the welfare implications of the Bush Steel tariffs.

2 Background: The Bush Steel Tariffs

In this section I provide a brief overview of the Bush steel tariffs, show that they were a meaningful shock to steel imports in the United States, and discuss some advantages of using the setting to estimate the impact of a temporary shock to upstream inputs on downstream industries.

2.1 The Policy

While protection for the steel industry had been renewed or extended by almost every president since the 1970s, the practice was phased out in the late 80s and early 90s under Presidents (George H. W.) Bush and Clinton.[3] Immediately upon taking office in January 2001, however, President George W. Bush faced intense pressure from the steel lobby and Congress to take action to protect the struggling domestic steel industry. In June 2001, President Bush announced his Administration would self-initiate a Section 201 investigation for 33 types of imported steel. Under a Section 201 investigation, if the International Trade

[3] See, for example, Irwin (2017).

Commission (ITC) determines that the volume of a particular import constitutes a "substantial threat of serious injury" to a domestic industry, the president has the authority to impose temporary import relief. The investigation began on June 22, 2001, and in October 2001 the ITC announced its findings that imports were injuring U.S. steel producers in almost half of the categories under investigation.

In March 2002, President Bush announced that the U.S. would impose three-year safeguards on 171 steel products (8-digit Harmonized System (HS) codes). The tariffs, which ranged from 8 to 30 percent on top of existing legislated rates, went into effect on March 20, 2002 and were slated to phase down in each year of the three-year period. Countries with free trade agreements with the United States at the time (Canada, Mexico, Israel, and Jordan) were exempt from the new tariffs, as were a list of developing nations with imports to the United States totaling less than 3 percent of the domestic market.[4]

Domestic steel consumers, free trade advocates,[5] and foreign trading partners[6] were outraged at the announcement. Many countries announced their intentions to retaliate against U.S. exports, and the European Union and seven other countries issued a complaint to the WTO about the legality of the Section 201 investigation under which the tariffs had been implemented. In November 2003, the WTO ruled that the safeguards were illegal, and before other countries were able to retaliate, President Bush announced on December 4, 2003 that he was terminating the Section 201 action. Ultimately the tariffs remained in place for almost two years. The sharp increase in tariff rates on the protected products during the period of implementation can be seen in Figure 1. The trade-weighted average statutory (legislated) ad valorem rate increased to around 25 percent in the first year and stepped down to around 20 percent in the second year, before the tariffs were eventually removed.[7]

2.2 Impact on Steel Imports and Import Prices

The extent to which downstream industries are affected by the steel tariffs depends in large part on the extent to which the tariffs are passed through to domestic import prices. If, in response to tariffs imposed by the United States, foreign countries reduce the prices of

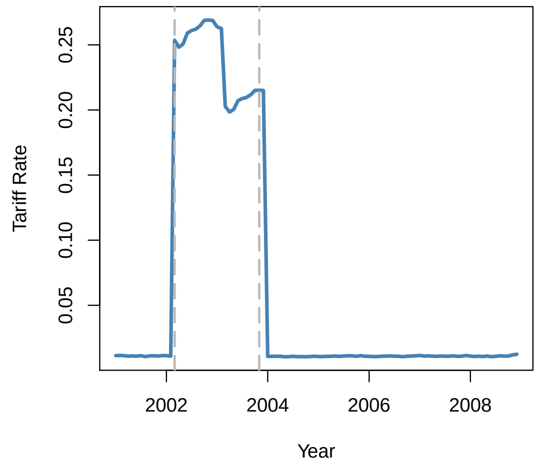
[4] In accordance with WTO rules.

[5] `https://www.nytimes.com/2002/01/23/business/steel-users-campaigning-against-curbs-on-imports.html?searchResultPosition=83`

[6] According to the New York Times, "Within minutes of the White House announcement, America's European allies and Japan said they would most certainly challenge the action before the World Trade Organization." (March 6, 2002) `https://www.nytimes.com/2002/03/06/us/bush-puts-tariffs-of-as-much-as-30-on-steel-imports.html?searchResultPosition=96`

[7] Legislated tariff rates are collected from President George W. Bush's Presidential Proclamation 7529 and its appendix. `https://www.federalregister.gov/documents/2002/07/08/02-17272/to-provide-for-the-efficient-and-fair-administration-of-safeguard-measures-on-imports-of-certain`

Figure 1: Trade-Weighted Average Tariff Rate on Protected Steel Products



NOTE. The figure above shows the trade-weighted average statutory tariff rate on steel products under the Bush steel tariffs. Tariff rates collected from Presidential Proclamation 7529 and are weighted by trade flows in 2001.

their steel exports to the United States—that is, there is little pass-through—downstream exporters may feel little effect. On the other hand, if tariffs are passed through to domestic import prices, downstream steel users in the U.S. will bear the cost of the tariffs in the form of higher input prices.

Figure 2 shows the response of steel import values, prices, and quantities to higher statutory tariff rates relative to their 2001 (pre-tariff) levels.[8] These responses are estimated using the following specification:

$$y_{ij,t} - y_{ij,2001} = \alpha_{j,t} + \beta_t(\tau_{i,2003} - \tau_{i,2001}) + \Sigma_{ij,t}, \tag{1}$$

where $y_{ij,t}$ is the log value, log price, or log quantity of imports of steel product i from country j in year t. The independent variable of interest is $(\tau_{i,2003} - \tau_{i,2001})$, the change in the statutory tariff rate on steel product i as a result of the Bush tariffs. Regressions include country-year fixed effects.[9]

Figure 2a shows that there was a relatively large decline in imports of steel products that faced higher tariff protection. In response to a one percent increase in tariffs, import values fell by an average of 4.3 percent in 2002 and 2003, with little evidence of any persisting

[8] I use data on import values and quantities from U.S customs at the HS8-digit level. Import prices are calculated as import value divided by import quantity.

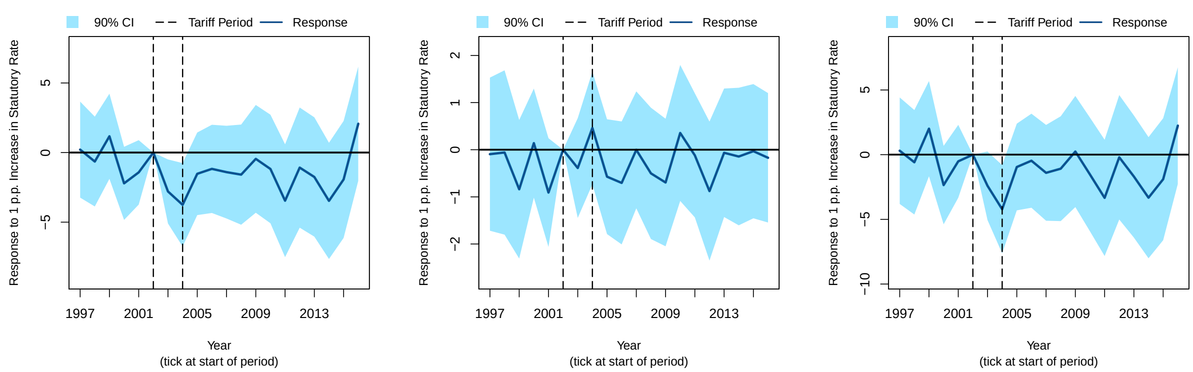
[9] I run these regressions at the individual country level to account for the fact that many countries were exempt from the tariffs. In the specification described, an exempt country faces a change in tariff of 0. For the downstream part of the analysis I will study aggregate trade flows.

effects post-2003. Figure 2b shows that there was no measurable impact of higher statutory tariff rates on steel import prices. Consistent with these results, Figure 2c shows a drop in imported quantities during the 2002-2003 period. A one percent increase in the statutory rate is associated with a 4.4 percent decline in imported quantities. This implies a trade elasticity at the low end of standard estimates in the literature which typically lie between 4 and 8.[10]

The lack of persistence in the response of steel imports to the tariffs provides some insights into the potential production relocation effects of tariffs. If the steel tariffs had induced more entry into the U.S. steel sector (as in the theoretical work of Venables (1987) and Ossa (2011)), this could have been beneficial for downstream producers if it gave them easier access to cheaper steel inputs. The rest of my results will suggest that these relocation effects only occur in the downstream sector, limiting the potential for upstream tariffs to be beneficial. Antràs et al. (2021) explore the impact of the production relocation effects of tariffs on optimal trade policy, and show that trade policy featuring higher tariffs on inputs is sub-optimal.[11]

Together, the response of upstream inputs that U.S. consumers of imported steel, not foreign suppliers, bore the cost of the steel tariffs. Recent papers on the pass-through of the Trump tariffs to consumer prices (Amiti et al., 2019; Cavallo et al., 2019) find similar results. The rest of this paper will be devoted to examining the resulting impact of the steel tariffs on downstream industry outcomes.

Figure 2: Effect of Higher Statutory Rates on Steel Imports and Import Prices



(a) Steel Import Values (b) Steel Import Prices (c) Steel Import Quantities

Note. The figures above show the responses of U.S. steel import values (left), import prices (middle) and import quantities (right) to a one percentage point change in the steel tariff rate that each industry faced during the Bush steel tariffs. Responses are estimated using equation 1.

[10] See, for example, Simonovska and Waugh (2014), and Eaton and Kortum (2002).

[11] They find that instead, tariff escalation—higher tariffs on downstream goods—is first-best.

2.3 Advantages of this Policy Setting

There are several advantages to using the Bush Steel Tariffs to examine the effects of upstream tariffs on downstream industry outcomes. First, because steel is a broadly used input—Cox and Russ (2020) estimate that the number of jobs in steel-using industries outnumber the number of jobs in steel-producing industries by 80 to 1—distortions in the steel industry are particularly prone to having widespread downstream effects. I show evidence in Section 3.1 that the Bush steel tariffs were placed on steel products used by a large swath of U.S. manufacturing industries.

Second, the tariffs were a "shock," in more ways than one. As noted in Section 2.1, the two Administrations prior to George W. Bush had phased out protection for the steel industry to the point where tariffs on most steel products were near zero at the beginning of 2002. When the steel tariffs went into effect, rates on these products increased substantially for a short (two-year) period of time, and then returned back to their near-zero levels, providing a clean setting for studying the dynamic impacts of a temporary shock. The tariffs were also a shock in a more literal sense—because Bush was a newly elected Republican president who had campaigned on a free-trade platform, his imposition of trade safeguards was politically unexpected. I discuss in detail in Section 4.3 how the nature of this shock to the steel industry created plausibly exogenous variation in input costs for downstream producers.

My empirical strategy will also take advantage of several features of the Bush steel tariffs that differ from the Trump trade war that has been the subject of several recent papers that seek to empirically estimate the effects of tariffs. First, unlike the Trump Tariffs, which were uniform within most product categories (e.g., 25 percent for all types of protected steel), there was variation in the tariff rates Bush applied to different types of steel. This means that different downstream industries faced different taxes on their inputs, depending on which inputs they used. This allows for causal inference using variation in actual tariff rates, rather than exposure to tariffs—the more common source of variation in similar studies like those of Lake and Liu (2021) for the Bush steel tariffs and Flaaen and Pierce (2019) and Handley et al. (2020) for the Trump steel tariffs. Second, since steel was the only target of the Bush tariffs, it is easier to discern the effects of the steel tariffs, without having to disentangle them from the effects of tariffs on other products, both domestic and retaliatory.[12] Lastly, and most importantly, while studies of the effects of the Trump tariffs are necessarily short-term due to data availability,[13] studying the Bush tariffs allows for the estimation of long-term

[12] While there were threats of retaliation from foreign countries in response to the Bush steel tariffs, none was enacted.

[13] It is worth noting that because of the COVID-19 crisis, it will be difficult to ever discern long-term effects using the Trump tariffs, even as a longer time series becomes available.

effects—something largely missing from the literature until now.

3 Steel-Specific Input-Output Table

My identification approach will leverage both the variation in tariffs on upstream products and the varied composition of upstream inputs used by downstream industries to causally estimate the impact of those tariffs on downstream industry outcomes. I face one primary challenge in carrying this out: identifying which of the 171 protected steel products are inputs to which downstream industries. Traditional input-output tables like the ones published by the Bureau of Economic Analysis (BEA), are too coarse to aid in creating this mapping. Tariffs are placed on very specific products, for example:

> *Flat-rolled products of iron or nonalloy steel, of a width of 600 mm or more, hot-rolled, not clad, plated or coated, not in coils, not further worked than hot-rolled, with patterns in relief of a thickness of 4.75mm or more.*

Even the most detailed BEA input output table, however, provides data on industry use of only two broad categories of steel input: *Iron and Steel Mills and Ferroalloy Manufacturing* and *Steel Product Manufacturing from Purchased Steel*. To take advantage of the fact that different downstream industries use different steel inputs that faced different tariff rates requires a much more detailed mapping of steel inputs to downstream industries. The first innovation of this paper is the creation of a new, highly-detailed, steel-specific input output table that provides a detailed enough mapping to accomplish the task at hand. The rest of this section is devoted to describing the creation of this new input-output table and illustrating its effectiveness.

3.1 Identifying Steel Product to Downstream Industry Linkages

To map specific steel inputs, and their associated tariff rates, to specific downstream industries, I create a steel-specific input-output table using exclusion requests that were filed in response to the steel tariffs that were announced by the Trump Administration in March 2018. After the 2018 tariffs were announced, companies were given the opportunity to submit requests to exclude certain products from the tariffs.[14] These publicly available "exclusion requests" contain information on the company requesting the exclusion, the specific 10-digit subheading of the Harmonized Tariff Schedule of the United States (HTSUS) of the product the company wanted excluded, and other information describing the company's use of the

[14] Specifically, OMB Form 064-1039.

product and why it felt an exclusion was justified. I collect over 70,000 of these requests from the website Regulations.gov and parse several variables of interest from each, creating a database of exclusion requests for detailed steel products that were subject to the Trump steel tariffs. The steel products covered by the Bush steel tariffs were a subset of those under the Trump tariffs, which is why the database is relevant for the empirical exercise in this paper.

I take advantage of the fact that, by definition, an exclusion requesting firm is a *downstream user* of a very specific (10-digit) upstream steel product. By merging the exclusion requesting firm names with both Orbis and the Dunn & Bradstreet (D&B) database,[15] I connect each firm to a downstream NAICS industry. This merge provides a mapping between upstream steel inputs and downstream NAICS industries. To facilitate analysis of downstream global trade flows, I then map the downstream NAICS industries back to HS codes using the concordance developed by Pierce and Schott (2012). As shown in the schematic in Figure 3, this process leaves me with a concordance between a highly detailed set of steel inputs and the downstream industries that use them. While the concordance theoretically allows for an input-output mapping at the 10-digit level, for the purposes of this analysis I link upstream steel products at the HS8 level—the level at which tariffs are implemented—to downstream industries at the HS6 level—the most detailed level for which global trade flows data are available. Admittedly, the need to concord from the given NAICS industries back to HS codes is a downside of this approach, but is necessary in order to study world trade flows which are classified only under the HS system. Studies of U.S. outcomes alone should omit this step to reduce noise.[16]

To illustrate more concretely how the mapping procedure works, consider an example. The steel-specific input-output table identifies HS 210320 —*tomato ketchup and tomato sauces*—as a downstream user of two upstream steel products that were protected by the Bush tariffs: 72101100 and 72102000 —*flat-rolled products of iron or nonalloy steel, of a width of 600 mm or more, clad, plated or coated with tin* of a thickness of 0.5 mm or more, or less than 0.5 mm, respectively.[17] According to the Wiley Encyclopedia of Packaging Technology, modern "tin" cans that typically hold foods like tomato sauce are made of a thin piece of iron or steel that is coated with a thin layer of tin. In this case, the steel-specific IO table does what it is supposed to do—matches a specific steel input to a downstream industry that uses it.

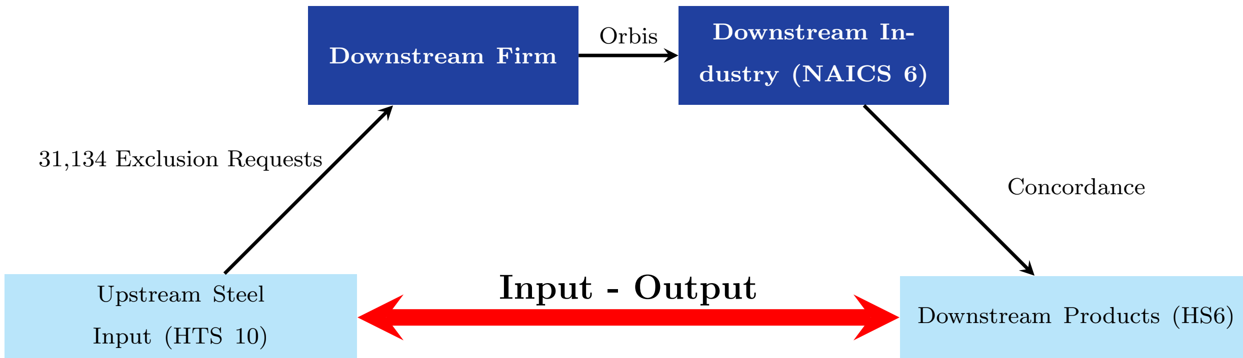
Of the roughly 70,000 exclusion requests submitted for the Trump steel tariffs, 31,134

[15] For details on these databases and the merge, see Appendix A.1.1.

[16] I discuss adjustments I make in my estimation procedure as well as robustness in Section 4.

[17] One exclusion request for these steel products was made by Seneca Foods Corporation—an American food processor and distributor headquartered in Marion, New York.

Figure 3: Input-Ouput Schematic



requests were for products that were also covered by the Bush steel tariffs and were submitted by companies that could be merged with Orbis or D&B. These 31,134 requests cover 170 of the 171 steel products that were covered by the Bush tariffs. The steel-specific input-output table links those 170 steel inputs to over 1200 downstream products (HS6). To put into perspective the scope of the downstream impact that steel tariffs can have, the downstream industries identified as steel users represented $176 billion in exports in the year 2001—roughly a quarter of U.S. exports in that year.

There are a few advantages to using the exclusion requests as a source of highly disaggregated input-output relationships, relative to potential alternatives such as the confidential firm-level data collected by the U.S. Census Bureau. Because the exclusion requests are publicly available, they provide a public source of detailed input-output data. In Appendix A.1.2 I show that this methodology can be used for inputs other than steel, specifically aluminum. In addition, the exclusion requests provide information that is not likely to be found in other data sets. For example, on the exclusion request, firms are required to report the percent of the product they are requesting an exclusion for that *cannot* be produced in the U.S. One might imagine this information would be important for understanding the extent to which a firm or industry will be affected by tariffs, but it is not the type of information that is likely to be found elsewhere. Finally, the exclusion requests may be better suited to identify final users of steel imports than the Census data, where firm-level imports do not always reflect firm use in cases where firms import a product and re-sell it to another industry.

3.2 Performance of the Steel-Specific IO Table

Before turning to my empirical analysis of the Bush steel tariffs, I will present some evidence that the steel-specific input-output table that I have created is an effective way to match detailed steel inputs with relevant downstream industries. Note that the exercises I present throughout the rest of this section are intended to address the ability of the IO table to map inputs to industries in a general sense (i.e., they have nothing to do with the steel tariffs levied by either Bush or Trump). First, I will address the key assumption that is required in order to use the steel-specific IO table for causal inference. Namely, because the exclusion requests were filed in response to tariffs put in place starting in 2018, I must assume that steel inputs to different industries in 2018 are a good representation of steel inputs in 2002. Next, I will show some evidence that I am able to link downstream industries to relevant steel inputs—inputs that those industries actually use. Finally, I will compare my steel-specific input-output table to other published input-output tables to underscore its importance for the empirical question that I am studying in this paper.

3.2.1 Input-Output Relationships Over Time

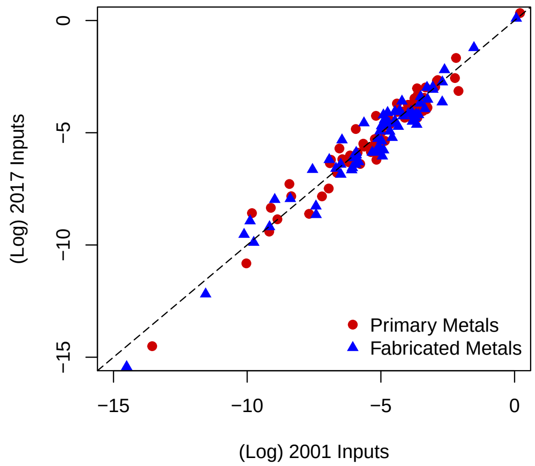
Because the exclusion requests that underlie the steel-specific input-output table were filed in 2018, I assume that steel input-output relationships in 2018 are a reasonable representation of steel input-output relationships in 2002. A comparison of the input-output tables published by the Bureau of Economic Analysis (BEA) over time illustrates that steel inputs were allocated similarly across industries in 2018 as they were in 2002. The BEA publishes a "Use Table," which reports the use of different commodities by different industries. The most detailed version of this table that is available on an annual basis covers 73 different sectors. Steel is not separately defined among these 73 sectors, but is encompassed in "Primary Metals" and "Fabricated Metal Products." A simple comparison of the shares of each of the two metal commodities allocated to each industry in 2001 and 2017 shows little change in industry use over the period. Figure 4 shows that absolute changes in the share of metals used by different industries between 2001 and 2017 were less than one percentage point for most industries.

3.2.2 Efficacy of Downstream Industry Selection

Next, I show that changes in steel import unit values predict changes in material costs in downstream manufacturing industries that are linked using the steel-specific IO table. For this exercise, I use data from the NBER-CES Manufacturing Industry Database (Bartelsman and Gray (1996)) on the cost of materials for 473 manufacturing industries, classified at the NAICS 6 level. Of these 473 industries, I am able to map 81 to one or more steel products using the steel-specific IO table. Using trade data, I calculate the weighted average unit value[18] of the relevant steel imports for each downstream industry.

[18]Details of how I calculate this weighted average are provided in Section 4.1.

Figure 4: Distribution of Change in Industry Use of Metal, 2001-2017

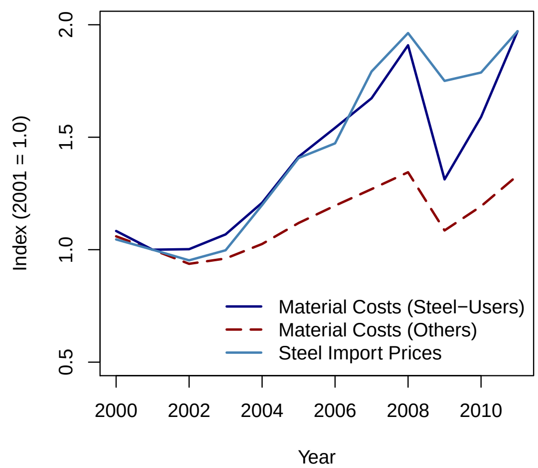


NOTE. This figure shows total metal inputs by industry required to deliver one dollar of output in 2001 and 2017.

In Figure 5, I show a time-series of the average unit value of steel inputs and a time-series of average material costs in downstream manufacturing industries. I split the downstream manufacturing industries in the NBER-CES Manufacturing Industry Database into two groups: those that I identify as steel-using industries with my IO table, and those that I don't. The red dashed line shows average material costs in manufacturing industries from the database that are *not* identified as steel users, the dark blue line shows average material costs in manufacturing industries that *are* identified as steel users, and the light blue line shows the average cost (unit value) of the relevant steel inputs. Costs are indexed to equal 1.0 in 2001 for ease of comparison. Steel prices and material costs for identified steel-using industries relative to non steel-using industries appear highly correlated.

I then use the steel-specific input-output table to estimate the impact that specific imported steel product prices have on downstream material costs, industry by industry. The table in the left panel of Figure 6 shows regressions at the downstream industry level of the effect of changes in the unit value of linked upstream steel imports to the change in material costs of corresponding downstream industries. The regression includes both the changes in the Producer Price Index (PPI) for Iron and Steel, to control for average changes in the price of steel, and six-digit NAICS fixed effects. Column (1) shows that an increase in the unit value of linked steel inputs leads to a statistically significant increase in material costs of the corresponding downstream industry between 1995 to 2008—well before the Trump tariffs were put in place, and over and above changes in the average PPI for steel. As a placebo test, I run the same regression but randomize the matching of steel products to downstream industries instead of using my IO table. The right panel of Figure 6 shows a histogram of the point estimates generated from this randomized regression, alongside the point estimate generated when using the IO table linkages. The IO table linkages clearly generate a stronger relationship between the variables of interest. The relationship between steel-product costs and linked downstream industry material costs suggests both that the steel products that I link to downstream industries using the exclusion requests are relevant ones, and that they are relevant outside of the Trump era in which the table was constructed.

Figure 5: Manufacturing Industry Material Costs and Steel Import Prices



Note. This figure shows the average unit value of steel inputs (relative to 2001 levels and the average material costs in manufacturing industries, using data from the NBER CES Manufacturing Industry Database. Manufacturing industries are split into groups based on whether or not they are identified by my Steel-Specific IO table as steel users.

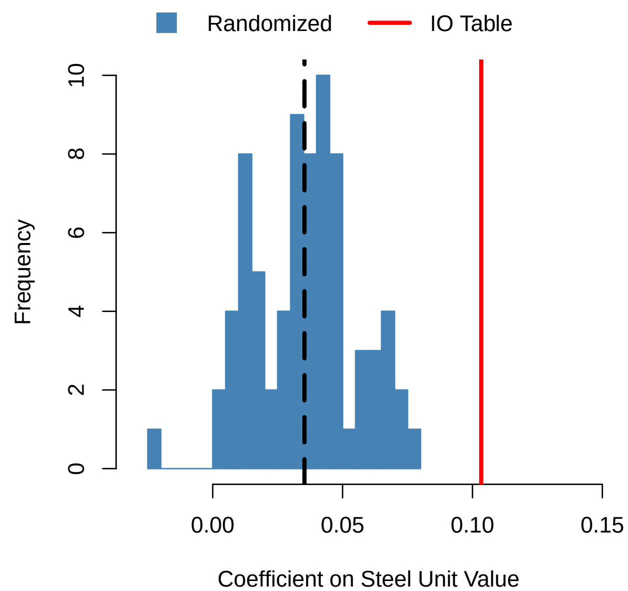
3.2.3 Intensity of Use

Input-output tables typically provide more than just binary indicators of use—they provide a measure of the intensity of which a downstream industry uses an upstream input. The exclusion requests I use to formulate the steel-specific IO table provide two key pieces of information that can be used to proxy for the intensity of an industry's use of a given product. First, on each exclusion request, the requesting party must provide the average annual volume of the 10-digit steel product being requested for exemption consumed between 2015 and 2017. This volume, provided in kilograms, can be converted to dollars using unit values (dollars per kilogram) of imports of the 10-digit steel import in question. The second measure of intensity comes from a simple count of the number of downstream industries

Figure 6: Accuracy and Stability of IO Mapping Over Time

	(1)
	Δ Material Costs
Δ Steel Unit Value	0.103
	(0.025)
Δ PPI Steel	0.123
	(0.042)
Constant	0.019
	(0.032)
Sector Fixed Effects	Yes
Observations	959

Standard errors in parentheses
Sample years: 1995-2008



Note. The left panel shows a regression of year-over-year changes in material costs in downstream industry d at time t on changes in associated steel unit values. The regression takes the form: $\Delta\text{Material Cost}_{d,t} = \alpha + \beta\Delta\text{Steel Unit Value}_{d,t} + \Xi' X_{d,t} + \epsilon_{d,t}$. The mapping between steel unit values and downstream industries is done using the Steel-Specific IO table. The right panel shows the point estimates generated from 1000 runs of the same regression, but instead of using the IO table to match steel inputs to downstream industries, I randomize the mapping.

that filed an exclusion request for a particular upstream input. This is a coarser measure of intensity of use, but is useful under the assumption that if a steel input is more important to or more intensely used by a downstream industry, more parties may file requests to exclude that input from the tariffs.

To test the strength of these measures of intensity, I compare them to a measure of steel inputs as a share of a downstream industry's total input requirements, calculated using the BEA's input-output table. Both the quantity measure and the count measure are highly correlated with the BEA steel-cost share, with correlation coefficients (standard errors) of 0.912 (0.001) and 0.711 (0.02), respectively.

3.2.4 Comparison with Other Published IO Tables

Finally, comparing my steel-specific input-output table to other published input-output tables—such as the BEA's "Use Table" and the input-output mapping constructed by Berlingieri et al. (2018)[19]—helps underscore the importance of the high-level of detail that my steel-specific input-output table provides. The published versions of the two aforementioned external tables provide data on industry use of one or two broad categories of steel.[20] In principle, what my steel-specific IO table does is expand these one or two broad categories into several hundred specific products. Collapsing my table down, I can calculate a measure of industry use of one broad category of steel that is comparable to what is available in the public IO tables.

According to the steel-specific IO table, the top downstream industry consumers of steel products protected by the Bush steel tariffs were: *other metal container manufacturing*, *metal coating, engraving, and allied services*, and *fruit and vegetable canning*. According to the BEA table, the top users of steel (in general) are *motor vehicle metal stamping*, *fabricated structural products*, and *metal tank (heavy gauge) manufacturing*. The implication of this difference is that using the BEA table to calculate a measure of exposure to the Bush steel tariffs would not do a good job of indicating the industries likely to be most affected. Just because those industries are heavy users of steel, in general, does not mean that they are heavy users of the specific steel products that were protected by tariffs. The same is true of the Berlingieri et al. (2018) concordance, which reflects use of steel imports by French firms, but again, not necessarily imports of products protected by the Bush steel tariffs.[21]

[19] Berlingieri et al. (2018) use transaction-level import data from French Customs and administrative information for private sector French enterprises to create a detailed input-output table for French imports. They have published an aggregated version of the table (4-digit SIC codes), which is used here for comparison.

[20] *Iron and Steel Mills Ferroalloy Manufacturing* and *Steel Product Manufacturing from Purchased Steel* in the case of the BEA and *Manufacture of Basic Iron and Steel* in the case of Berlingieri et al. (2018).

[21] Table 10 in Appendix A.1.3 shows a comparison of the top 10 steel-using industries according to all

Table 1: Sensitivity of Steel-Specific IO Table

Steel-Specific IO: Bush Tariffs	Steel-Specific IO: Trump Tariffs
Other Metal Container Mfg	Iron & Steel Pipe and Tube Mfg
Metal Coating, Engraving, Allied Services	New Single-Family Housing Construction
Fruit & Vegetable Canning	Other Metal Container Mfg
Other Motor Vehicle Parts Mfg	Steel Wire Drawing
Other Transportation Equip. Mfg	Other Motor Vehicle Parts Mfg
Support Activities: Oil & Gas	Metal Coating, Engraving, Allied Services
Fabricated Structural Metal Mfg	Fabricated Pipe and Pipe Fitting Mfg
All Other Plastics Prod. Mfg	Fruit and Vegetable Canning
Crane, Hoist, Monorail Sys. Mfg	Other Machinery Mfg
Metal Can Mfg	Other Transportation Equipment Mfg
Hardware Mfg	Other Fabricated Wire Product Mfg

To underscore this point, the left panel of Table 1 shows the top users of steel products covered under the Bush tariffs according to the steel-specific IO table, while the right panel of the table shows the top users of steel products covered under the Trump steel tariffs according to the steel-specific IO table. Again, the lists are different, illustrating the level of detail that the steel-specific IO table is designed to capture.

One final example can help to illustrate the richness of the steel-specific IO table. Consider three downstream industries—HS 840310 *central heating boilers* and HS 820740 *molds for metal or metal carbides*. According to the BEA input-output table, these two downstream industries use similar amounts of steel, with steel representing about 5 percent of total costs in both industries.[22] According to my steel-specific IO table, however, these two industries use very different types of steel, and as a result, faced different tariff rates on their inputs. In Table 2, I show that HS 840310 is associated with one upstream steel inputs and faced an average increase in steel tariff rate of 12.5 percent as a result of the Bush steel tariffs. HS 848049, on the other hand, is associated with ten upstream steel inputs and faced a much larger change in its average steel tariff rate of 27.4 percent.[23] It is this variation that I will leverage in my empirical analysis, that I would not be able to do using a more aggregated input-output table. In the last row of Table 2, I show the change in exports in each industry between 2001 and 2003. This is purely correlative, but gives a flavor of the evidence that I will present in Section 5.

three input-output tables.

[22]The BEA Cost-Share Proxy is constructed using the Industry by Industry Total Requirements table. Specifically, I calculate an industry's total steel requirements as use of the two BEA steel industries: "iron and steel mills and ferroalloy manufacturing" and "steel product manufacturing from purchased steel." I then divide total steel requirements by total industry output requirements.

[23]Construction of this variable is described in Section 4.1.

Table 2: Example Demonstrating Richness of Steel-Specific IO Table

	HS 840310	HS 848049
Steel-Specific IO Inputs	73069010	72099000 72112920 72222000 72254011 72254030 72255080 72269115 72283060 72283080 72285010
BEA Steel Cost Share	5.17 %	5.27 %
Δ Average Tariff	14.6 %	27.4 %
Δ U.S. Exports, 2001-2003	-1.3 %	-12.5 %

4 Estimation Strategy and Threats to Identification

In this section, I discuss the empirical strategy that I use to estimate the effect of tariffs on upstream steel inputs on the downstream industries that use them. Using the new steel-specific input-output table described in Section 3, I leverage variation in steel tariff rates faced by downstream users in 2002-2003 to causally estimate the impact of changes in those rates on downstream industries. Estimation of these effects is carried out dynamically, providing new evidence about the long-term effects of tariffs on upstream inputs on downstream industries.

4.1 Construction of Downstream Variables

Using the steel-specific input-output table, I construct the key dependent variable of interest: $\tau_{d,y}$—the average statutory tariff rate on steel inputs faced by downstream industry d in year y. To see how this variable is constructed, consider a downstream industry d that has N associated upstream steel inputs, which faced tariffs ($\tau_{1,y}$,..., $\tau_{N,y}$), respectively, in year y. The average tariff rate faced by downstream industry d is given by:

$$\tau_{d,y} = \sum_{u=1}^{N} \omega_u \tau_{u,y}$$

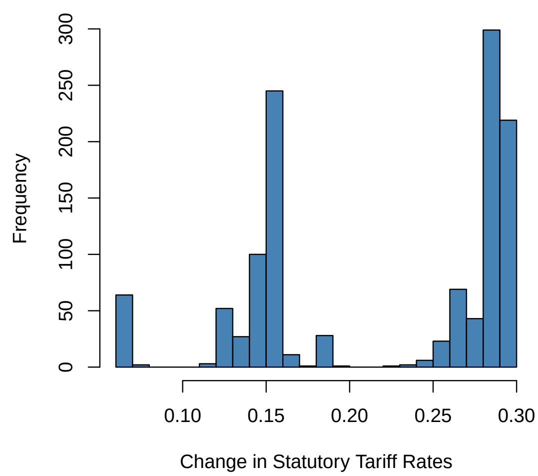
where ω_u is the share of consumption of upstream input u:

$$\omega_u = \frac{p_u \bar{Q}_{u,d}}{\sum_{u=1}^{N} p_u \bar{Q}_{u,d}}.$$

The share of consumption of the upstream inputs is calculated using the average consumption in kilograms of an upstream product u by a firm in downstream industry d, $\bar{Q}_{u,d}$. This quantity is provided on the exclusion request for each individual firm requesting an exclusion for product u, and I take the average for all firms in downstream industry d. I convert this volume to a dollar value using the average (across all countries) unit value of product u from trade flows data in 2001.[24] I use the same weights to construct several control variables, including a measure of downstream industry's pre-tariff (2001) exposure to the tariffs,[25] and a measure of the percent of an industry's steel inputs that cannot be produced in the United States.[26]

Due to the different inputs used by different downstream industries, there is substantial variation in the steel tariff rates those industries faced. This variation, shown in Figure 7, is the basis for the empirical estimation of the impact that tariffs on upstream inputs have on downstream industries.

Figure 7: Distribution of Changes in Statutory Tariff Rates from 2001 to 2003



NOTE. The figure above shows a histogram of the statutory tariff rates on steel products that downstream industries faced as a result of the Bush steel tariffs. This is the main dependent variable of interest in my empirical analysis.

[24]Trade flows data are simply Customs data, downloaded from the U.S. ITC.

[25]This variable is calculated as the average share of the downstream industry's imported steel inputs that come from countries that were not exempt from the Bush tariffs. For example, suppose downstream industry d uses two upstream steel inputs, i and j, in equal proportions. Of total U.S. imports of industry i, 50 percent came from non-exempt countries in 2001. For input j, 25 percent came from non-exempt countries in 2001. For this industry, I calculate pre-tariff exposure to be: $\eta_d = \frac{1}{2}(0.5 + 0.25) = 0.375$.

[26]A variable I take from the exclusion requests.

4.2 Estimation Specification

My primary estimating equation is given by:

$$x_{d,t} - x_{d,2001} = \alpha_t + \beta_t(\tau_{d,2003} - \tau_{d,2001}) + \Xi_t' X_d + \epsilon_{d,t} \tag{2}$$

The left hand side, $x_{d,t} - x_{d,2001}$, is the change in an outcome variable x in downstream industry d between year t and 2001. The coefficient of interest is β_t, which governs the change in the average statutory steel tariff rate on steel inputs faced by downstream industry d between 2001 (pre-Bush tariffs) and 2003. Standard errors are clustered by downsteram NAICS 6 industry.[27] In Appendix A.2 I show that the results are robust to concording in the opposite direction and aggregating by NAICS 6 industry. Control variables, X_d, include the average share of the imported steel products used by downstream industry d that come from countries exempt from the steel tariffs (a measure of exposure to the tariffs) and the average share of the downstream industry's steel inputs that cannot be produced in the U.S. (a value calculated from the exclusion requests). In practice, these controls are uncorrelated with the right-hand-side variable of interest, so their inclusion makes little difference in the results. I also control for the share of costs that steel represents for downstream industry d, C_d. Note that the coefficients of interest have time subscripts because this regression is estimated separately in each year, t, in order to assess how the effects play out over time. This "local-projection" approach is common in the macro literature (see Jordà (2005)), and will yield very similar results to using a pooled event-study difference-in-differences type of specification. For a comparison of the two approaches and additional robustness checks, see Appendix A.2.

In addition to the steel tariff rate downstream industry d faces, the share of costs that steel represents for downstream industry d, C_d, will be an important determinant of industry d's response to the tariffs. Rather than directly interacting the tariff variable with a measure of steel cost share, I run my regressions in two samples: first for all industries (so the point estimates will correspond to the response of an industry with average steel cost share) and second for steel-intensive industries (industries with an above-median steel cost share, so point estimates reflect the response of the average cost share in this above-median group). In Appendix A.2, I show that this will give the same result as running a regression with an interaction of $\tau_d \times C_d$, and then estimating the effect of a tariff increase on an industry with cost-share $\bar{C}$ by calculating a linear combination of estimated coefficients. In Appendix A.3, I show that interacting the cost share variable with the tariff and estimating the effects of a

[27] The industries in my sample are classified at the HS6 level of detail, however, due to how the I-O table is constructed, NAICS 6 is the level of aggregation of the tariff variable.

one percent increase in "costs" due to the tariffs will simply re-scale the results that I obtain in my baseline specification.

4.3 Threats to Identification

While focusing on the downstream impacts of upstream tariffs eliminates many potential threats to identification,[28] Gawande et al. (2012) and Bown et al. (2020) point out several sources of endogeneity that can thwart identification of the negative impacts of tariffs along supply chains. First, because tariffs on upstream products have the potential to hurt downstream industries, there may be counter-lobbying by downstream firms, especially those that stand to lose the most. To the extent that counter-lobbying efforts are successful, some of the negative impacts of the tariffs will fail to materialize in the data. In the case of the Bush steel tariffs, there is some evidence to suggest that these concerns can be at least partially alleviated. A document published by USTR following the announcement of then tariffs indicates that the level of tariffs that were levied on all but one category of steel product (stainless steel bar) were equal to or higher than the level recommended by the majority of ITC commissioners.[29] In other words, if there was lobbying by downstream industries to reduce tariff rates relative to ITC recommendations, it appears to have been unsuccessful.

There is anecdotal evidence to support this story as well. According to an article published by the Wall Street Journal[30] on March 6, 2002 (days after the tariffs were announced):

> For months, trade analysts and even some administration officials had thought the president would impose only very limited tariffs. In the months-long lobbying war that preceded Tuesday's decision, those who opposed high tariffs appeared to have the upper hand. Steel-using manufacturers and port owners gained the administration's ear, arguing that tariffs would cost far more jobs than they saved... But in the final days, Bush advisers say, the White House came under intense pressure from the steel unions, the big steel companies, and perhaps most important, lawmakers from steel states. The unions held a mass rally outside the White House last Thursday, while steel-state legislators made their case in the Oval Office. Officials say Mr. Bush and his advisers most feared a possible backlash among voters in the "rust belt," as well as erosion of support for Mr. Bush's other trade objectives in Congress... Sharply limited tariffs would have let the weakest coke-and-iron-ore steelmakers die and helped the strongest to

[28] When looking at the own-industry impact of protection, an industry's need for protection is likely correlated with its performance. Downstream industries, however, are more likely to be collateral damage—they are not specifically targeted.

[29] `http://lobby.la.psu.edu/_107th/097_Steel_Safeguard/Agency_Activities/USTR/USTR_Bush_decides_on_safeguards.pdf`

[30] `https://www.wsj.com/articles/SB101533904883100680`

grow and become more efficient competitors of mini-mills. Instead, Mr. Bush extended help to the steel industry across the board.

In other words, the will of the downstream lobby appears to have been overridden by other political concerns.

A second potential source of endogeneity is that there is an omitted variable that is correlated with both the tariff on upstream inputs faced by a downstream industry, and the downstream industry outcome. For example, suppose foreign input suppliers experience a positive productivity shock that leads to an influx of imported inputs. On one hand, the influx of imported inputs might induce a higher tariff rate on those inputs as domestic input suppliers demand a greater level of protection. On the other hand, the influx could also boost domestic downstream production, leading to a positive correlation between downstream outcomes and input tariffs. Similarly, a productivity shock in the domestic downstream industry could lead to an influx of imported inputs that leads to a higher tariff rate. I test for endogeneity of this form by regressing changes in downstream industry outcomes leading up to the tariffs on the tariff rates those industries faced. Specifically, I run the following:

$$\Delta y_{d,1998-2001} = \alpha + \beta(\tau_{d,2003} - \tau_{d,2001}) + \varepsilon_d \tag{3}$$

Where y is the change in the downstream variable of interest between 1998 and 2001.

The results are reported in Table 3. There is not a statistically significant relationship for any of the outcome variables of interest, suggesting downstream industries that faced higher upstream tariffs were not on differential trajectories prior to those tariffs being implemented. The dynamic regression specification that I employ throughout Section 5 similarly shows that there are no apparent pre-trends.[31] Together, this evidence assuages concerns about the presence of endogeneity in the form of an omitted variable. Finally, it is worth noting that any of the sources of endogeneity discussed will likely bias my results upward, making it *harder* to identify negative impacts of tariffs on downstream industries.

5 The Downstream Impact of Steel Tariffs

In this section, I describe my empirical findings on the impact of steel tariffs on downstream industries. Unless otherwise noted, results are estimated using the dynamic specification in equation 2, and results are shown for two samples: all downstream industries (dark blue

[31] Lake and Liu (2021) similarly highlight the absence of pre-trends between 1998 and 2000 in their difference-in-differences specification to show that the parallel trends assumption holds.

Table 3: Testing for Pre-Trends

	(1) Δ Export Share (98-01)	(2) Δ Log Exports (98-01)	(3) Δ Log Export Price (98-01)
Δ statutory_tariff	0.023	0.382	0.223
	(0.024)	(0.245)	(0.655)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note. This table shows the results of the following regression:
$\Delta y_{d,1998-2001} = \alpha + \beta(\tau_{d,2003} - \tau_{d,2001}) + \varepsilon_d$, where y is an outcome variable in downstream industry d in the years leading up to the Bush steel tariffs, and $\tau_{d,2003} - \tau_{d,2001}$ is the change in tariff rate the industry faced after the 2002 policy was implemented. We cannot reject the null hypothesis that there is no causal relationship between the LHS and RHS variables, supporting my identifying assumptions.

line), and steel-intensive industries (red line, defined as industries for which steel constitutes an above-median share of costs).[32]

5.1 Downstream Export Market

I first consider the impact of the tariffs on the export performance of downstream industries. I consider both the log level of nominal exports and the U.S. share of global exports—a measure of U.S. competitiveness in the global market.

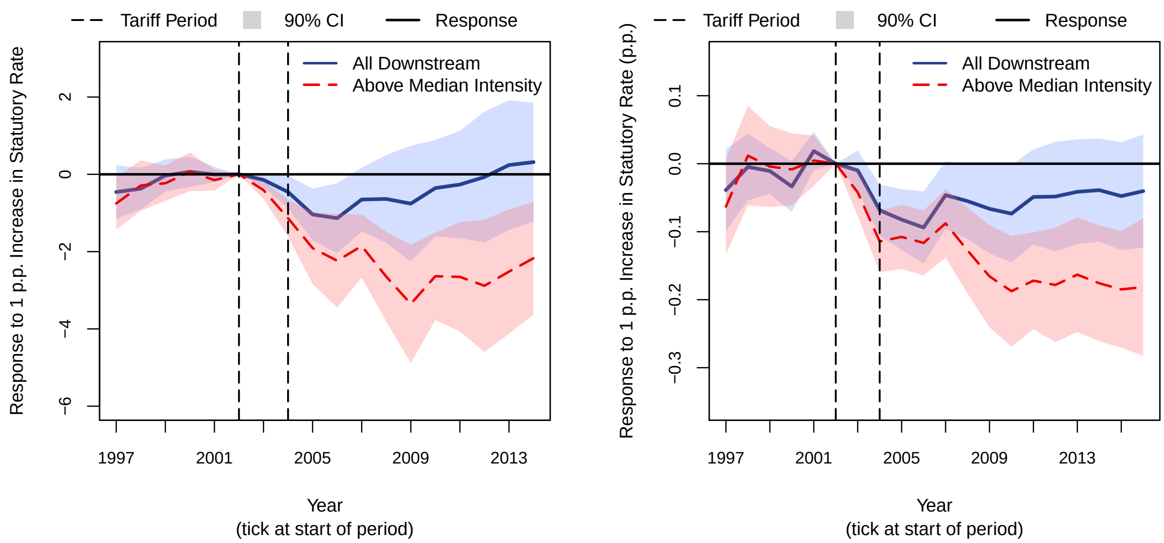
Figure 8a shows that downstream industries that faced relatively high steel tariffs saw relatively large declines in nominal exports. Specifically, a one percentage point increase in an industry's steel tariff rate is associated with a peak decline of one percent in exports relative to pre-tariff levels (3 percent for steel-intensive industries).[33] Exports remain dampened for 6 years after the tariffs are removed for all industries, and for even longer for steel-intensive industries. These responses may seem large—at the maximum, implying that by 2009, a steel-intensive industry that faced a 20 percent tariff on its steel inputs would have a reduction in exports relative to 2001 levels of 80 percent compared to a steel-intensive industry that faced no steel tariff. However, recall that these are cumulative effects: if the industry that faced the 20 percent tariff experienced no export growth between 2001 and 2009, the industry that faced no tariff grew 7.6 percent per year at an average annual rate.

Figure 8b shows the response of the U.S. share of global exports in downstream industries to the tariffs—a measure of the industry's global competitiveness. For downstream industries

[32]I categorize industries using cost-shares calculated from the BEA total requirements table, but I get similar results using measures of intensity discussed in Section 3.2.3.

[33]Handley et al. (2020) study the impact of the Trump tariffs on downstream industry export values. While the magnitude I estimate cannot be compared directly with the theirs due to the use of a different independent variable (they use a measure of industry exposure to the tariffs), the direction is consistent with their findings.

Figure 8: Effect of Higher Statutory Rates on Downstream Exports



(a) Export Values (b) Export Share

NOTE. The left panel shows the response of downstream industry exports to a 1 percentage point increase in steel statutory tariff rates. The right panel shows the response of the U.S. share of world exports. Coefficients are estimated using regressions of the form in equation 2.

that faced relatively high steel tariffs, export shares exhibited a sharp decline during the period in which the tariffs were in place and remained depressed relative to pre-tariff levels for at least 8 years after the tariffs were removed. To put the magnitude of the estimated impact into perspective, shifting an industry from the 25th to the 75th percentile in terms of the change in upstream tariff it faces between 2001 and 2003 (a swing of 13.5 percentage points) results in a relative decline in global market share of around 1 percentage point for the average industry, and 2 percentage points for steel-intensive industries. Robustness exercises and regression output can be found in Appendices A.2 and A.4.

5.2 Reconfiguration of Global Trade Flows

The notion that temporary tariffs can have persistent downstream effects on the competitiveness of U.S. exports implies that there is a reconfiguration of downstream global trade flows in response to the tariffs that does not revert back once the tariffs are lifted. Intuitively, the countries most likely to take over forfeitted market share by the United States would be the other top producers of the relevant downstream products at the time. To test this, I use data on exports of the top 25 non-U.S. exporters of the relevant downstream products in 2001. I run the analogous specification to equation 2, but replace the dependent variable with the change in export share in downstream industry d in country j between year t and 2001.[34]

$$x_{dj,t} - x_{dj,2001} = \alpha_t + \beta_t(\tau_{d,2003} - \tau_{d,2001}) + \Xi_t' X_d + \Sigma_{t,d} \tag{4}$$

Of the top 25 exporters I find that higher tariffs in a U.S downstream industry indeed led to increases in global market share for the other top producers in the downstream industries at the time. Figure 9 shows the response of global market share in the top ten non-U.S. exporters in the relevant downstream industries to a one percentage point increase in the steel tariff rate in the United States. The solid purple line shows the response for the top five non-U.S. exporters—Germany, Japan, France, Italy, and Canada. This set of countries experiences a collective increase in market share on impact of the Bush steel tariffs that is of the same magnitude as the decrease in the United States (about 0.1 p.p. for a 1 p.p. increase in tariff). As was the case for the United States, the change in market share is highly persistent. The dashed gray line shows the response of market share for the next five exporters of downstream products in 2001—the United Kingdom, Belgium, Korea, Spain, and the Netherlands[35]—do not experience any significant response in market share to the tariffs in the United States. The individual country responses can be found in Appendix A.5.

5.3 Export Response: Intensive vs. Extensive Margin?

To understand the drivers behind the persistent response of downstream exports to an increase in input tariffs, it is important to know whether the observed response in the data reflects changes on the intensive or extensive margin. I present two exercises in this subsection that hint at the latter—declining exports in U.S. industries are the result of extensive margin changes.

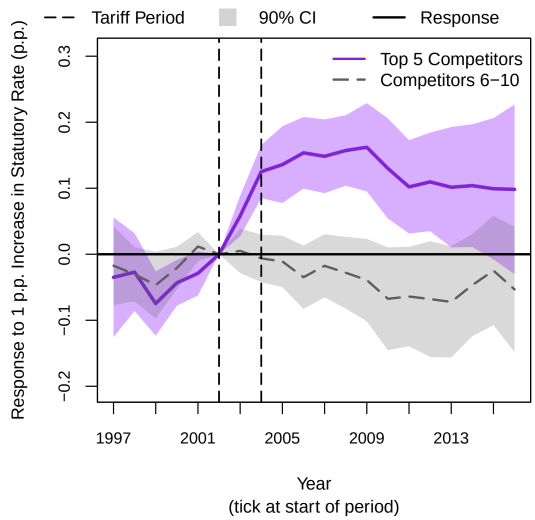
5.3.1 Number of Trade Relationships

Using industry-level data, it is impossible to perfectly observe extensive margin changes, however in the first exercise I present, I proxy for the extensive margin using highly disaggregated U.S. trade data. Specifically, I use district-level U.S. export data from Schott (2008). These data show exports of 10-digit products from each individual customs district

[34] Note that because I am comparing the relative outcomes of U.S. industries that faced different upstream tariff rates *and* because I am estimating the results separately in each year (i.e., my regressions have time fixed effects), exchange rates will not be a factor in these results.

[35] I omit China and Mexico from this group, but results and discussion including those two countries can be found in Appendix A.5.

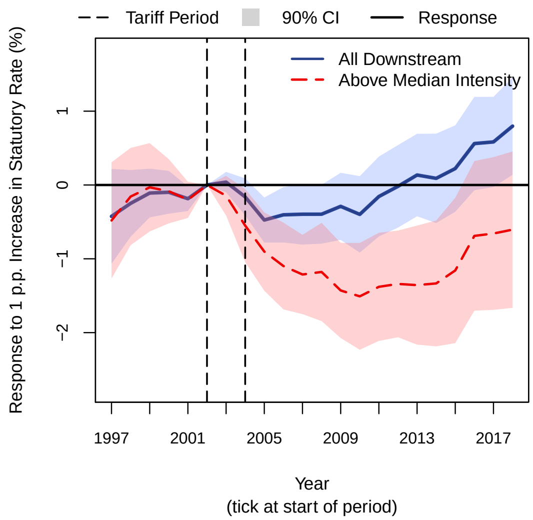
Figure 9: Global Market Share Shifts to Other Top Producers



Note. This figure shows the response of world export shares of top non-U.S. exporters of downstream products in the year 2001 to higher steel tariff rates in the United States. Responses are estimated using $x_{dj,t} - x_{dj,2001} = \alpha_t + \beta_t(\tau_{d,2003} - \tau_{d,2001}) + \Xi_t' X_d + \Sigma_{t,d}$, where j is a country or group of countries and d is a downstream industry. Controls are the same as in the baseline specification.

in the United States to each individual destination country. I define a "trade relationship" as a district $\times$ product $\times$ country triplet—for example, a car that is exported from the San Diego customs district to Japan. To provide a sense of magnitude, there are 47 customs districts in the United States, and in 2001, the mean (median) 10-digit product had 120 (172) trade relationships. I then count the number of "trade relationships" for each downstream product in each year, and estimate the response of this number to higher steel tariffs using my baseline specification (equation 2). The results are shown in Figure 10. As the figure shows, a 1 percentage point increase in the statutory rate on steel inputs leads to an 0.5 to 1 percent decline in the number of trade relationships in a downstream industry, depending on the industry's steel intensity. To put this into perspective, an interquartile shift in the tariff burden (an increase of 13.5 p.p.) is associated with a loss of 8 to 15 trade relationships. These declines are highly persistent, with the number of trade relationships remaining dampened relative to pre-tariff levels for 7 plus years after the tariffs are removed. In the figure below, I omit observations from the HS Chapter 84, which is an outlier and causes a large kink in the response of steel-intensive industries in the year 2009 that distracts from the point of the figure. The results with the full sample are shown in Appendix A.6.

Figure 10: Effect of Steel Tariffs on Downstream Trade Relationships



NOTE. This figure shows the response of the number of "trade relationships" in a downstream industry, defined as an HTS10 $\times$ customs district $\times$ country destination triplet to an increase in the tariff rate on steel inputs. Coefficients are estimated using my baseline specification—equation 2.

5.3.2 Price and Quantity Responses are Consistent

Lastly, the implied response of downstream export prices and quantities to the tariffs is also consistent with an extensive margin response. Though data on export quantities—or real exports—are notoriously noisy, we can compare the response of real exports to the tariffs with the response of nominal exports to the tariffs to ascertain the response of export prices. Figure 11 shows that, especially in the post-tariff period, nominal exports (the dashed gray line) fall more in response to higher steel tariffs than real exports (the solid blue line), implying a decline in both export prices and quantities. While it may seem counter-intuitive that higher input prices could ultimately lead to lower export prices, this is consistent with a Melitz-type model in which the least-productive (highest price) exporters are forced out of the export market. This extensive margin change leads to an increase in the average productivity of exporters, and therefore a decrease in average export prices.

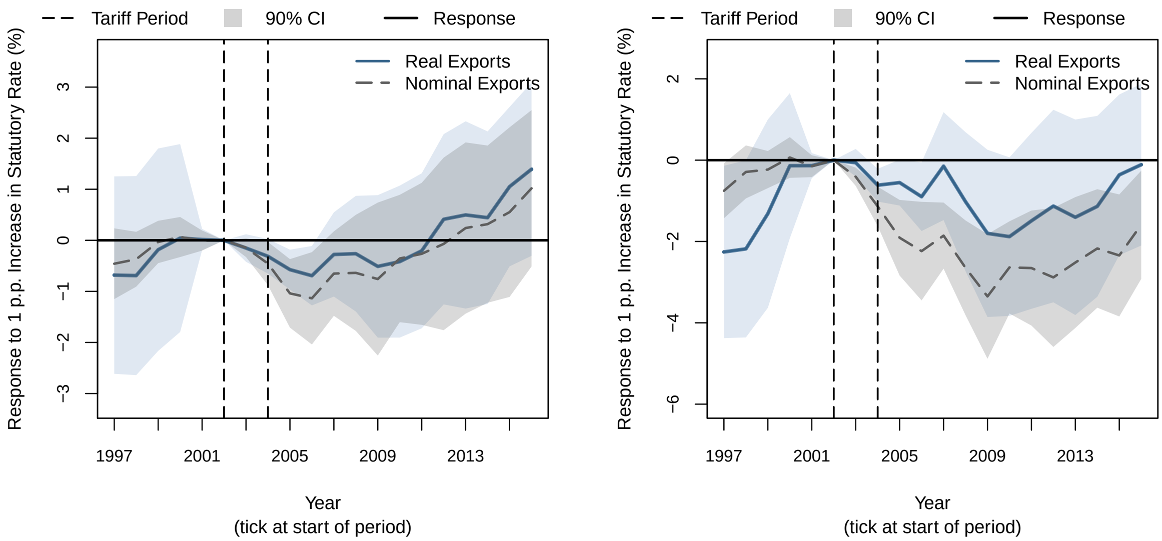
5.4 Downstream Domestic Outcomes

Though the primary focus of this paper is on the response of downstream trade flows to higher input tariffs, I also consider the impact of the upstream tariffs on two domestic outcomes: domestic absorption and employment.

Figure 11: Response of Nominal and Real Exports

(a) All Industries

(b) Steel-Intensive Industries



NOTE. This figure shows the response of nominal exports (export values) and real exports (export quantities) to a one percentage point increase in steel tariff rate. The left panel shows the responses for all downstream industries, and the right panel shows the response for steel-intensive industries.

5.4.1 Transitory Shift in Domestic Consumption to Foreign Production

Data on domestic production for domestic consumption (i.e., excluding exports) are not readily available, so instead I estimate the response of U.S. imports of downstream industry products.[36] Intuitively a relative increase in imports for products that faced higher tariffs upstream would indicate that domestic consumers substituted toward presumably lower-priced foreign downstream products in response to the tariffs (holding domestic consumption fixed). Indeed, I show in Table 4, that this is the exact response found in the data. During the period in which the tariffs are in place (2002-2003), nominal imports of downstream products that faced a one percentage point higher input tariff in the U.S. rose by about 0.65 percent for all industries, and 1 percent for steel-intensive industries (commensurate in absolute value with the declines seen on the export side). Import quantities rose by similar amounts suggesting the changes are not driven by changes in price. Unlike exports, however, the increase in imports is transitory—returning to pre-tariff levels immediately after the tariffs were lifted. This suggests that while downstream domestic producers suffered a

[36] In the Appendix I show results using a variable created using data on the value of shipments from the NBER CES Manufacturing Database, less industry exports, but this is a relatively noisy measure since the two data sources are measured using different industry classifications. The results are consistent, but are not measured with precision.

Table 4: Estimated Changes in Import Values and Quantities

	Years	Average Cost Share		75th Percentile Cost-Share	
		β_{Values}	$\beta_{\text{Quantities}}$	β_{Values}	$\beta_{\text{Quantities}}$
Pre-Tariff	1995-2000	-0.58 (0.64)	-0.11 (1.26)	-1.86 (1.02)	0.19 (2.44)
Base Period	2001	–	–	–	–
Tariff Period	2002-2003	0.64 (0.38)	0.65 (0.40)	1.04 (0.44)	1.45 (0.64)
Post-Tariff I	2004-2008	-0.60 (0.55)	0.05 (0.45)	-1.57 (0.64)	0.75 (0.62)
Post-Tariff II	2009-2014	0.20 (0.79)	0.66 (0.82)	-0.27 (0.72)	2.06 (1.07)

NOTE. Standard errors in parentheses. This table shows the effect of one percentage point increase in steel tariffs on downstream industry import values and quantities for an industry with the average steel cost share in my sample (12.7 percent). To illustrate the transitory nature of the import response more clearly, results are given as the linear combination of coefficients estimated using the following specification: $x_{d,p} - x_{d,2001} = \alpha + \sum_p \theta_p \mathbf{1}(P = p)(\Delta\tau_d \times \mathrm{C}_d) + \sum_p \gamma_p \mathbf{1}(P = p)(\Delta\tau_d) + \sum_p \omega_p \mathbf{1}(P = p)(\mathrm{C}_d) + \delta_d + \delta_t + \varepsilon_{d,p}$. Estimates using my baseline specification are shown in the Appendix.

temporary decline in domestic market share in response to the tariffs, producers were able to regain this market share much more quickly than they were able to regain global market share. In the model presented in Section 6, the transitory response of imports is generated by an asymmetry in the fixed cost associated with forming an export relationship. In the model, it is costly to start a new supplier relationship with a foreign country, but not costly to start relationships with domestic firms. The validity of this modeling choice warrants some more empirical exploration in future work.

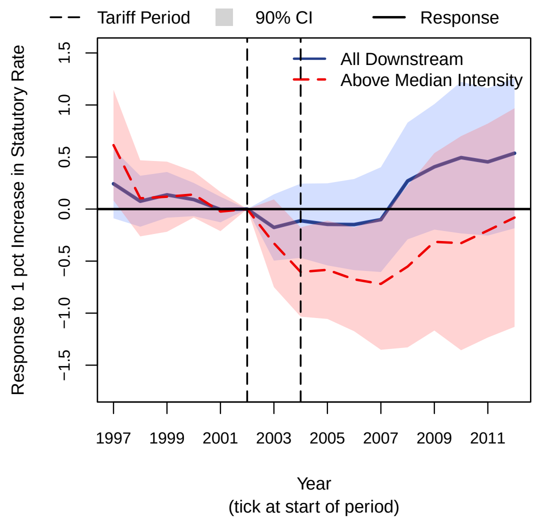
5.4.2 Domestic Employment

Lastly, Figure 12 shows the response of U.S. downstream industry employment to higher upstream steel tariffs. Particularly in steel-intensive industries, I find relative declines in employment for industries that faced relatively high steel tariffs. Employment declines are somewhat persistent—remaining (statistically significantly) depressed in steel-intensive industries for 4 years after the tariffs are removed. These findings are in line with those of Lake and Liu (2021), who find that employment in local labor markets more exposed to the Bush steel tariffs remains relatively depressed until their sample ends in 2008.

6 Theoretical Framework

The results presented in Sections 5.1 through 5.4 can be summarized by three main findings: (1) higher tariffs on steel inputs have a persistent negative impact on exports in downstream industries; (2) global market share in downstream industries that faced higher steel tariffs

Figure 12: Effect of Tariffs Domestic Employment



NOTE. This figure shows the response of domestic employment in downstream industries to a one percentage point increase in the statutory tariff rate on steel. Data for downstream employment come from the NBER CES Manufacturing Industry Database. Coefficients are estimated using a regression of the form in equation 2, but standard errors are not clustered because the data are classified by NAICS 6.

shifted to other top exporting countries; and (3) higher input tariffs have a negative impact on downstream domestic production, but this impact is more transitory. In this section, I present a partial equilibrium dynamic model of trade that features relationship-specific sunk costs of forming supplier relationships. I use the model to show that the presence of these sunk costs can generate responses that are in line with the three patterns I find in the data.

6.1 Overview

The model features two asymmetric countries (Home and Foreign). Each country has two sectors: a steel sector, which uses labor and capital to produce tradable steel products; and a downstream manufacturing sector, which uses labor, capital, and a composite of home and foreign steel to produce a tradable consumption good. The focus of the model is on the sourcing decision of downstream consumers. As in a standard Eaton and Kortum (2002) framework, consumers choose to purchase goods from the cheapest possible source. However, there is a hitch: there is a sunk cost of forming business relationships with new foreign suppliers. A consumer purchasing from a domestic source in period $t-1$ must pay a fixed cost κ to start purchasing from the foreign source in period t. The presence of these relationship-specific sunk costs are the key force generating persistence in the model.

That sunk costs can play this role is not a new finding—seminal work by Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989) showed that the presence of such a sunk cost generates hysteresis in export dynamics in response to temporary shocks, and more recent papers[37] have embedded sunk costs of exporting into both partial- and general-equilibrium dynamic models to show how they impact trade dynamics.

6.2 Model Setup

6.2.1 Steel Sector

Steel is produced both at home and abroad using capital and labor. Since the focus of this modeling exercise is on the downstream sector, I do not model the steel sector in earnest, instead making the simplifying assumption that downstream manufacturing producers consume a composite of home and foreign steel, M_t. In ongoing work, production and trade dynamics of the steel industry are taken more seriously.

6.2.2 Downstream Manufactured Goods

There are J downstream firms in each of D downstream industries. Firm j in country i produces downstream good d according to the production technology:

$$y_{jd,t} = z_j \left[k_{jd,t}^{\psi} \ell_{jd,t}^{1-\psi} \right]^{1-\alpha_d} M_{jd,t}^{\alpha_d}$$

Where z_j is a firm-specific productivity parameter, k and ℓ are capital and labor, M is the composite steel input, and α_d is the industry-specific steel-intensity. Downstream goods are sold at unit cost:

$$p_{jd,t} = \frac{1}{z_j} \left[\left(\frac{P_{jd,t}^{M}}{\alpha_d} \right)^{\alpha_d} \left[\left(\frac{R_t}{\psi} \right)^{\psi} \left(\frac{W_t}{1-\psi} \right)^{1-\psi} (1-\alpha_d)^{-1} \right] \right]^{1-\alpha_d} \tag{5}$$

The price of the steel composite, $P_{jd,t}^{M}$, is given by:

$$(1+\tau_{d,t}) P_{jd,t}^{M}$$

[37] Roberts and Tybout (1997) and Bernard and Jensen (2004), for example, show that the presence of sunk costs is an important determinant of firm entry into exporting. More recent papers, for example Das et al. (2007), Burstein and Melitz (2013), Atkeson and Burstein (2010), and Alessandria and Choi (2014), have embedded sunk costs of exporting into both partial- and general-equilibrium dynamic models to show how they impact trade dynamics. Bernard et al. (2018) emphasizes the importance of relationship-specific sunk costs. This list is not comprehensive.

Where $\tau_{d,t}$ is the steel tariff rate faced by downstream industry d in country at time t. The differential tariff rates faced by each industry can be thought of as being due to a combination of downstream industries using different types of steel inputs, which face different tariffs. The extent to which higher steel tariffs are passed through into downstream manufacturing good prices will be governed by the steel intensity, α_d of the industry. In each industry, d, the tariff rate (and therefore the price of the downstream good) follows a Markov process, and can take on two values: $\tau_{L,d}$ and $\tau_{H,d}$.

6.2.3 Dynamic Sourcing Problem

Consumers in country i consume a CES bundle of the differentiated manufactured products within an industry D, and for simplicity, spend equal proportions of income across industries.[38] Within industries, consumers choose one source for each differentiated product j. Consumers choose the cheapest source for each product, subject to one hitch: consumers must pay an adjustment cost, κ_t in order to form a new relationship with a foreign supplier. For example, if a consumer in country F was buying good j from a domestic supplier in period $t-1$, they must pay a one-time fixed cost of κ_t to switch and purchase good j from a foreign supplier from country H in period t. The fixed cost, κ_t is asymmetric, in that it is only costly to switch suppliers to a foreign source: $\kappa_t = 0$ if the consumer is switching to a domestic source. κ_t is also subject to idiosyncratic shocks.

In each period, consumers choose a source s for each good j in each sector D to minimize expected future costs:

$$C_i(s, \kappa, \tau) = \min_{s'} \left[p_{s'}(\tau) + \kappa \times \mathbf{1}(s' \neq s) \times \mathbf{1}(s' \neq i) + \beta \mathbb{E}_i \left[C_i(s', \kappa', \tau')\right]\right] \tag{6}$$

As equation 6 shows, conusmers minimize the cost of the good today, taking into account switching costs if relevant— $p_{s'}(\tau) + \kappa \times \mathbf{1}(s' \neq s) \times \mathbf{1}(s \neq i)$—plus the entire path of expected future costs, including the possibility that the consumer may want to switch sources again down the line—$\beta \mathbb{E}_i \left[C_i(s', \kappa', \tau')\right]$.

6.3 Simulation

To simulate the model, I start by drawing 2000 different goods (goods and firms will be synonymous in what follows). Each good is produced by a firm in the Home and by a firm in the Foreign country. Each good has three characteristics: (i) a tariff on inputs that is drawn uniformly from one of six different downstream industries (the tariff ranges from 0 to 30 percent); an indicator for whether the firm gets fixed cost relief ($\kappa_t = 0$ with 2 percent

[38] In ongoing work to place this model in general equilibrium, I will do away with this abstraction.

probability); (iii) a productivity parameter, δ, which equals the relative price $(p_F - p_H)$ of good j between the firm in H and the firm in F. For simplicity, prices in F are normalized to 1, and firms in H draw prices from a normal distribution with mean of (1-δ) and standard deviation of 0.2, where $\delta = 0.1$. In other words, on average, Home country producers are more productive and charge lower prices than the Foreign producers. Note that in partial equilibrium, the prices drawn serve as a summary statistic for τ, α_j, and z_j in equation 5, since the other elements of the equation are fixed. In period 0, consumers purchase each good from whichever country charges a cheaper price.

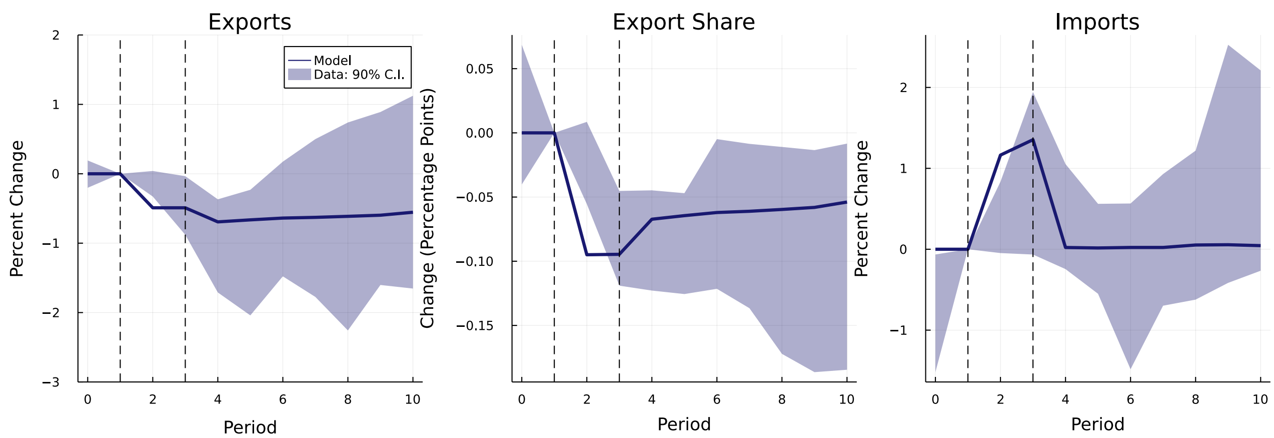
Consumers in each country believe that tariffs follow a two-state Markov process, which is calibrated such that they believe that in their own country, tariffs will stay in place for 2 years, on average, and tariffs will be put in place every 15 years. In the other country, consumers have little certainty about tariff policy: they always believe that that there is a 50 percent chance that tariffs will be implemented or removed. Consumers have a discount rate, β, of 0.99 (equivalent to an annual real rate of 1 percent). Other model parameters are calibrated to match the model-generated impulse responses to the data. The fixed cost, κ is set to 0.4. This is equivalent to 40 percent of current period prices (or costs for the consumer) or 0.4 percent of lifetime costs. In this partial equilibrium framework, consumers in each country start off with an initial endowment. Initial endowments are set such that the Home country starts off with an export share of 8 percent.

Figure 13 shows the results the model-simulated analogs to the baseline regressions presented in Section 5.1. Specifically, I regress changes in industry-level exports, export shares, and imports relative to pre-tariff levels on industry tariff rates. This is analogous to the empirical specification shown in equation 2. I plot the point estimates from the model-generated regression against the confidence intervals estimated in reduced form (see Figure 8). For all three variables, the point estimates from the model lie squarely within the confidence intervals estimated on the data. As the figures show, the model is able to match the three primary patterns in the data: (1) higher input tariffs have a persistent negative impact on downstream exports (left panel), (2) global market share shifts away from the home country toward other top competitors (middle panel—in the two-country model, the shift is toward foreign production), and (3) the response of home country imports is much more transitory than what we see on the export side (right panel).

6.4 Counterfactuals

In Figure 14, I show the model-simulated response of exports, export shares, and the number of exporting firms in the baseline and in two counterfactual scenarios. Rather than the re-

Figure 13: Model-Simulated Regression Results



NOTE. The figures above show the model-simulated analogs to the regressions presented in Figure 8. Confidence intervals from the reduced form results are shown against the simulated point estimates.

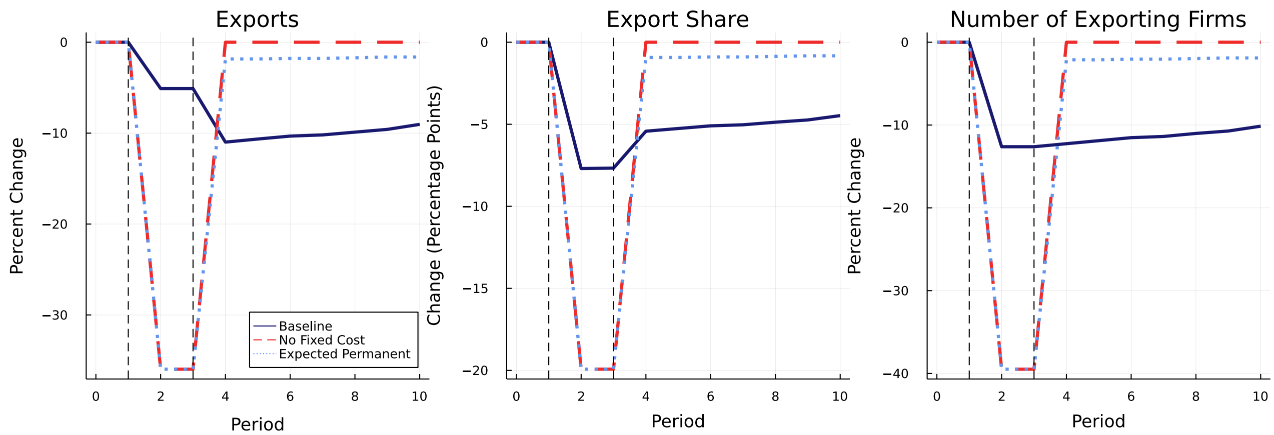
gression estimates shown in Figure 13, which show relative effects, the impulse responses are shown for aggregate variables. The baseline model is represented by the solid navy blue line. In response to the tariff shock, aggregate exports (left panel) suffer a peak decline of 10 percent relative to pre-tariff levels. Export shares (middle panel) fall by 7.5 percentage points, and the number of exporting firms (right panel) falls by just over 10 percent. Responses in the baseline case are highly persistent.

The first counterfactual, represented by the red dashed lines, shows the export responses in a model with no relationship-specific fixed costs ($\kappa = 0$). On impact of the tariffs, all three outcome variables exhibit much stronger responses relative to the baseline. Exports and export shares decline by 35 and 20 percent, respectively, and the number of exporting firms declines by 40 percent. Intuitively, this is because it is costless to transition from one supplier to another. In contrast to the baseline however, as soon as the tariff shock ends, exports revert to their pre-tariff levels. Unlike in the baseline case where the relationship-specific fixed costs slow this reversion, consumers are able to quickly shift back to their initial sources. This counterfactual shows that the fixed costs are crucial to matching the persistent nature of the reduced form evidence.

The light blue dotted line represents the response in a scenario where consumers believe that the tariff shock is permanent. (Specifically, they believe whichever state that tariffs are currently in will be permanent.) Again, the shock lasts for two periods, and when it is over, consumers believe that tariffs will permanently be in their low state. Interestingly, this change in expectations generates responses that align closely with the no-fixed-cost scenario. Since consumers believe the shock will be permanent, they are more likely to shift sources.

Once the tariffs are lifted, consumers believe the home country will permanently return to its "good state," which is why responses rebound more than in the baseline. Exports do not immediately revert back to pre-tariff levels, however, due to the fixed cost which is present in this counterfactual.

Figure 14: Model-Simulated Regression Results



NOTE. The figures above show the model-simulated counterfactuals for aggregate exports, export shares, and the number of exporting firms in the Home country. The solid blue line shows the baseline response, the red dashed line shows the response in a model with no relationship-specific trade costs, and the light blue dotted line shows the response if consumers believe the tariffs will be in permanently (but in reality they are only there for two periods, as in the baseline case).

7 Reduced Form Estimates of Welfare Impacts

In the final section, I use my reduced form results to calculate partial equilibrium estimates of the overall welfare effects of the Bush steel tariffs. The welfare will materialize both in the market for imported steel—through changes in consumer surplus, terms of trade, and tariff revenue—and in the market for downstream products, through changes in producer surplus. Assuming fairly general forms for the downstream industry export supply curve and the steel import demand curve, I empirically estimate the U.S. elasticities of downstream export supply and steel import demand, respectively, and then use reduced form evidence to calculate changes in aggregate surplus due to the Bush steel tariffs between 2002 and 2009.

7.1 Downstream Industries

In the downstream export market, changes in welfare will be represented by changes in aggregate producer surplus, or aggregate profit.[39] In general terms, consider a policy change that lowers prices in a sector, d, from $p_{d,t}$ to $p_{d,t+k}$. If we assume that production is allocated optimally across firms,[40] the ensuing change in producer surplus will be given by:

$$\Delta PS_{d,t+k} = \Pi_d(p_t) - \Pi_d(p_{t+k}) = -\int_{p_{t+k}}^{p_t} q_{d,t+k}(s)ds$$

Making one further assumption, that downstream industry supply curves are upward sloping and take the (inverse) form:

$$p_t = aq_t^{\sigma}, \tag{7}$$

where a is a marginal cost shifter and σ is the elasticity of supply, I rewrite the formula for producer surplus as:

$$\Delta PS_{d,t+k} = -\int_{p_{t+k}}^{p_t} (ap)^{\frac{1}{\sigma}} = -q_t p_t^{\sigma+1} \frac{\sigma}{\sigma+1} \left[1 - (\Delta \ln p_{t+k} + 1)^{\frac{\sigma+1}{\sigma}}\right] \tag{8}$$

For the scenario in question, I estimate σ, the elasticity of supply for downstream U.S. exporters. I observe $p_{d,t}$ and $q_{d,t}$, pre-tariff export prices and quantities; and using the estimate of σ and dynamic estimates of changes in quantities due to the tariffs, we can calculate the change in downstream producer surplus in each year due to the steel tariffs.

Estimating the Elasticity of Supply, σ

Starting with the production function (7) and taking log-differences yields:

$$\Delta \ln p_{t+k} = \sigma \Delta \ln q_{t+k}. \tag{9}$$

In this case, $\Delta \ln p_{t+k}$ is the change in U.S. export prices between periods t and $t+k$, and $\Delta \ln q_{t+k}$ is the change in export quantities during the same period. Of course, the endogeneity of prices and quantities precludes us from credibly running a regression of the form above. We can, however, instrument for $\Delta \ln q_{t+k}$ with an appropriate exogenous foreign

[39] The conventional method for measuring policy-induced changes in welfare in a partial equilibrium model is to estimate changes in aggregate surplus—the net of producer surplus, consumer surplus, and tax revenue. In this case, consumer surplus accrues in the foreign market, and there is no tax revenue downstream.

[40] That is, marginal costs of production are equated across firms in an industry.

demand shock to get an unbiased estimate of σ.

I construct a foreign demand shock as follows. First, I consider the top 10 sources of U.S. exports of downstream products.[41] Let $\tilde{m}_{id,t}$ be imports of downstream product d by country i in year t from all sources *excluding* the United States and define $\tilde{M}_{d,t} = \sum_i \tilde{m}_{id,t}$. Following Mayer et al. (2016), in each year, t, I calculate a first difference as:

$$\Delta\tilde{M}_{d,t} = (\tilde{M}_{d,t} - \tilde{M}_{d,t-1})/(0.5\tilde{M}_{d,t} + 0.5\tilde{M}_{d,t-1})$$

This measure is useful because it preserves observations when $\tilde{M}_{d,t}$ switches from 0 to a positive number and is bounded between -2 and 2. $\Delta\tilde{M}_{d,t}$, then, represents increases in "world" demand (as represented by the top 10 U.S. buyers), and can be used to instrument for $\Delta \ln q_{t+k}$ in equation 9 to estimate σ.

Results of the estimation are shown in Table 5. I estimate an inverse elasticity of export supply of $\sigma = 0.29$, suggesting export supply is fairly elastic. This estimate is in line with similar estimates from the literature, for example Romalis (2007) who estimates a value between 0.24 and 0.52. The estimate is also in line with the export supply elasticity of 0.36 that I back out from the full structural model in the next section. I use the estimate from column (1) of Table 5, which covers sample years 1995-2001 (pre-tariff), but the estimate is robust to sample selection.

Table 5: U.S. Export Supply Elasticity

	(1)	(2)	(3)
	Δ Price	Δ Price	Δ Price
Δ Quantity	0.285***	0.244**	0.298***
	(0.082)	(0.085)	(0.046)
F-Statistic	213.544	180.100	651.058

Standard errors in parentheses
Sample years:1995-2001, 2001-2010, 1998-2010
Regressions include commodity and year fixed effects.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Calculating the Percent Change in Prices

To estimate $\Delta \ln p_{t+k}$, I use estimates of the change in export quantities due to input tariffs in each year relative to pre-tariff levels. These estimates are calculated using the dynamic specification shown in equation 10, the results of which are presented in Section 5, Figure 11.

[41] Canada, Mexico, Japan, Germany, United Kingdom, France, Brazil, China, South Korea, Netherlands

$$q_{d,t} - q_{d,2001} = \alpha_t + \beta_t^q \ln((1+\tau_{d,2003})/(1+\tau_{d,2001})) + \Xi_t' X_d + \epsilon_{d,t} \tag{10}$$

The coefficients, β_t^q, recovered from this estimation in each year t, can be used to calculate $\Delta q_{d,t+k}$ as:

$$\beta_t^q \Delta\tau_d \approx \frac{q_{d,t+k} - q_{d,t}}{q_{d,t}} = \Delta \ln q_{d,t+k}$$

Using equation 9 and the estimate of σ, we can then estimate $\Delta \ln p_{d,t+k}$ in each year, t. Plugging this as well as observed values of initial prices and quantities ($p_{d,2001}$ and $q_{d,2001}$) into equation 8 yields estimates in the change in downstream industry producer surplus in each year, t, due to the steel tariffs. The results, displayed in Table 6, show losses to downstream producers of 2 to 6 percent of exports between 2002 and 2009. Although in many years I cannot reject the null hypothesis that the change in producer surplus due to the tariffs was 0,[42] the results strongly suggest economically significant and persistent losses to downstream producers from the steel tariffs.

Table 6: Downstream Loss in Producer Surplus

Year	ΔPS ($B)	90%CI	% of Exports
2002	-1.99	[-5.93, 2.13]	1.09
2003	-5.98	[-11.90, 0.36]	3.19
2004	-11.06	[-17.56, -4.01]	5.16
2005	-15.51	[-22.40, -7.94]	6.36
2006	-11.83	[-22.19, 0.00]	4.22
2007	-6.38	[-20.19, 9.95]	1.97
2008	-9.59	[-23.52, 7.05]	2.59
2009	-11.25	[-24.81, 4.93]	4.13
2010	-7.28	[-21.48, 9.61]	2.12
2011	3.59	[-12.74, 23.02]	-0.86

7.2 Upstream (Steel) Industry

I use a similar process to estimate changes in welfare in the steel industry. First, I assume that U.S import demand for steel is given by:

$$m_{ig,t} = \kappa p_{ig,t}^{-\gamma}$$

Where $p_{ig,t}$ the duty-inclusive price, i.e., $p_{ig,t} = (1+\tau_{ig,t})p^*_{ig,t}$, and γ is the U.S. import demand elasticity. Taking log-differences, we can estimate the desired elasticity, γ, from a

[42]This is due to imprecision in the estimates of the change in quantity due to the tariffs.

regression of the form:

$$\Delta \ln m_{ig,t} = -\gamma \Delta \ln p_{ig,t}$$

Where i are steel industries, g are source countries, and $\Delta \ln p_{ig,t}$ is instrumented with an exogenous supply shifter. In this case, we can use the steel-tariffs themselves to instrument for $\Delta \ln p_{ig,t}$. The results of the first and second stages are displayed in columns (1) and (2) of Table 7, respectively. Though the tariffs are a weak instrument for the change in prices according to the F-statistic, the resulting estimate of $\gamma = -2.389$ is exactly in line with the U.S. import demand elasticity of -2.53 that Fajgelbaum et al. (2020) estimate using the Trump tariffs.

Table 7: U.S. Import Demand Elasticity

	(1) Δ Log Duty-Inclusive Price	(2) Δ Log Quantity	(3) Δ Log Quantity
Δ Log (1+τ)	0.737*		-4.598**
	(0.295)		(1.443)
Δ Log Duty-Inclusive Price		-2.389*	
		(1.090)	
Constant	0.047		0.420
	(0.053)		(0.223)
F-Statistic		5.835	

Standard errors in parentheses
Sample years: 2002-2003
Regressions include country-year fixed effects.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Following the same process that I did for the downstream industries, I use the estimated coefficient, β^s, from a regression of the change in imported steel quantities on the change in the statutory tariff rate faced by that steel industry (column (3) of Table 7), to calculate:

$$\Delta \ln q_{ig,t} = \beta^s (1 + \tau_{ig,t})$$

in years 2002 and 2003. The estimate of $\Delta \ln q_{ig,t}$ combined with the (assumed) formula for the demand curve yields an estimate for $\Delta \ln p = -\frac{1}{\gamma} \Delta \ln q$ for each year.

From here, following the same logic as for the downstream sector, I calculate the change in consumer surplus in the steel sector due to the tariffs as:

$$\Delta CS_{d,t+k} = q_t p_t \left(\frac{1}{1-\gamma} \right) \left[1 - (1 + \Delta p_{t+k})^{1-\gamma} \right]$$

The resulting estimates, shown in the third column of Table 8, also include changes in tariff revenue earned due to the tariffs in the two years in which the tariffs were in place.

7.3 Overall Change in Welfare

Combining estimates of changes in welfare in the downstream sectors with changes in the steel sector, I calculate the overall change in welfare due to the steel tariffs, relative to pre-tariff levels, in each year. The results are shown in Table 8. I find that welfare losses amount to between 1 and 6 percent of exports in each year. Losses are primarily concentrated in the downstream sector, though persistent declines in the downstream sector may have had a continuing negative impact upstream as well (in most years, I cannot reject the null hypothesis of 0 change in welfare in the upstream sector). More important than the magnitudes estimated in each year is the fact that welfare losses accrue for years after the tariffs were removed, something that conventional methods for evaluating the impacts of such a policy traditionally miss. A comprehensive estimate of the welfare impacts of an input tariff will be substantially underestimated if the downstream dynamic impacts are not taken into account.

Table 8: Overall Welfare Loss from 2002-2003 Steel Tariffs

Year	Downstream ($B)	Upstream ($B)	Total ($B)	Total % of Exports
2002	-1.99*	-0.51	-2.49*	1.37*
2003	-5.98*	-0.88	-6.86*	3.66*
2004	-11.06*	-0.37*	-11.42*	5.33*
2005	-15.51*	-0.18	-15.69*	6.43*
2006	-11.83*	-0.52	-12.35*	4.41*
2007	-6.38	-0.38	-6.76	2.09
2008	-9.59	0.13	-9.46	2.55
2009	-11.25	-0.52	-11.77	4.32

A * indicates that result is statistically significant with a 90 percent confidence interval.

8 Conclusion

Using a case study of the steel tariffs levied by George W. Bush in 2002-2003 and a newly devised method for mapping detailed steel inputs to downstream users, I provide the first comprehensive estimates of the long-term effects that temporary upstream tariffs have on downstream industries. I find that temporary upstream tariffs have negative impacts on downstream industries, both in terms of their competitiveness in the export market and in terms of domestic outcomes like employment and production. Crucially, I find that these declines are highly persistent, particularly on the export margin and especially for steel-intensive industries. The global market share of U.S. downstream industries remained depressed long after the tariffs were removed as foreign buyers permanently shifted sourcing patterns toward other top producers. Using a dynamic model of trade, I show that the presence of relationship-specific sunk costs of trade can generate a persistent response of downstream exports to a temporary input tariff that is consistent with the patterns I find in the data. Intuitively, because it is costly for buyers to change sources of imports, if an input tariff induces a change in sourcing patterns, those patterns will not immediately revert when the tariffs are lifted.

Overall, my results highlight the complex nature of tariff policy in a world with globally integrated production networks. Even temporary tariffs on a small subset of imports can have persistent effects on a broad swath of the economy. Failing to take this persistence into account can lead to a substantial underestimate of the welfare implications of tariff policy.

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A Appendices

A.1 Steel-Specific IO Table

A.1.1 Data and Merge

I use three data sources to create the steel-specific input output table: exclusion requests from Regulations.gov, firm-level data from Orbis, and firm-level data from the Dunn & Bradstreet Database. Data from Regulations.gov are publicly available, and I had access to the firm-level databases through Harvard's library.

From Regulations.gov, using their API, I pulled all exclusion requests that were filed under OMB Form 064-1039 — the form that related to Trump's Section 232 steel and aluminum tariffs.

I merge firm names from the exclusion requests with Orbis to match those firms with NAICS industry classifications. For the merge, I use the fuzzy matching algorithm described in Appendix 3 of Schoenle (2017). In brief, I standardize all firm names in both databases by removing capitalization and punctuation, and transforming generic terms (like "Inc." and "Co.") into standard forms. I then merge the databases on firm name and location (U.S. state). Using this methodology I am able to match about 50 percent of exclusion requesting firms.

After the merge with Orbis I was left with 12 steel products that were covered by the Bush tariffs, were covered by the exclusion requests, but that I did not have a merge match for. I manually searched for exclusion-requesting firms for these products in the Dunn & Bradstreet database. I was able to match 11 of the 12.

A.1.2 Extending the Steel-Specific IO Methodology to Other Inputs

In this Appendix, I show that the methodology I use to create the steel-specific input-output table also works for aluminum. In principle, the same methodology should work for any input that was protected by the Trump tariffs (for which a substantial number of exclusion requests were filed). In Table 9 shows regressions of changes in material costs in downstream industries to changes in the unit value of aluminum imports. I link aluminum imports to industries using the same exclusion-request methodology that I used for the steel sector. The results show that changes in linked aluminum import unit values are significant predictors of changes in downstream material costs, even after controlling for the average price of aluminum.

Table 9: Aluminum-Import Prices Predict Downstream Material Costs: Industry-Level

	(1) Δ Material Costs	(2) Δ Material Costs
Δ Aluminum Unit Value	0.094	0.153
	(0.049)	(0.049)
Δ PPI Aluminum (Non-Ferrous Metals)		0.530
		(0.049)
Constant	-0.048	-0.009
	(0.034)	(0.033)
Year Fixed Effects	Yes	No
Sector Fixed Effects	Yes	Yes
Observations	650	650

Standard errors in parentheses
Sample years: 2001-2011.

A.1.3 Comparison with Other IO Tables

In Table 10, I list the top 10 downstream using industries of steel according to my steel-specific IO table, the publicly available IO table from the BEA, and the IO table from Berlingieri et al. (2018). The differences in these lists highlight the level of detail that my IO table is able to capture. Instead of representing industry use of *all* steel products, my IO table represents industry use of a very specific set of steel products—those that were covered by the Bush steel tariffs.

A.2 Estimation Specification and Robustness

A.2.1 Baseline "Local Projection" Specification

The estimation specification that I employ in my baseline results (see Figure 8) is as follows:

$$x_{d,t} - x_{d,2001} = \alpha_t + \beta_t(\tau_{d,2003} - \tau_{d,2001}) + \Xi_t' X_d + \varepsilon_{d,t} \tag{11}$$

This is a fairly common way to compute impulse responses in the macro literature (see Jordà (2005)). In the current baseline in the paper, standard errors are clustered by NAICS6 industry. Note that though I cannot include industry fixed effects in these cross-sectional regressions, I am subtracting out a baseline level—$x_{d,2001}$—from my left-hand side variables,

Table 10: Intensity of Steel Use: Comparison with BEA IO Table

Steel-Specific IO	BEA IO	Berlingieri et al. (2018)
Other Metal Container Mfg	Motor Vehicle Metal Stamping	Forging, Pressing, Stamping & Roll-Forming
Metal Coating, Engraving, Allied Services	Fabricated Structural Product	Fabricated Metal Products, n.e.c.
Fruit & Vegetable Canning	Metal Tank (Heavy Gauge) Mfg	Other Transport Equipment n.e.c.
Other Motor Vehicle Parts Mfg	Spring and Wire Product Mfg	Casting of Iron and Steel
Other Transportation Equip. Mfg	Metal Crown, Closure, Metal Stamping	Bearings, Gears, Driving Elements Mfg.
Support Activities: Oil & Gas	Ornamental & Architectural Metal Prod.	Tanks, Reservoirs, Metal Container Mfg.
Fabricated Structural Metal Mfg	Other Fabricated Metal	Pumps, Compressors, Taps & Valves Mfg.
All Other Plastics Prod. Mfg	Turned Product, Screw, Nut & Bolt Mfg	Structural Metal Products Mfg.
Crane, Hoist, Monorail Sys. Mfg	Cutlery & Handtool Mfg	Treatment and Coating of Metals
Metal Can Mfg	Motor Vehicle Steering, Susp., Brakes	Domestic Appliances n.e.c. Mfg
Hardware Mfg	Other Motor Vehicle Parts Mfg	Electric Motors, Generators, Transformers Mfg.

which serves a similar role as de-meaning at the industry level. This is the predominant reason why, as I show below, the pooled regression including industry fixed effects gives almost identical results.

Rather than interacting the tariff variable with the industry's steel cost-share, I split the results into two samples: all industries, which reflects the response of an industry with an average steel cost share; and steel-intensive, which reflects the response of an industry around the 75th percentile[43]. This choice is simply for ease of interpretation—it saves the step of having to compute linear combinations of interacted variables to interpret the regression results.

The control variables included in X_d in the baseline specification are:

- The weighted average share of steel products used by downstream industry d that was imported from non-exempt countries in 2001 (pre-tariff "exposure").
- The weighted average percent of steel products used by downstream industry d that cannot be produced in the United States.

In practice, these controls turn out to be uncorrelated with the independent variable of interest, so their inclusion does not alter the response of left-hand side variables to the tariffs. Additionally, I can control for the downstream industry's steel cost share (a variable that comes from the more aggregated I-O table from BEA and so is at the NAICS 6 level of detail) and the change in China's share of world exports in downstream industry d between year t and year 2001. My results are also robust to including these controls.

A.2.2 "Diff-in-Diff" Approach

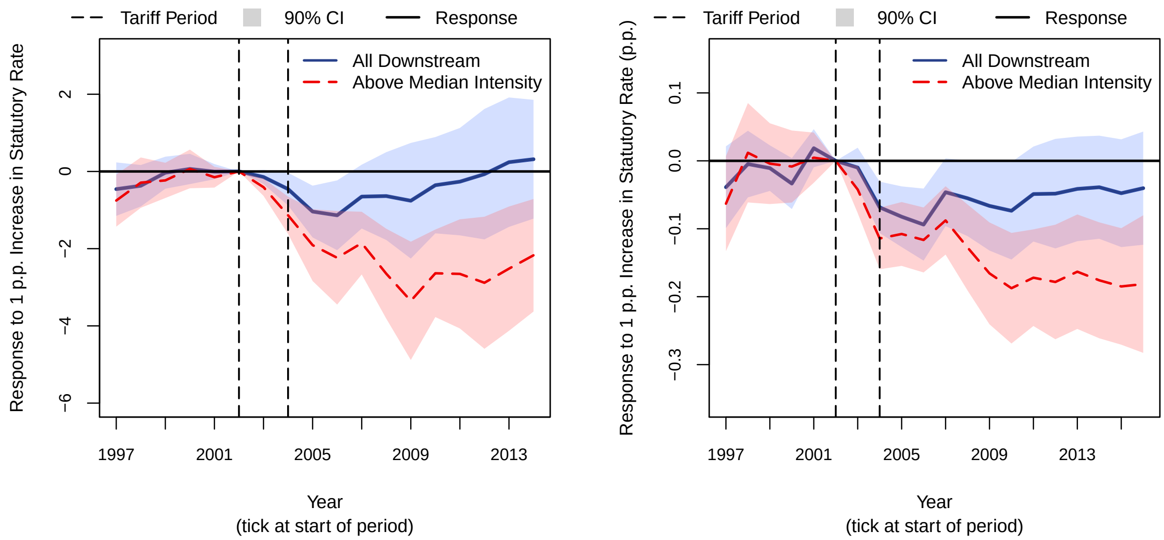
For the reasons described above, the local projection methodology yields similar results to running pooled regressions as in the "event-study diff-in-diff" approach. I can re-run my specifications as follows, with the most saturated version being:

$$\begin{aligned}\Delta x_{d,t} - x_{d,2001} = \alpha + \sum_t \theta_t \mathbf{1}(Y_t = t)(\Delta\tau_d \times \mathrm{C}_d) \\ + \sum_t \gamma_t \mathbf{1}(Y_t = t)(\Delta\tau_d) + \sum_t \omega_t \mathbf{1}(Y_t = t)(\mathrm{C}_d) + \delta_d + \delta_t + \varepsilon_{d,t} \qquad (12)\end{aligned}$$

Where C_d is industry d's steel cost share and $\Delta\tau_d = \tau_{d,2003} - \tau_{d,2001}$ is the same tariff variable used in the baseline specification. Here I include both downstream industry fixed effects, δ_d

[43] Really, the average of the above-median steel cost shares.

Figure 15: Baseline Specification



(a) Export Values

(b) Export Share

(at the HS6 level of detail), and year fixed effects, δ_t. In addition, the tariff variable, the cost-share variable, and the interaction of the two are each interacted with a set of year dummies. As above, standard errors are clustered by NAICS 6. Note that because of the inclusion of industry fixed effects, my additional industry-level controls (e.g., pre-tariff "exposure") are redundant. From these results, we can calculate the percent change in outcome variable x in downstream industry d and year t relative to 2001 due to a one percentage point increase in $\Delta\tau_d$ for an industry with steel cost-share $\bar{C}$ as:

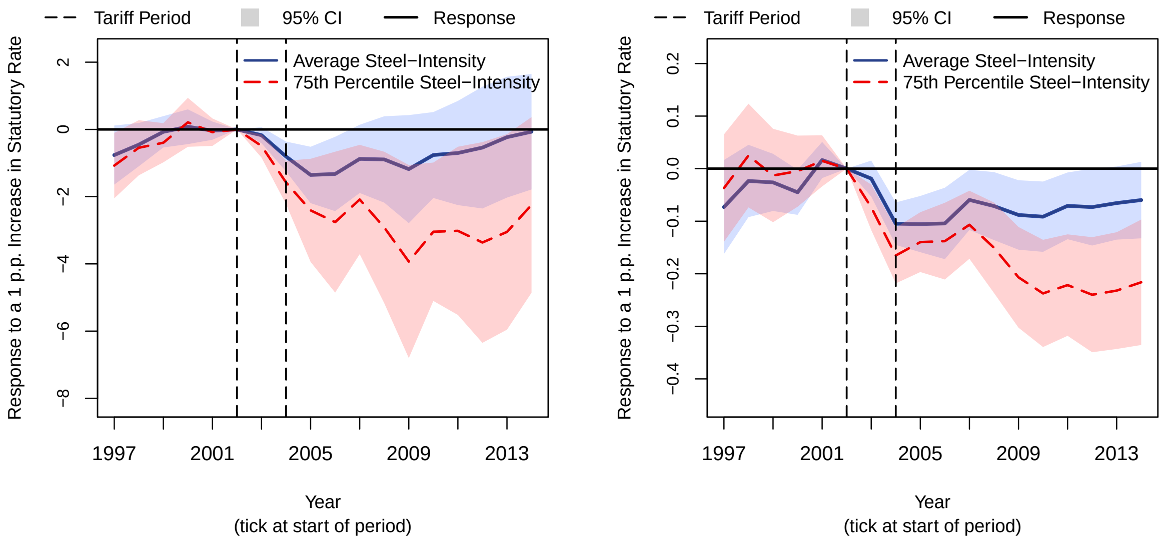
$$(\bar{C} \times \theta_t) + \gamma_t \tag{13}$$

For ease of comparison with my baseline specification, I plot these linear combinations and their standard errors for the average steel cost share (12.7 percent)[44] and the 75th percentile (24.3 percent) in Figure 16. As expected, the results are similar to the baseline specification. In my baseline specification I already remove an industry specific time "trend," by subtracting out 2001 values. In Figure 17, I show that these results are robust to removing a longer trend, from 1996-2001.[45]

[44]This is just slightly above the median of (10.6 percent)

[45]In a similar study of the Trump tariffs, Flaaen and Pierce (2019) use a similar methodology and detrend their left-hand-side variables using one year of monthly data in the year prior to the tariff shock.

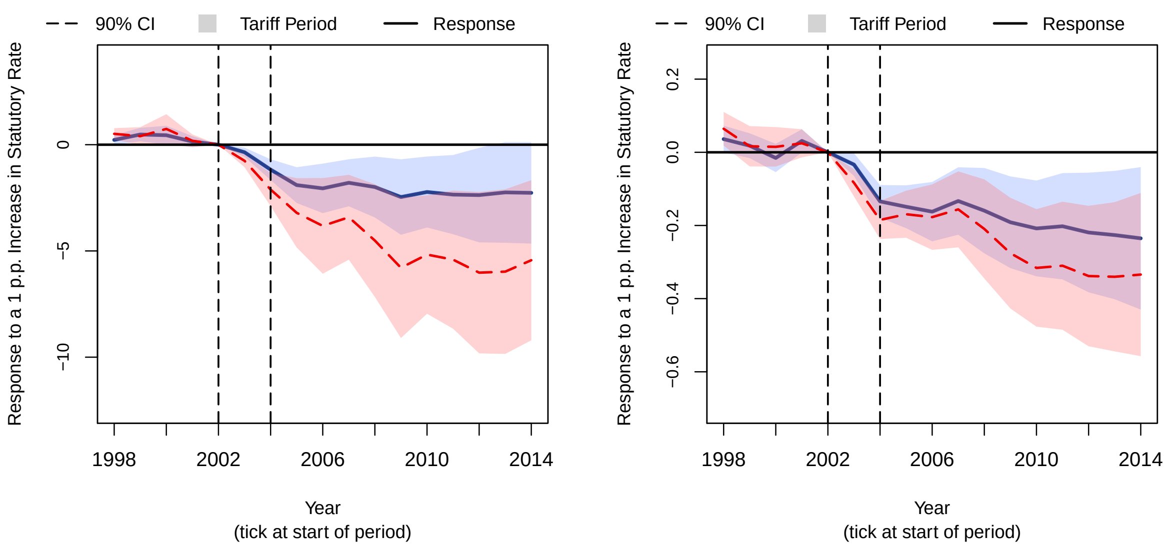
Figure 16: Alternative "Diff-in-Diff" Specification



(a) Export Values

(b) Export Share

Figure 17: Alternative "Diff-in-Diff" Specification: Detrended



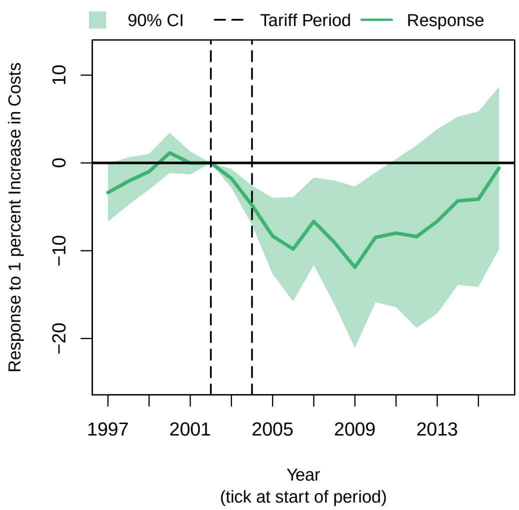
(a) Export Values

(b) Export Share

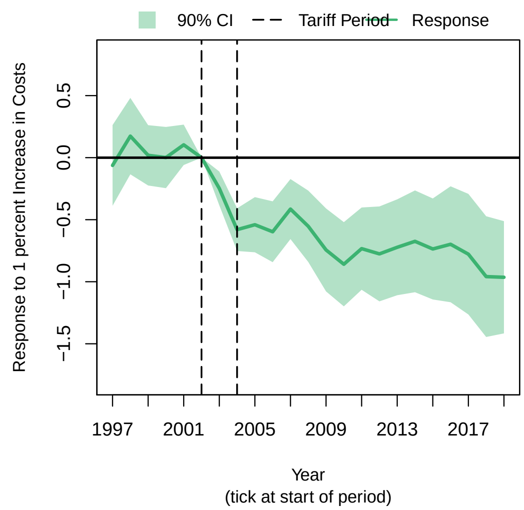
A.3 Integration of the Cost-Share Measures

Instead of using the statutory tariff rate on downstream industry d's steel inputs as the independent variable of interest, we can also use $c_d^\tau = \tau_d \times C_d$—a measure of the percent increase in industry d's input costs due to the tariffs. As shown in Figures 18a and 18b, switching to this independent variable will simply re-scale the results. In Figure 18a, the interpretation here is that a one percent increase in input costs (due to the tariffs) leads to

Figure 18: Alternative Specification: Response to Increased Costs



(a) Exports



(b) Export Shares

around a peak decline in exports of 10 percent by 2005.

A.3.1 Other Robustness Exercises

In response to concern about the potentially skewed distribution of steel cost shares across industries, in Figure 19, I show the alternative specification (equation 12, NAICS 6 clustering), excluding the top percentile of steel users to show that results are not driven by the far right tail of the distribution.

In both the baseline responses of export shares and export values, there appear to be dips in the responses for steel-intensive industries in 2009, creating potential concern about an omitted variable that is correlated both with the tariff rates imposed in 2002 and how industries fared during the Great Recession. It is not abundantly clear how to control for this potential "second shock." The second dip occurs more for steel-intensive industries, yet steel intensity in a downstream industry is not correlated with the tariff rate the downstream industry faced. Adding fixed effects at the HS2-digit level (which, in the local projection specification is equivalent to adding HS2 $\times$ year fixed effects, smooths the second dip to some extent, but it is not clear that this is variation we want to be absorbing in all cases. Figure 20 shows how the export share response changes if I drop individual HS2 categories. Dropping one category—HS 72—eliminates the kink to some extent, but the response remains within the confidence bands of my baseline.

Figure 19: Alternative Specification: Excluding Top Percentile of Steel Users

(a) Export Values (b) Export Share

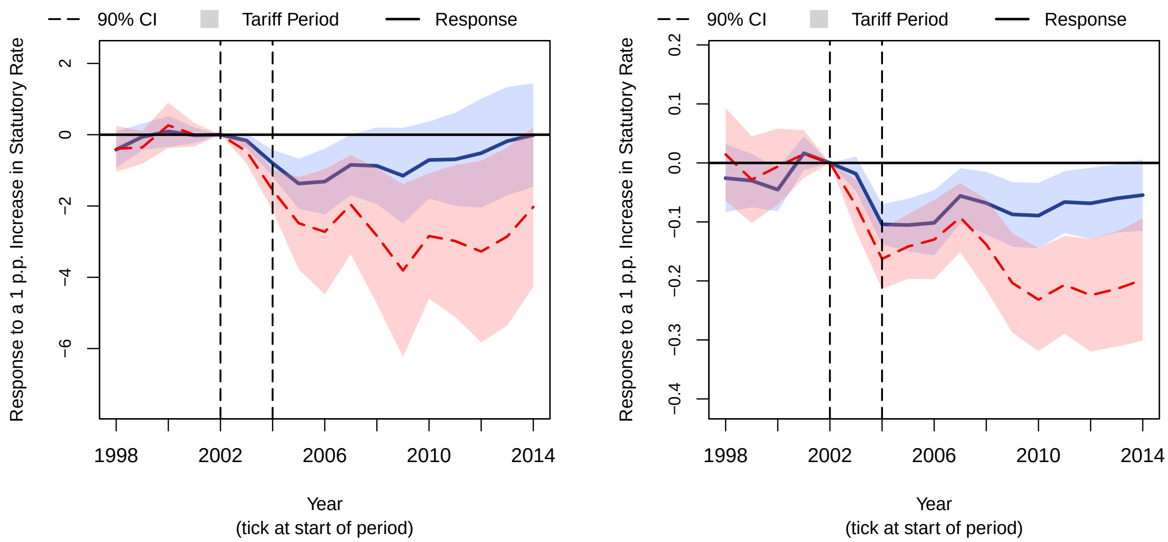
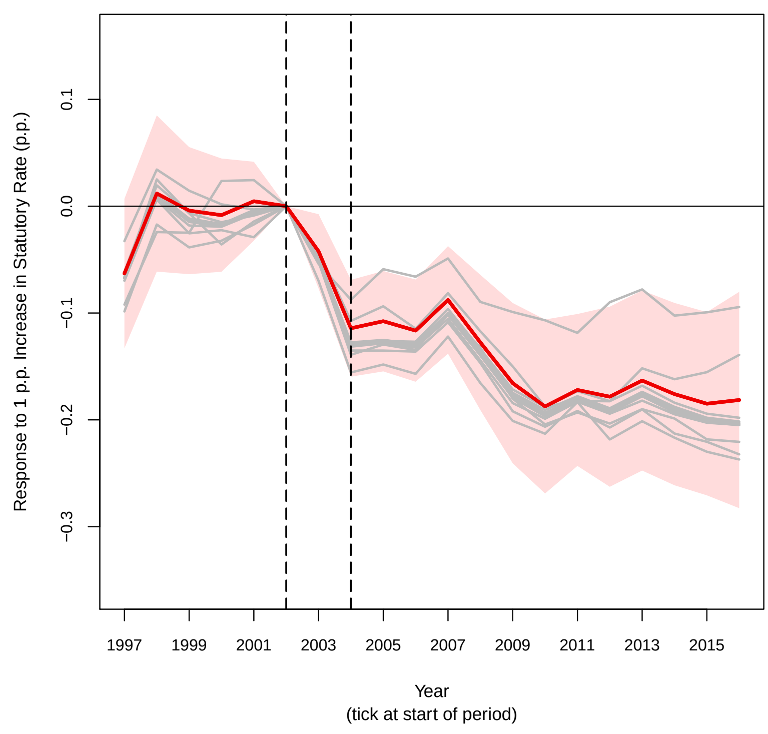
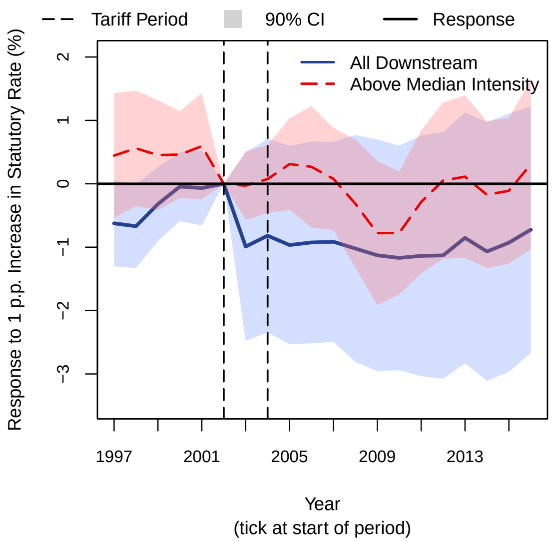


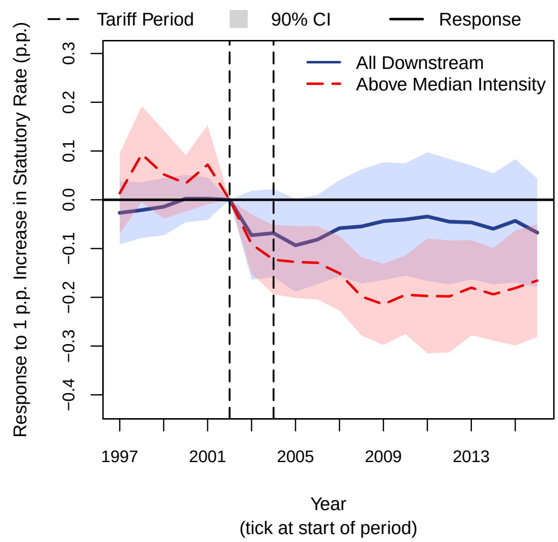
Figure 20: Dropping Individual HS2 Industries



Note. This figure shows the response of the export shares of steel-intensive industries to a one percentage point increase in steel statuory tariff rates, omitting one HS2 chapter at a time.

Figure 21: Aggregation to the NAICS 6 Level





A.4 Regression Tables

Regression tables for my baseline results are shown below.

Table 11: Regression Output for Downstream Export Values

β	90% CI (Low)	90% CI (High)	Year	N
-0.46	-1.15	0.23	1996	1089
-0.37	-0.91	0.17	1997	1089
-0.03	-0.45	0.38	1998	1090
0.06	-0.33	0.46	1999	1090
0	-0.2	0.19	2000	1090
0	0	0	2001	1090
-0.14	-0.33	0.04	2002	1090
-0.46	-0.88	-0.03	2003	1090
-1.04	-1.71	-0.37	2004	1089
-1.14	-2.04	-0.23	2005	1089
-0.65	-1.48	0.17	2006	1090
-0.64	-1.77	0.5	2007	1090
-0.76	-2.26	0.74	2008	1090
-0.36	-1.6	0.89	2009	1089
-0.26	-1.65	1.12	2010	1089
-0.07	-1.76	1.62	2011	1089
0.24	-1.43	1.91	2012	1089
0.32	-1.22	1.85	2013	1089
0.55	-1.11	2.21	2014	1088
1.02	-0.51	2.55	2015	1089

Table 12: Regression Output for Downstream Export Shares

β	90% CI (Low)	90% CI (High)	Year	N
-0.06	-0.14	0.02	1996	590
0.02	-0.05	0.09	1997	590
-0.02	-0.1	0.06	1998	590
-0.03	-0.1	0.04	1999	590
0.01	-0.04	0.07	2000	590
0	0	0	2001	590
-0.02	-0.06	0.01	2002	590
-0.08	-0.12	-0.05	2003	590
-0.08	-0.12	-0.04	2004	590
-0.09	-0.13	-0.05	2005	590
-0.06	-0.12	0	2006	590
-0.07	-0.14	-0.01	2007	590
-0.09	-0.17	-0.01	2008	590
-0.1	-0.19	-0.01	2009	590
-0.1	-0.18	-0.01	2010	590
-0.09	-0.17	0	2011	590
-0.06	-0.14	0.02	2012	590
-0.09	-0.17	-0.01	2013	590
-0.07	-0.15	0.02	2014	590
-0.06	-0.14	0.02	2015	590

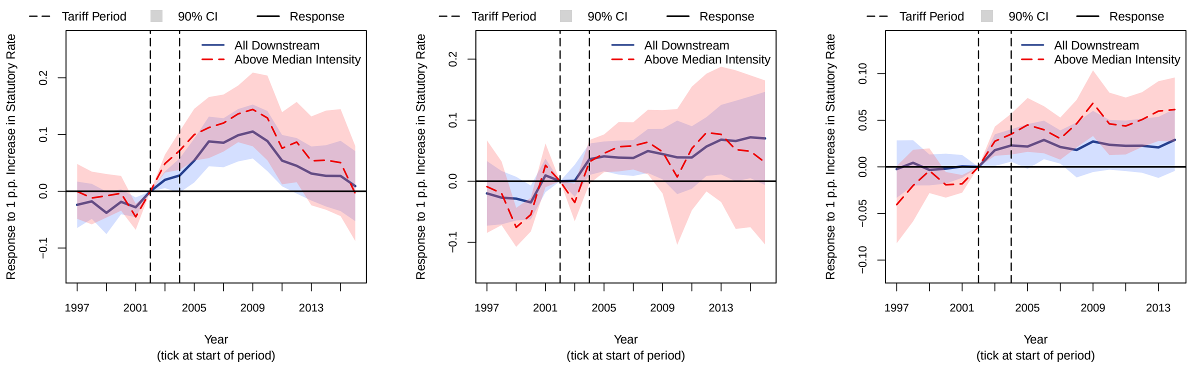
Table 13: Regression Output for Top 5 Competitor Export Shares

β	90% CI (Low)	90% CI (High)	Year	N
-0.03	-0.13	0.06	1996	1023
-0.03	-0.09	0.03	1997	1021
-0.07	-0.12	-0.03	1998	1019
-0.04	-0.08	-0.01	1999	1020
-0.03	-0.06	0	2000	1025
0	0	0	2001	1033
0.06	0.03	0.09	2002	1023
0.13	0.08	0.17	2003	1017
0.14	0.08	0.19	2004	1027
0.15	0.1	0.21	2005	1017
0.15	0.09	0.2	2006	1018
0.16	0.1	0.21	2007	1016
0.16	0.1	0.23	2008	1012
0.13	0.05	0.21	2009	1010
0.1	0.03	0.17	2010	1004
0.11	0.03	0.18	2011	1008
0.1	0.01	0.19	2012	1001
0.1	0.01	0.2	2013	1001
0.1	-0.01	0.21	2014	1006
0.1	-0.03	0.23	2015	1002

A.5 Global Market Share Shifts to Other Competitors

Figure 22 shows the individual country responses underlying the results shown in Figure 9 in the main text.

Figure 22: Global Market Share Shifts to Other Top Producers

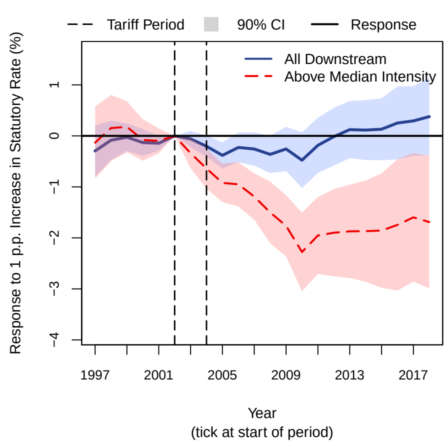


(a) Germany (b) Japan (c) France

A.6 Extensive Margin

In Figure 10 in the main body of the text, I omit HS sector 84, which is an outlier that causes a large kink in the impulse response of the number of trade relationships in 2009. The full sample is shown below for transparency—the message of the figure does not change.

Figure 23: Number of Trade Relationships (Full Sample)

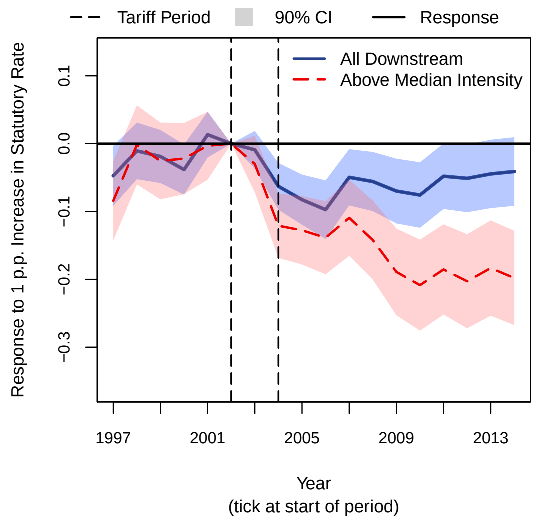


A.7 Global Reconfiguration: China

In Figure 24, I show the results of my main specification with an additional control: the change in China's share of world exports in downstream industry d between year t and 2001. Results are virtually unchanged from the baseline result presented in Figure 8b.

Additionally, Figure 25 shows that, unlike Germany, Japan and France (shown Section 5.2),

Figure 24: Robustness to China Shock: U.S. Share of World Exports



U.S. export shares do not appear to have shifted persistently toward China in the wake of the steel tariffs, at least at first. Chinese exports do appear to shift up in the later part of the sample, but I leave exploration of this pattern to future work.

Figure 25: Chinese Export Shares