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

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Abstract

In this paper, I study the long-term effects that temporary upstream tariffs have on downstream industries. Using a novel method for mapping downstream industries to detailed steel inputs, I estimate the effect of the steel tariffs levied by President Bush in 2002 and 2003 on downstream industry outcomes. I find that upstream steel tariffs have highly persistent negative impacts on downstream industry exports, production, and employment. I then use a simple dynamic trade model to show that relationship-specific sunk costs and policy uncertainty can generate persistence of the magnitude that I find in the data.

Keywords: Trade policy, tariff, steel, global value chains, hysteresis

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 especially 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 simple dynamic model of trade that is 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 findings are threefold. First, I find that the increase in steel tariffs had immediate negative impacts on downstream industry exports. Specifically, industries that suffered a one percent larger increase in input costs due to the Bush steel tariffs suffered around a 3 percent decline in exports and a 0.3 percentage point decline in global market share relative to pre-tariff levels.[2] Declines in nominal exports were entirely driven by declines in exported quantities, as the tariffs led to a slight increase in export prices (proxied for by export unit values) while in place. Higher input tariffs are also associated with relative declines in overall domestic production (value of shipments) and employment.

Second, in the export market, I find suggestive evidence that these declines occurred on the extensive margin, rather than the intensive margin. Because I rely on industry-level data in this paper, I am unable to directly observe the extensive margin. However, I create a proxy for the extensive margin, which I call a "trade relationship," using highly disaggregated customs-district level imports data. A "trade relationship" is defined as a customs district $\times$ 10-digit product $\times$ destination country triplet (e.g., a golf cart exported from Savannah to Japan). A 1 percentage point increase in input tariff is associated with a 1 percent decline in the number of trade relationships an industry has, relative to pre-tariff levels.

Lastly, despite the temporary nature of the Bush steel tariffs, I find that the negative impacts on downstream exports, production, and employment were highly persistent. While the tariffs were in place, export prices rose and export quantities fell—consistent with the expected inward shift of the export supply curve in response to an increase in input costs. Once the tariffs were lifted, however, export prices returned to their pre-tariff levels, but other downstream industry outcomes remained depressed relative to pre-tariff levels until at least 2010—seven years after the Bush tariffs were lifted. The U.S. share of world exports—a proxy for the United States' global market share—exhibits even more persistence, failing to rebound to pre-tariff levels for the entire sample period. Evidence suggests that the tariffs induced a reconfiguration of global trade flows toward other top producing countries in downstream industries, that did not revert when the tariffs were lifted.

Back-of-the-envelope calculations show that the estimated losses in downstream industries due to the increase in steel tariffs were substantial. Relative to 2001 levels, my reduced form estimates suggest the tariffs caused declines in exports of between 10 and 50 billion dollars per year between 2002 and 2009—equivalent to around 4 percent of exports. Declines in manufacturing industry shipments ranged from 25 to 85 billion over the same period, or around 1 percent of total manufacturing industry shipments per year. Over the 2002-2009

[2] I typically measure the response to changes in input costs. In my data, the average industry has a steel share of input costs of 5 percent, so a 1 percent increase in input costs is consistent with a 20 percentage point increase in the steel tariff rate.

period, the tariffs were also responsible for an average of 168 thousand fewer jobs per year relative to pre-tariff levels in downstream industries—more jobs than there are in the entire (upstream) steel sector. A substantial portion of these losses accrued in heavy steel-using industries like automobile and other machinery manufacturing.

In the last part of the paper, I use a simple dynamic trade model to show that three model features are important for generating a persistent response of downstream exports to a temporary input tariff that is consistent with the patterns I find in the data: (1) a relationship-specific sunk cost of importing, (2) uncertainty about the persistence of the tariff shock, and (3) a high degree of price competition among possible sources. 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 in order to choose a source for each downstream good. Consumers choose to purchase each good from the cheapest possible source. However, they face a sunk cost of forming relationships with new suppliers. A consumer purchasing from source i in period $t-1$ must pay a fixed cost to purchase from source $j \neq i$ in period t. Consumers also face uncertainty about trade policy in the foreign country. Through simulated regressions and counterfactuals, I show that if the two countries charge competitive enough prices for downstream products, then the presence of these relationship-specific sunk costs and uncertainty about trade policy can generate persistence of the magnitude that I find in the data.

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. (2019c), Cavallo et al. (2019), and Fajgelbaum et al. (2020), who estimate the impacts of the Trump tariffs on prices and welfare. 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. There are a handful of studies that use other periods of tariff implementation to estimate the effects of tariffs through supply chains. 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 considering optimal tariff policy in the context of global value chains, as in Antràs et al.

(2021), Caliendo et al. (2021), and Blanchard et al. (2021); and work on the impact of input tariff liberalization on the economy—e.g., Amiti and Konings (2007), Goldberg et al. (2010), Topalova and Khandelwal (2011), and Blaum et al. (2018)—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.[3] 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 study the long-term effects of the Bush steel tariffs 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, and my results focus on industry-level outcomes rather than local effects.

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. Among the few papers in the trade literature that provide causal evidence of hysteresis in response to a temporary exogenous shock are Choi and Levchenko (2022), who document the long-term effects of industrial policy in South Korea on export performance; Xu (2021), who studies the 1866 London banking crisis to show that temporary financial shocks have a persistent impact on exports; and Juhász (2018) who studies the effects of temporary trade

[3] A few of these recent papers include Amiti et al. (2019c), Cavallo et al. (2019), Fajgelbaum et al. (2020), and Flaaen and Pierce (2019).

protection on long-term economic development in the 19th century French Empire.[4] On the theoretical side, seminal work by Baldwin (1988), 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. 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 and understand the important theoretical mechanisms potentially driving my empirical results.

Overall, this paper highlights the complex nature of tariff policy in a world with global production networks. Even temporary tariffs on a small subset of imports can have persistent effects on a broad swath of the economy. The rest of the paper proceeds as follows: In Section 2, I provide 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, and in Section 6 I use a simple model to discuss the potential theoretical mechanisms driving my empirical findings.

2 Background: The Bush Steel Tariffs

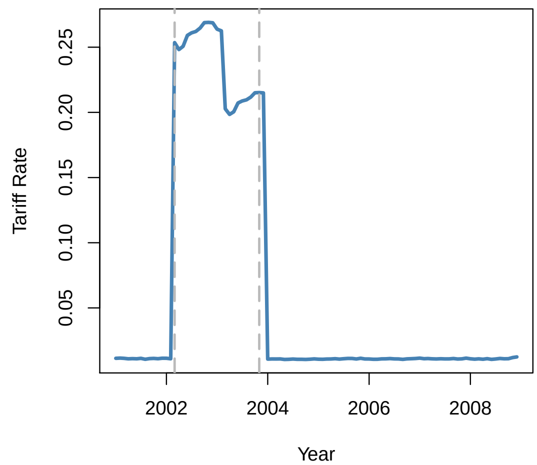
In this section I provide a brief overview of the Bush steel tariffs, show that they were a meaningful shock to U.S. steel imports, and discuss some advantages of using the setting to estimate the impact of a temporary shock to upstream inputs on downstream industries.

2.1 The Policy

While protection for the steel industry had been renewed or extended by almost every U.S. president since the 1970s, the practice was phased out in the early 90s under the (first) Bush and Clinton administrations (Irwin, 2017). Immediately upon taking office in January 2001, however, 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, Bush announced his administration would self-initiate a Section 201 investigation for 33 categories of imported steel. Under a Section 201 investigation, if the International Trade Commission (ITC) determines that the volume of a particular import constitutes a "substantial threat of serious

[4] There is also some work in the macro literature using vector autoregression frameworks to detect hysteresis in macro data, for example, Benati and Lubik (2022).

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



NOTE. Tariff rates collected from Presidential Proclamation 7529 and are weighted by imports in 2001.

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 Tariff Schedule (HTS) codes, or HS8-digit 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.[5]

Steel consumers, free trade advocates,[6] and foreign trading partners[7] were outraged. 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

[5] Providing such exemptions for developing countries was done in accordance with WTO rules.

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

[7] 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

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 on protected products 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.[8]

2.2 Impact on Steel Imports and Import Prices

The extent to which downstream industries—the focus of this paper—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 their steel exports to the United States—that is, there is little pass-through—downstream producers will feel little effect. On the other hand, if tariffs are passed through to domestic import prices, downstream steel users in the United States will bear the cost of the tariffs in the form of higher input prices.

Table 1 shows the response of steel import values, quantities, and prices to the Bush steel tariffs. Data on import values and quantities are published by the U.S. Census Bureau and downloaded from the U.S. International Trade Commission (USITC) at the HS8-digit level. Import prices are calculated as import value divided by import quantity. These responses are estimated using the following specification:

$$y_{ij,t} - y_{ij,2001} = \beta \log(1 + \Delta\tau_{ij,2003-2001}) + \delta_i + \delta_{j,t} + \delta_t + \varepsilon_{ij,t}, \quad (1)$$

where $y_{ij,t}$ is the log value, log quantity, or log unit value of imports of steel product i from country j in year t. The independent variable of interest is $\log(1+\Delta\tau_{ij,2003-2001})$, the change in the statutory tariff rate on steel product i from country j as a result of the Bush tariffs. Regressions include product (HS8) and country-year fixed effects.[9]

The first column of Table 1 shows that there was a relatively large decline in imports of steel products that faced higher tariff rates. In response to a 1 percent increase in tariffs, import values fell by an average of 4.1 percent in 2002 and 2003. The second and third columns show that this decline in nominal imports was entirely driven by a decline in imported quantities: a one percentage point (p.p.) increase in the statutory rate is associated with a 4.1 percent decline in imported quantities. This implies a trade elasticity at the low

[8] 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

[9] This setup is similar to the one used by Amiti et al. (2019c) to estimate the effect of the Trump tariffs on imports. I run these regressions at the individual country level to account for the fact that several 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.

Table 1: Impact of Tariffs on Steel Imports: 2002-2003

	Δ Imports (p x m)	Δ Quantity (m)	Δ Unit Value (p)
Log (1 + τ)	-4.087	-4.123	0.054
	(1.066)	(1.308)	(0.621)
Year FE	Yes	Yes	Yes
HS8 FE	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes
Observations	5312	5103	5103
R^2	0.202	0.187	0.153

Standard errors in parentheses

Note. Regressions above are estimated using the specification shown in equation 1. The independent variable of interest is the log of one plus the increase in the statutory tariff rate imposed on a steel product under the Bush tariffs. From left to right, the columns show the effect of higher statutory rates on nominal steel imports, steel import quantities, and steel import unit values. Sample years are 2002 and 2003.

end of standard estimates in the literature which lie between 4 and 8.[10] The third column shows that there was no measurable impact on import unit values—a proxy for the price charged by exporters (pre-tariff). The unit value response, or lack thereof, suggests that terms of trade gains for U.S. importers were limited. As a result, downstream U.S. consumers likely bore the brunt of the tariff increase. Several papers studying pass-through of the Trump tariffs to consumer prices find similar results with regard to tariff pass-through.[11]

Just as the tariffs were temporary, the response in the steel import market also appeared to be temporary. In Figure 2, I plot the impulse responses of import values, quantities, and prices to the tariff shock. Impulse responses are estimated using the local projection specification shown in equation 2.

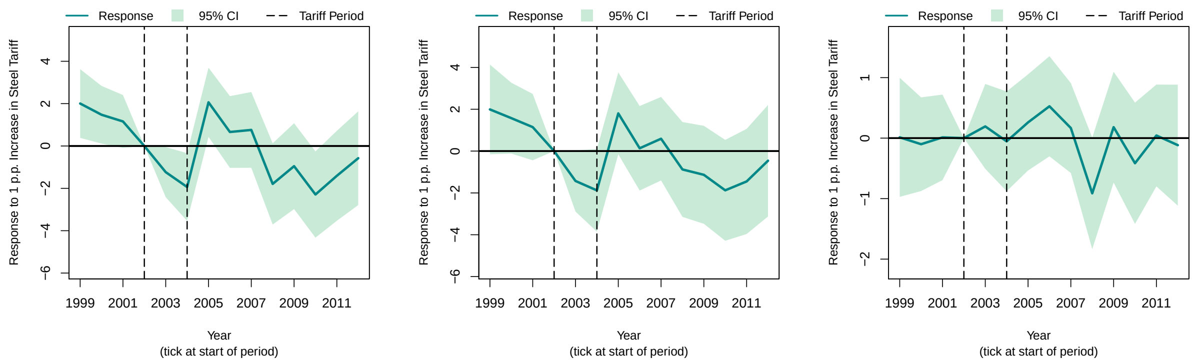
$$y_{ij,t} - y_{ij,2001} = \beta_t \log(1 + \Delta\tau_{ij}) + \delta_{j,t} + \varepsilon_{ij,t} \tag{2}$$

The panels show the response of nominal steel imports (left), import quantities (middle), and import unit values (a proxy for import prices, right) to a 1 p.p. increase in the steel tariff rate. Confirming the findings shown in Table 1, imports decline by relatively more relative to pre-tariff levels for steel products protected by higher statutory rates. Again, it is clear that the decline in imports is entirely driven by declining quantities—there is no evident change in import prices. The dynamic responses provide two additional pieces of insight: First, the impact of the steel tariffs on steel imports is as transitory as the tariffs themselves. As soon as the tariffs were lifted, imports rebound (even spike above) their

[10] See, for example, Simonovska and Waugh (2014), and Eaton and Kortum (2002).
[11] See, for example, Amiti et al. (2019c) and Cavallo et al. (2019).

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

(a) Import Values (b) Import Quantities (c) Import Unit Values



NOTE. The impulse responses above are estimated using the specification shown in equation 2. From left to right, the panels show the response of nominal steel imports, steel import quantities, and steel import unit values to a 1 p.p. increase in the stautory tariff rate. Regressions include country time fixed effects.

pre-tariff levels. Second, there are some notable pre-trends: Steel imports were higher prior to 2001 for industries that ultimately recieved higher statutory rate protection. This should not come as a surprise, as the intent behind the legislative process through which the Bush tariffs were enacted (Section 201 of the 1974 Trade Act) is to provide protection for industries suffering from import competition. Crucially, for this reason, I will not be making the claim that the differential rates across steel products was exogeneous for my identification strategy. Instead, I will claim that the differential rates ultimately faced by downstream industries was exogenous. I will discuss this identifying assumption in more detail in Section 4. Lastly, in Appendix A1 I show that, as expected, the effects on steel imports are present only for imports coming from countries that were *not* exempt from the Bush steel tariffs. Exempt countries exhibited no significant response.

The lack of persistence in the response of steel imports to the tariffs provides some preliminary 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 domestic 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.[12]

[12] 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.

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 Bush 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 of being unexpected. Because Bush was a newly elected Republican president who had campaigned on a free-trade platform, his imposition of trade safeguards took many by surprise. I discuss in more detail in Section 4 how the nature of this shock to the steel industry created plausibly exogenous variation in input costs for downstream producers.

Lastly, I 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 tariff rates, in addition to exposure to tariffs—the more common approach in similar studies.[13] 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.[14] Lastly, and most importantly, while studies of the effects of the Trump tariffs are necessarily short-term due to data availability, studying the Bush tariffs allows for the estimation of long-term effects—something largely missing from the literature until now.

[13]For example, Lake and Liu (2021) for the Bush steel tariffs and Flaaen and Pierce (2019) and Handley et al. (2020) for the Trump steel tariffs.

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

3 Data and Variable Construction

In this section, I describe the data that I use for my empirical estimation. All of the data that I rely on come from publicly available sources, and most are easy to obtain. For trade outcomes, I use data from either UN Comtrade, the U.S. International Trade Commission (ITC) DataWeb, or from the data published by Census and made available by Peter Schott (Schott, 2008). I also use data from the NBER CES Manufacturing Industry Database (Bartelsman and Gray, 1996) on manufacturing industry material costs, shipments, and employment. The challenge I face, from an empirical standpoint, however, is in figuring out how to link downstream (steel-using) industries to the increased steel tariff rates that they faced as a result of the Bush tariffs. In the remainder of this section, I will describe this challenge in more detail, and outline the approach I take to circumvent it.

3.1 Challenge: Linking Steel Inputs to Downstream Industries

To identify the effects of the Bush steel tariffs on downstream industry outcomes, my goal is to leverage both the variation in tariffs on upstream products and the varied composition of upstream inputs used by downstream industries. The independent variable of interest for a downstream industry d is the change in the steel tariff rate that industry faced as a result of the Bush steel tariffs. Construction of this variable requires knowledge of the set of upstream steel inputs, s, used in production by each downstream industry d. Crucially, in order to leverage variation in tariff rates, I need this $s \rightarrow d$ mapping at the tariff-line level, which, in the trade data is given by an HS8x code. HS8 codes describe highly specific types of steel, 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.*

However, traditional input-output tables, like the ones published by the Bureau of Economic Analysis (BEA), tend to provide information on just one or two categories of aggregated steel input. For example, the most detailed BEA input-output table 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*. Other input-output tables, such as the World Input Output Database (WIOD), suffer similar issues. To address this data challenge, 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, how it is used to construct the key variables of interest, and providing evidence that this new methodology is effective.

3.2 Exclusion Requests: Revealed Use of Steel Inputs

To map specific steel inputs, and their associated tariff rates, to 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.[15] 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 for which the company is requesting an exclusion, and other information describing the company's use of the product and why it feels an exclusion is justified. Figure 3 contains an example of a (part) of a request filed by a company called Aiken Precision Technologies for steel product HTS 7227105030. 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. Over 80 percent of the steel products covered by the Bush steel tariffs are covered in this database.

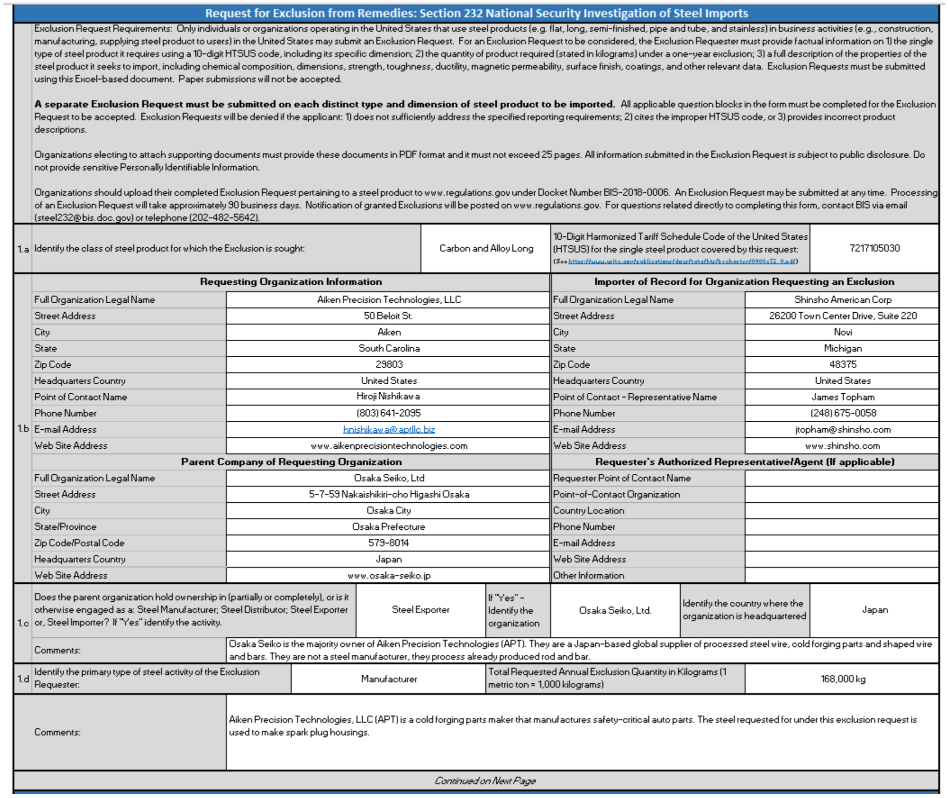
I take advantage of the fact that, by definition, an exclusion requesting firm is a *downstream user* of a very specific (10-digit) upstream steel product, and many of the requests provide detailed descriptions of how the steel product in question is used in production. In the example shown in Figure 3, the "Comments" section explains: *"The steel for this exclusion request is used to make **spark plug housings**."* Of the roughly 70,000 exclusion requests in my database, 15,045 contain useful descriptions, meaning they directly describe the product that the requested steel is used to produce.[16] I manually match these descriptions to one or more (if multiple uses are mentioned) 4- or 6-digit HS codes using descriptions of HS codes in the HTSUS and a free online Schedule B Search Engine provided by the U.S. Census Bureau.[17] In the example above, "spark plug housings" is mapped to HS 851110, which is the HS code for *spark plugs used for spark-ignition or compression-ignition internal combustion engines*. This process generates a mapping from detailed 10-digit steel products to 4- and 6-digit HS codes. In cases where a product is mapped to a 4-digit industry, I

[15] Specifically, OMB Form 064-1039.

[16] The remainder have either no description at all, or no direct explanation of the product being produced.

[17] Schedule B codes are the 10-digit code used to classify U.S. exports. Schedule B codes are the counterpart to 10-digit HTS codes used to classify imports. The Census Bureau provides a Schedule B Search Engine to aid exporters in determining their correct export commodity code. https://www.census.gov/foreign-trade/schedules/b/index.html

Figure 3: Example Exclusion Request Form (Partial)



Request for Exclusion from Remedies: Section 232 National Security Investigation of Steel Imports

Exclusion Request Requirements: Only individuals or organizations operating in the United States that use steel products (e.g. flat, long, semi-finished, pipe and tube, and stainless) in business activities (e.g., construction, manufacturing, supplying steel product to users) in the United States may submit an Exclusion Request. For an Exclusion Request to be considered, the Exclusion Requester must provide factual information on 1) the single type of steel product it requires using a 10-digit HTSUS code, including its specific dimension; 2) the quantity of product required (stated in kilograms) under a one-year exclusion; 3) a full description of the properties of the steel product it seeks to import, including chemical composition, dimensions, strength, toughness, ductility, magnetic permeability, surface finish, coatings, and other relevant data. Exclusion Requests must be submitted using this Excel-based document. Paper submissions will not be accepted.

A separate Exclusion Request must be submitted on each distinct type and dimension of steel product to be imported. All applicable question blocks in the form must be completed for the Exclusion Request to be accepted. Exclusion Requests will be denied if the applicant: 1) does not sufficiently address the specified reporting requirements; 2) cites the improper HTSUS code, or 3) provides incorrect product descriptions.

Organizations electing to attach supporting documents must provide these documents in PDF format and it must not exceed 25 pages. All information submitted in the Exclusion Request is subject to public disclosure. Do not provide sensitive Personally Identifiable Information.

Organizations should upload their completed Exclusion Request pertaining to a steel product to www.regulations.gov under Docket Number BIS-2018-0006. An Exclusion Request may be submitted at any time. Processing of an Exclusion Request will take approximately 90 business days. Notification of granted Exclusions will be posted on www.regulations.gov. For questions related directly to completing this form, contact BIS via email (steel232@bis.doc.gov) or telephone (202-482-5642).

1.a	Identify the class of steel product for which the Exclusion is sought:	Carbon and Alloy Long	10-Digit Harmonized Tariff Schedule Code of the United States (HTSUS) for the single steel product covered by this request: (See [illegible])	7217105030

1.b	**Requesting Organization Information**		**Importer of Record for Organization Requesting an Exclusion**	
	Full Organization Legal Name	Aiken Precision Technologies, LLC	Full Organization Legal Name	Shinsho American Corp
	Street Address	50 Beloit St.	Street Address	26200 Town Center Drive, Suite 220
	City	Aiken	City	Novi
	State	South Carolina	State	Michigan
	Zip Code	29803	Zip Code	48375
	Headquarters Country	United States	Headquarters Country	United States
	Point of Contact Name	Hiroji Nishikawa	Point of Contact - Representative Name	James Topham
	Phone Number	(803) 641-2095	Phone Number	(248) 675-0058
	E-mail Address	hnishikawa@aptllc.biz	E-mail Address	jtopham@shinsho.com
	Web Site Address	www.aikenprecisiontechnologies.com	Web Site Address	www.shinsho.com
	Parent Company of Requesting Organization		**Requester's Authorized Representative/Agent (If applicable)**	
	Full Organization Legal Name	Osaka Seiko, Ltd	Requester Point of Contact Name	
	Street Address	5-7-59 Nakaishikiri-cho Higashi Osaka	Point-of-Contact Organization	
	City	Osaka City	Country Location	
	State/Province	Osaka Prefecture	Phone Number	
	Zip Code/Postal Code	579-8014	E-mail Address	
	Headquarters Country	Japan	Web Site Address	
	Web Site Address	www.osaka-seiko.jp	Other Information	

1.c	Does the parent organization hold ownership in (partially or completely), or is it otherwise engaged as a: Steel Manufacturer; Steel Distributor; Steel Exporter or, Steel Importer? If "Yes" identify the activity.	Steel Exporter	If "Yes" - Identify the organization	Osaka Seiko, Ltd.	Identify the country where the organization is headquartered	Japan
	Comments:	Osaka Seiko is the majority owner of Aiken Precision Technologies (APT). They are a Japan-based global supplier of processed steel wire, cold forging parts and shaped wire and bars. They are not a steel manufacturer, they process already produced rod and bar.				
1.d	Identify the primary type of steel activity of the Exclusion Requester:	Manufacturer	Total Requested Annual Exclusion Quantity in Kilograms (1 metric ton = 1,000 kilograms)	168,000 kg		
	Comments:	Aiken Precision Technologies, LLC (APT) is a cold forging parts maker that manufactures safety-critical auto parts. The steel requested for under this exclusion request is used to make spark plug housings.				

Continued on Next Page

Note. This is an image of a part of an exclusion request form filed by Aiken Precision Technologies, LLC. Exclusion requests are downloaded from `regulations.gov`.

assume it is an input to all of that four-digit industry's six-digit sub-industries. I map 270 different HS8-digit steel inputs to 787 downstream HS6-digit industries. Of those 270 steel inputs, 136 were covered by the Bush steel tariffs.

One important advantage of using the exclusion requests to create a mapping of detailed steel inputs to downstream industries is the degree of specificity that they provide. For example, the same firm from the example in Figure 3, Aiken Precision Technologies, filed multiple requests for different steel products, and described different uses for each of those products. In the Figure 3, the firm reveals that it uses HTS 7217105030 in the production of spark plug housings. In a separate request, the same firm reveals that it uses a different steel input—HTS 7217905090—for the production of seat belt components. The standard U.S. firm-level datasets (e.g., the confidential Census microdata) might show that Aiken Precision Technologies imports both of the aforementioned steel inputs and produces both spark plug housings and seat belt components, but would not necessarily allow one to match each steel input to its respective output.

3.3 Constructing the Tariff Variable

The mapping described in the previous subsection is a binary description of which downstream industries use which steel inputs. In this subsection, I describe how I use this binary mapping to create the independent variable of interest in my empirical analysis: a measure of the weighted average tariff rate that a downstream industry, d, faces on its steel inputs. Consider a downstream industry d that uses a set Ω_d of upstream steel inputs, s. Each input, $s \in \Omega_d$, can potentially face a different tariff rate in year y, which I denote $\tau_{s,y}$. The average tariff rate faced by downstream industry d on its steel inputs in year y is given by:

$$\tau_{d,y} = \sum_{s \in \Omega_d} \omega_{s,d} \tau_{s,y}, \tag{3}$$

In the above, the tariff rates on individual steel products, $\tau_{s,y}$, are collected from the HTSUS in each year, y, and the additional tariff rates applied in 2002 and 2003 as a result of the Bush steel tariffs are collected from the policy announcement—Presidential Proclamation 7529. The $\omega_{s,d}$'s, weight the relative importance of each steel input for that downstream industry among the steel inputs in Ω_d.

Calculating the relevant weights, $\omega_{s,d}$, requires information on the quantities of each steel input used by each downstream industry. The exclusion requests themselves provide this information: firms are required to report the average annual quantity (in kilograms) of the steel product in question that they used in the years from 2015 to 2017. Thus, for each steel input, s, used by a downstream industry, d, I calculate its weight, $\omega_{s,d}$, as:

$$\omega_{s,d} = \frac{p_s Q_{s,d}}{\sum_{s' \in \Omega_d} p_{s'} Q_{s',d}} \tag{4}$$

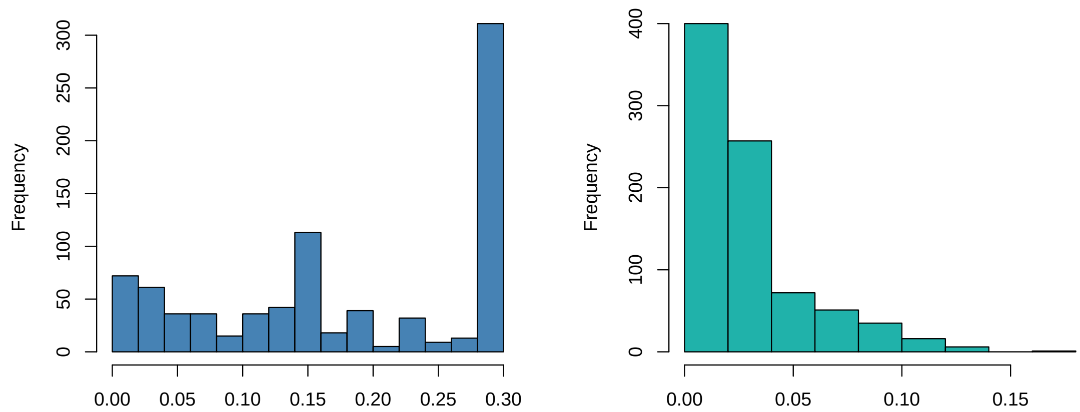
Where p_s is the average import unit value of steel input s between 2015 and 2017 (the period relevant for the exclusion requests), and $Q_{s,d}$ is the total consumption of steel input s by all exclusion-requesting firms producing in downstream industry d.[18] With the $\omega_{s,d}$'s in hand, it is straightforward to calculate the $\tau_{d,y}$'s in equation 3.

Becauase different downstream industries use steel, in the aggregate, at different intensities relative to overall input costs, I scale τ_d by steel's share of input costs in industry d. Unfortunately, I do not possess data on the total input costs of each exclusion-requesting firm, so I approximate each downstream industry's steel-cost share using the *Use Table* published as part of the the BEA Input-Output Accounts. The *Use Table* provides information on the use of *iron and steel mills and ferroalloy manufacturing* and *steel product manufac-*

[18]Firms are also required to report the quantity of the steel product in question for which they are requesting an exclusion. In the few cases when the average annual quantity used in 2015-2017 is missing, I use the requested quantity in its place.

Figure 4: Distribution of Constructed Variables: $\Delta\tau_d$ and $\Delta\tilde{\tau}_d$

(a) $\Delta\tau_d$ (b) $\Delta\tilde{\tau}_d$



NOTE. The left panel shows the distribution of the change in tariffs that downstream industries faced on their steel inputs as a result of the Bush steel tariffs. The right panel shows the change in tariffs scaled by the industry's steel cost share.

turing from purchased steel as well as total intermediate input use by 405 industries (at a level of aggregation roughly comparable to a six-digit NAICS sector). Using the BEA data, I calculate a downstream industry k's steel cost share as:

$$\alpha^{BEA}_{\text{steel},k} = \frac{\text{Dollars of Steel Use}_k}{\text{Total Intermediate Input Use}_k}, \tag{5}$$

where I combine dollars of steel use (the numerator) from the two available steel categories. These cost shares are calculated for more aggregated industries (BEA/NAICS 6) than the rest of my steel-specific input-output table (HS6), so I apply them to the HS6-digit industries, first using a crosswalk provided by the BEA to convert the 405 BEA industries to NAICS 6, then using the NAICS to HS concordance developed by Pierce and Schott (2012).

Note that if the exclusion requests covered the universe of steel inputs, using this more aggregated cost-share measure would be innocuous. However, this is not the case. The steel products accounted for in the exclusion requests represent roughly 70 percent of the steel products represented in the BEA input-output table.[19] Thus, the steel-cost share in equation 5 is likely an overestimate, though I am unable to calculate exactly which steel inputs are "missing" from each downstream industry—a clear downside of this approach. In Appendix A2, I discuss the potential threats to identification associated with this mismeasurement and show that it does not appear to distort my results.[20]

[19] In terms of their share of imports in the year 2001. I determine this using a concordance provided by the BEA of Foreign Trade Harmonized Codes to Input-Output Commodity Codes.

[20] Importantly, the cost-share measure also does not distinguish between imported and domestic steel,

Using the tariff measure, $\tau_{d,y}$, I then calculate the change in tariffs each downstream industry faced as a result of the Bush steel tariffs as the difference between $\tau_{d,2003}$ (during the Bush tariff period) and $\tau_{d,2001}$ (the last year before the tariffs were put in place). Combining this with the steel cost share, $\alpha^{BEA}_{\text{steel},k}$, results in my primary independent variable of interest:

$$\Delta\tilde{\tau}_d = (\tau_{d,2003} - \tau_{d,2001}) \times \alpha^{BEA}_{\text{steel},k}$$

Intuitively, $\Delta\tilde{\tau}_d$ represents the percentage point change in tariff an industry faced on its total inputs as a result of the Bush steel tariffs. Histograms of the distributions of the unscaled tariff variable on steel, $\Delta\tau_d$, and the scaled tariff on inputs, $\Delta\tilde{\tau}_d$, are shown in Figure 4.

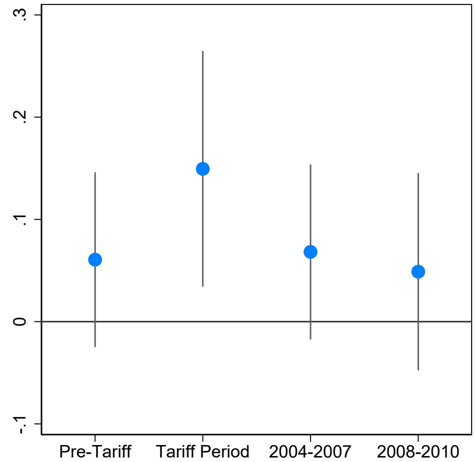
With these variables constructed, a brief example illustrates the information obtained from using the steel-specific input-output table rather than an existing, more aggregated, input-output table. Consider two industries: HS 830230 (Other mountings, fittings, and similar articles suitable for motor vehicles and parts thereof), and HS 841520 (air conditioning machines used for persons in motor vehicles). According to the BEA input-output table, steel represents a similar share of costs for both industries (11.9 percent in the former and 10.9 percent for the latter). However, because these industries use different *types* of steel inputs, they faced different tariff rates. The mountings and fittings industry faced an increase in tariffs of 18.2 p.p. on its steel inputs, while the air conditioner industry faced an increase of 25 p.p. Without knowing the specific inputs these industries use, one would be forced to treat these two industries the same.

3.4 Performance of the Steel-Specific IO Table

Before turning to my empirical analysis of the Bush steel tariffs, I present evidence in this subsection that the steel-specific input-output table that I have created is an effective way to link steel inputs to downstream industries. There are two important considerations that I will address: First, does this methodology link the correct inputs to the correct downstream industries? And second, were these the correct inputs in 2002 and 2003, when the Bush tariffs were put in place, despite being identified using data from 2018, when the exclusion requests were filed?

though the tariffs are only directly applied to imports. Implicitly, my assumption is that the increase in steel tariffs also led to increases in domestic steel prices. This assumption is supported by findings in Amiti et al. (2019b) who show that the Trump tariffs led to immediate increases in domestic prices. Amiti et al. (2019a) show that domestic producers change prices in response to changes in foreign prices, even if the domestic producers do not experience changes in marginal costs. That said, an overestimate of the cost-share measure will ultimately lead me to underestimate the effects of the tariffs, in terms of magnitude. Thus, my results should be taken as cautious estimates.

Figure 5: Effect of Steel Tariffs on the Price of Materials Downstream



NOTE. Estimates of γ_t from equation 6 are plotted above, along with their 95 percent confidence intervals. The Pre-Tariff period runs from 1995-2001 and the Tariff Period runs from 2002-2003, when the Bush Steel Tariffs were in place.

3.4.1 First-Stage Estimation

First, I show that the tariff rates that I match to downstream industries predict a temporary increase in the price of materials in those downstream industries during 2002 and 2003, when the Bush Tariffs were in place. In particular, I estimate the following:

$$p^{mc}_{d,y} - p^{mc}_{d,2001} = \alpha + \sum_t \gamma_t \mathbf{1}(y \in P_t)(\Delta\tau_d) + \sum_t \theta_t \mathbf{1}(y \in P_t)(\alpha^{BEA}_{\text{Steel},d}) + \delta_y + \delta_n + \varepsilon_{d,y} \quad (6)$$

Here, $p^{mc}_{d,y}$ is the (log) price index for material costs in downstream industry d in year y, which I obtain for U.S. manufacturing industries at the NAICS 6 level of aggregation from the NBER CES Manufacturing Industry Database. Thus, the left hand side of of equation 6 is the percent change in the price of material costs in downstream industry d relative to 2001 (the year before the Bush tariffs were enacted). The independent variable of interest on the right hand side is $\Delta\tau_d$—the steel tariff rate faced by downstream industry d as a result of the Bush tariffs, which I calculate as described in Section 3.3. For this exercise, I have to convert the baseline $\Delta\tau_d$'s, which are constructed at the HS6 level of detail, to a more aggregate NAICS 6 level of detail. Once again I rely on the Pierce and Schott (2012) concordance to concord from HS6 to NAICS 6, and estimate the NAICS 6 tariff rate as an export-weighted average of the underlying HS 6 tariff rates.

I break the regression into four periods, indicated by the variable P_t: P_1 = Pre-Tariff (1995-2001), P_2 = the Bush Tariff period (2002-2003), P_3 = the immediate post-tariff period (2004-2007), and P_4 = the longer-term post-tariff period from 2008-2010. I also control for the industry's overall steel cost share ($\alpha^{BEA}_{\text{Steel},d}$), year fixed effects ($\delta_y$), and a 4-digit NAICS sector fixed effect (δ_n). In Figure 5, I plot the γ_t coefficient for each of the four periods of interest. A one p.p. increase in the tariff on a downstream industry's steel inputs leads to a 0.149 percent increase in the price of materials during the two-year period in which the tariffs were in place. The average downstream manufacturing industry that faced a non-zero steel tariff has a steel-cost share of 0.116, so this is suggestive of the tariff increase being nearly fully passed through to downstream buyers. Importantly, because the tariffs were temporary, so too is this predictive relationship. Outside of the 2002-2003 tariff period, the point estimates are both smaller (by about half) and not precisely estimated. This exercise suggests that the tariffs that I assign to downstream industries using the steel-specific input-output table appear to be relevant, and their predictive power holds in the 2002-2003 period, despite being inferred from the exclusion requests filed 15 years later.

3.4.2 Placebo Test

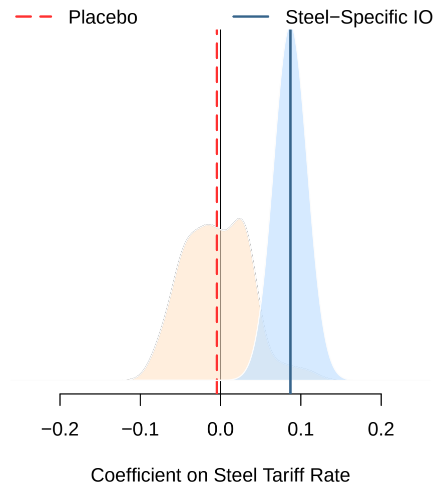
To build further confidence in the capabilities of the steel-specific input output table, I next perform a placebo test in which I compare the performance of the steel-specific input-output table to a randomized mapping of steel inputs to downstream industries. For ease of interpretation, I estimate a pooled version of the regression above, this time restricting the sample to 2002 and 2003. The specification is given by:

$$p^{mc}_{d,y} - p^{mc}_{d,2001} = \alpha + \gamma \Delta\tau_d + \theta \alpha^{BEA}_{\text{Steel},d} + \varepsilon_{d,y} \tag{7}$$

Once again, γ governs the relationship between the change in steel tariff rate faced by downstream industry d as a result of the Bush Steel tariffs and the change in the price of materials in that downstream industry relative to pre-tariff levels ($p^{mc}_{d,y} - p^{mc}_{d,2001}$).

After estimating this specification using the $\Delta\tau_d$ variable constructed using the steel-specific input-output table, I run the same specification 100 more times, each time randomly matching changes in steel tariffs to downstream industries. In Figure 6, I show the "true" (steel-specific input-output) coefficient (solid blue line) and its asymptotic distribution on the tariff variable. As in Figure 5, the point estimate is around 0.1. The dashed red line shows the average point estimate of the placebo tests, and the red shaded region shows the kernel density of those estimates. The placebo test, on average, generates an (imprecise) point estimate of 0. This suggests that the steel-specific input-output table is picking up an important relationship between steel inputs and their relevant downstream users.

Figure 6: Placebo Test: Coefficient on $\Delta\tau_d$



NOTE. This figure shows estimates of γ in equation 7 using the actual τ_d in blue, and the kernel density of 100 estimates of γ from running the same specification using a randomized measure of τ_d in red.

4 Empirical Specification and Identification

The goal of my empricial analysis is to estimate the effect of the Bush steel tariffs on downstream (steel-using) industry outcomes. My baseline empirical specification is given by:

$$y_{d,t} - y_{d,2001} = \alpha_t + \theta_t \Delta\tilde{\tau}_d + \psi_t \alpha^{BEA}_{d,\text{Steel}} + \gamma_t X_{d,2001} + \delta_{h,t} + \varepsilon_{d,t}. \tag{8}$$

On the left-hand side, $y_{d,t} - y_{d,2001}$ is the change in an outcome variable in an HS6-digit downstream industry d relative to pre-tariff levels (2001). The coefficient of interest, θ_t, governs $\Delta\tilde{\tau}_d$—the change in steel tariff rate that downstream industry d faced as a result of the Bush steel tariffs, scaled by industry d's steel cost share. Variation in this variable occurs at the HS4 to HS6-digit level of aggregation, so I cluster the standard errors by HS4 industry. I also control for $\alpha^{\text{BEA}}_{d,\text{Steel}}$—industry d's steel cost share—and $X_{d,2001}$—the share of industry d's steel inputs that were imported from countries exempt from the Bush steel tariffs in 2001 (a measure of exposure to the tariffs).[21] Note that by including the steel cost share as an additional control (even though it is already contained in $\Delta\tilde{\tau}_d$), I am ensuring that I am capturing changes driven by variation in tariff rates rather than variation in steel cost shares. This helps to address concerns about potential confounding factors, such as the fact that demand for durable (often steel intensive) goods tends to be procyclical.[22]

[21] To construct this variable, I use country-level import data to calculate the share of each steel product, s, imported from exempt countries in 2001. For each downstream industry, then, I calculate $X_{d,2001}$ as a weighted average of the exempt shares for each $s \in \Omega_d$. The weights are the same $\omega_{s,d}$'s that I use to construct the main tariff variable of interest.

[22] Multiplying the cost share variable in to the tariff rate simply helps with interpretation of magnitudes.

Following the standard local projection approach used in, for example, Jordà (2005) and Dube et al. (2022), regressions are estimated separately in each year. As a result, I cannot include *detailed* sector-level fixed effects, as these would absorb all of the variation. However, I do include Harmonized Tariff Schedule (HTS) Section fixed effects, denoted by $\delta_{h,t}$. In the HTS, Sections group like industries together, for example, *Vehicles, Aircraft, Vessels and Associated Trasnport Equipment* or *Arms and Ammunition; Parts and Accessories Thereof.* Note that these are HTS Section $\times$ year fixed effects, so this is a relatively stringent set of controls. In Appendix A3, I show that my baseline results are robust to using an alternative, pooled difference-in-differences, specification where I include HS4-digit fixed effects.

Lastly, note that in my dataset, there are industries where the primary variable of interest, $\Delta\tilde{\tau}_d$, is equal to zero. These are industries for which my steel-specific input output table did not identify a *protected* steel input (this includes industries with a steel cost share equal to 0). In my baseline specification, I include some of the industries with $\Delta\tilde{\tau}_d$, but not all. Specifically, I include all HS6 industries within an HS2 industry with a non-zero average $\Delta\tilde{\tau}_d$. In other words, if any HS6 product within an HS2 faces a non-zero change in costs, I include all of the HS6 codes within that HS2. In Appendix A3 I show that my results are robust to this choice.

4.1 Threats to Identification

My primary identifying assumption is that while the Bush steel tariffs were certainly endogenous to the steel industry itself, the variation in steel tariffs rates faced by *downstream* industries was exogenous. Gawande et al. (2012) and Bown et al. (2020) point out several potential threats to this assumption 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 the 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.[23] In other words, if there was lobbying by downstream

A 20 percent increase in the steel tariff has a different meaning for an industry with a 50 percent steel cost share than for an industry with a 10 percent steel cost share. More discussion of this relationship can be found in Appendix A2.

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

industries to reduce tariff rates relative to ITC recommendations, it appears to have been unsuccessful. Admittedly, this does not rule out the possibility that the ITC itself was lobbied by downstream industries before making its recommendations, however there is anecdotal evidence from the time suggesting that the policy decision was widely seen as a gift to the steel industry, at the expense of steel-users. According to an article published by the Wall Street Journal[24] 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 grow and become more efficient competitors of mini-mills. Instead, Mr. Bush extended help to the steel industry across the board.

In other words, from a purely anecdotal perspective, 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. The absence of apparent pre-trends in my results suggest no correlation between the treatment variable and pre-treatment industry outcomes.

Importantly, both of these endogeneity concerns are likely to bias my results in the opposite direction of what I ultimately estimate. Counter-lobbying is more likely to be done by downstream industries that would stand to hurt the most from the tariffs, making it harder to identify the negative impacts. Similarly, if the highest tariffs are imposed on an

[24] https://www.wsj.com/articles/SB101533904883100680

industry's inputs *because* that industry is on an upward trajectory ex ante, the negative effects of those tariffs will be masked.

5 The Effect of Steel Tariffs on Downstream Industries

In this section, I present results on the effects of the Bush steel tariffs on downstream industry outcomes. In Section 5.1, I show that the increase in steel tariffs led to persistent relative declines in downstream industry exports. In Section 5.2, I show that these declines in exports appear to be driven by changes on the extensive margin, as U.S. exporters lost trade relationships. In Section 5.3, I show that the Bush steel tariffs also caused persistent declines in the overall value of shipments and employment in U.S. manufacturing industries. Finally, for interpretation, I offer some simple estimates of the magnitudes of my results in Section 5.4. Unless otherwise noted, the independent variable of interest in the results below is $\Delta\tilde{\tau}_d$—the change in the steel tariff rate that downstream industry d faced as a result of the Bush tariffs, scaled by industry d's cost share. For simplicity, I will refer to this variable as representing the "tariff rate on inputs" for downstream industry d.

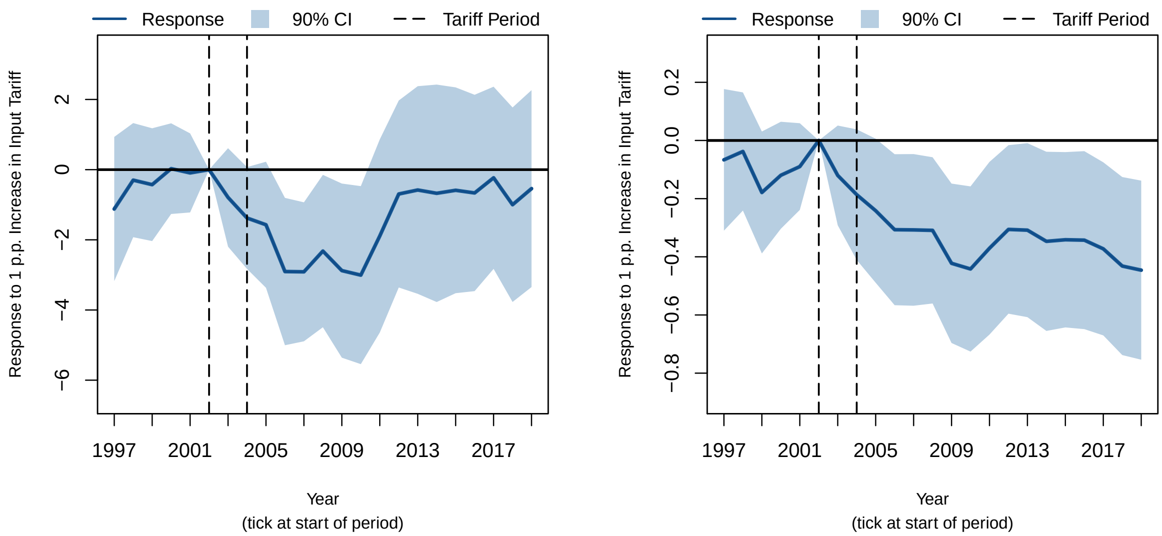
5.1 Exports and Global Market Share

In Figure 7a, I plot the estimated effect of a 1 p.p. increase in input tariffs due to the Bush tariffs on log U.S. exports in the left panel, and the U.S. share of world exports in the right panel. Starting with the effect on log exports, the figure shows that downstream industries that faced a 1 p.p. point larger increase in input tariff ($\Delta\tilde{\tau}_d$), suffered a 2 to 4 percent decline in exports relative to pre-tariff levels (2001). The decline happens on impact of the tariffs in 2002, and is highly persistent: exports remained depressed relative to pre-tariff levels through 2009. The average industry in my sample has a steel cost share of about 5 percent, meaning it would take a 20 percent (= 1/5) increase in the steel tariff rate to generate this effect in the average downstream industry.

Figure 7b shows a similar story for the U.S. share of world exports, or the global market share of U.S. downstream industries. Downstream industries that faced a 1 p.p. larger increase in input tariff suffered a decline in global market share of 0.2 to 0.4 p.p. relative to pre-tariff levels. Again, these effects are highly persistent: Downstream industry export shares remain depressed through the end of the sample period in 2018. That the response of export shares appears more persistent than the response of export values is consistent with downstream industries that faced larger tariff increases having a relatively harder time keeping up with world demand growth. In Figure 17 in Appendix A3, I show that my primary results are robust to using a pooled difference-in-differences specification rather than my baseline local projection specification. In Appendix A4, I show that market share lost

Figure 7: U.S. Share of World Exports in Downstream Industries

(a) Export Values (b) Export Shares



Note. These figures show estimates of θ_t from a regression of the form in equation 8. The left panel shows the response of log U.S. export values in downstream industries. The right panel shows the response of U.S. exports in downstream industries as a share of world exports, or the global market share of U.S. downstream industries. Shaded regions reflect 90 percent confidence intervals.

by U.S. exporters appears to have shifted to other top producers in downstream industries including Germany, the United Kingdom, France, Japan, and South Korea.

Figure 8a shows that the decline in nominal exports shown above was driven by a decline in exported quantities. Data on exported quanitities extracted from the U.S. customs data is notoriously noisy—quantities are often missing, or the unit of quantity is not specified. In my baseline results, I exclude industries that exhibit year-over-year growth in quantity of larger than 100 percent or less than -100 percent at any point during the sample period.[25] The response of exported quanitities to a 1 p.p. increase in input tariffs is plotted in Figure 8a. Industries that faced a 1 p.p. larger increase in input tariffs saw their exported quantities decline by around 2 percent more relative to pre-tariff levels—roughly the same magnitude as the decline in nominal exports shown above.

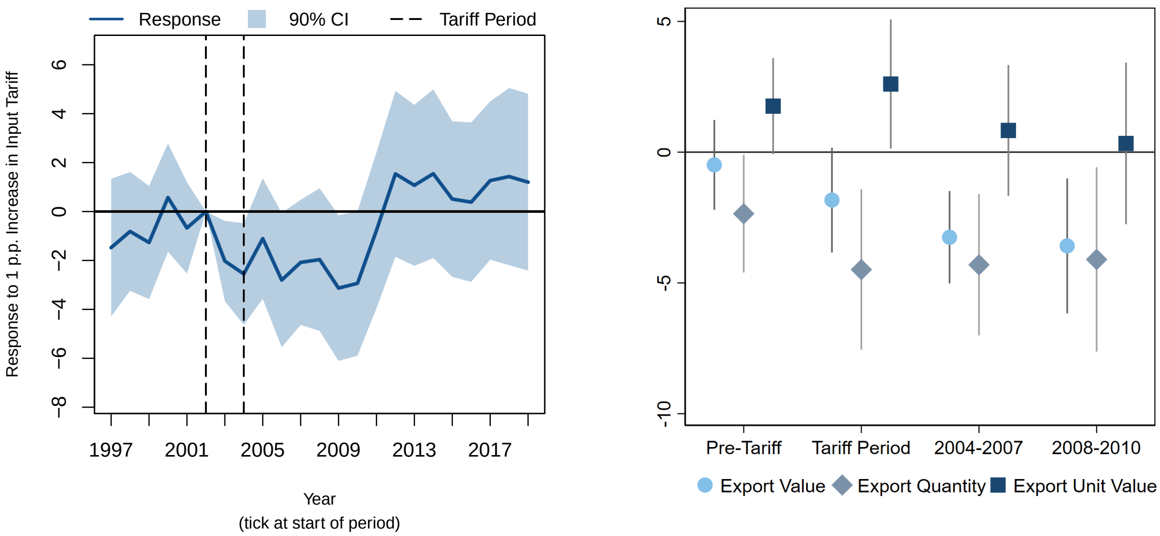
The impulse repsonse is still relatively noisy, so I adjust the specification slightly by pooling the results over two- to three-year periods, which allows me to estimate the quantity response more precisely. The pooled specification is shown in equation 9:

[25] I use this same sample for all export (value, price, or quantity) regressions presented in this section.

Figure 8: Export Values and Quantities

(a) Export Volume

(b) Pooled Estimates



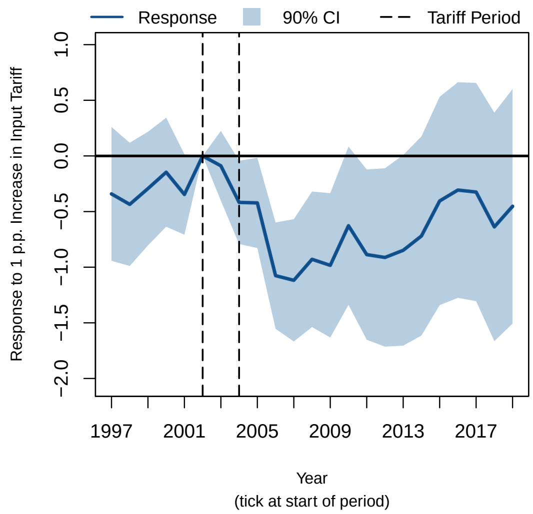
Note. The left panel shows the response of export quantities to an increase in input tariff. The point estimates shown are the θ_t's estimated using equation 8. The right panel shows estimates of the response of export values, export quantities, and export unit values, from the pooled specification in equation 9. The pooled estimates are shown with 95 percent confidence intervals.

$$\Delta y_{d,y} = \sum_t \theta_t \mathbf{1}(y \in P_t)\Delta\tilde{\tau}_d + \sum_t \psi_t \mathbf{1}(y \in P_t)\alpha^{BEA}_{d,\text{Steel}} + \gamma_t \sum_t \mathbf{1}(y \in P_t) X_{d,2001} + \delta_y + \delta_h + \varepsilon_{d,y}, \tag{9}$$

where P_t is a categorical variable indicating one of four periods: P_1 = the pre-tariff (1995-2001), P_2 = the tariff period (2002-2003), P_3 is the immediate post-tariff (2004-2007), and P_4 is the longer-term post-tariff period (2008-2010). The controls (steel cost share—$\alpha^{BEA}_{d,\text{Steel}}$—and exempt share of steel imports $X_{d,2001}$) are the same as in my baseline specification. The primary differences are twofold: First, because I am no-longer estimating the regressions separately in each year, I can now include an HS4-digit fixed effect (δ_h). Second, instead of recovering a coefficient for each year, I recover a coefficient for each period, which represents a set of two or three years.

The results, plotted in Figure 8b, paint a much clearer picture: downstream industries that faced a 1 p.p. larger input tariff suffered an immediate relative decline in exported quantities of roughly 5 percent relative to 2001 levels (depicted by the diamond-shaped

Figure 9: Extensive Margin: Number of Trade Relationships



NOTE. This figure shows the response of the number of "trade relationships" to an increase in input tariff, estimated using equation 8. "Trade relationships" are defined as a 10-digit product × customs district × destination country triplet. The shaded region reflects 90 percent confidence intervals.

points). Moreover, export quantities decline by *more* than nominal exports (the circular points) during the tariff period, suggesting relative increases in export prices in downstream industries that faced larger increases in input tariffs. This is confirmed by the square points which represent export unit values—the best proxy available for average export prices at the industry level.[26] Once the tariffs are lifted, export unit values return to pre-tariff levels, but export quantities remain depressed relative to pre-tariff levels through the 2008-2010 period. Because export unit values return to pre-tariff levels after the tariffs are lifted, the point estimates for nominal exports and export quantities converge in the two post-tariff periods.

5.2 Margin of Adjustment

To understand the mechanism driving the persistence of the downstream export response to higher steel tariffs, it is helpful to know whether the changes are occurring on the intensive or extensive margin. Because I am relying solely on industry-level data, the extensive margin of exports is not directly observable. Instead, I create a proxy for the extensive margin using the most detailed industry-level export data available. The U.S. Census Bureau publishes data on U.S. exports at the 10-digit (Schedule B code) level—the most disaggregated industry-level—and by U.S. Customs District and destination country. There are 47 Customs Districts

[26] Note that the relationship between the export quantity and export unit value responses in Figure 8b is purely mechanical, as unit values are calculated as nominal exports over export quantities.

in the United States, and each District represents a set of Ports through which imports and exports are shipped. Using these detailed data, I define a "trade relationship" as a (product $\times$ Customs District $\times$ destination country) triplet. For example, all exports of Schedule B code 8703105030—Golf Carts—from the Customs District in Savannah, Georgia to Japan in a given year constitutes one trade relationship. For perspective, the mean (median) 10-digit product had 120 (172) "trade relationships" in 2001.

I then count the number of trade relationships for each Schedule B product in each year, and estimate my baseline specification (equation 8) with the log number of trade relationships on the left-hand side. Figure 9 shows that the response of the number of trade relationships perfectly aligns with the export response: A one-percent increase in inputs costs due to the Bush tariffs leads to a relative loss of about 1 percent of a downstream industry's trade relationships relative to pre-tariff levels. Once again, this response is highly persistent: the number of trade relationships remains dampened relative to pre-tariff levels for around a decade after the tariffs are removed. While this is not direct evidence that the extensive margin is responsible for the export response shown in Section 5.1, it is suggestive, at least, that the extensive margin is likely at play.

5.3 Domestic Production and Employment

Lastly, I show estimates of the response of domestic production and employment to the Bush steel tariffs. For these responses, I rely on data from the NBER CES Database on the value of shipments and total employment in U.S. manufacturing industries. These data are available at the NAICS 6 level of industry aggregation, so I calculate my primary input tariff variable, $\Delta\tilde{\tau}_d$, at the NAICS 6 level as an average of the tariff rate changes on the HS 6-digit products contained in each NAICS 6 industry, weighted by export value in 2001.[27] My estimating specification (shown in equation 10) is identical to my baseline specification, with the exception of the level of aggregation.

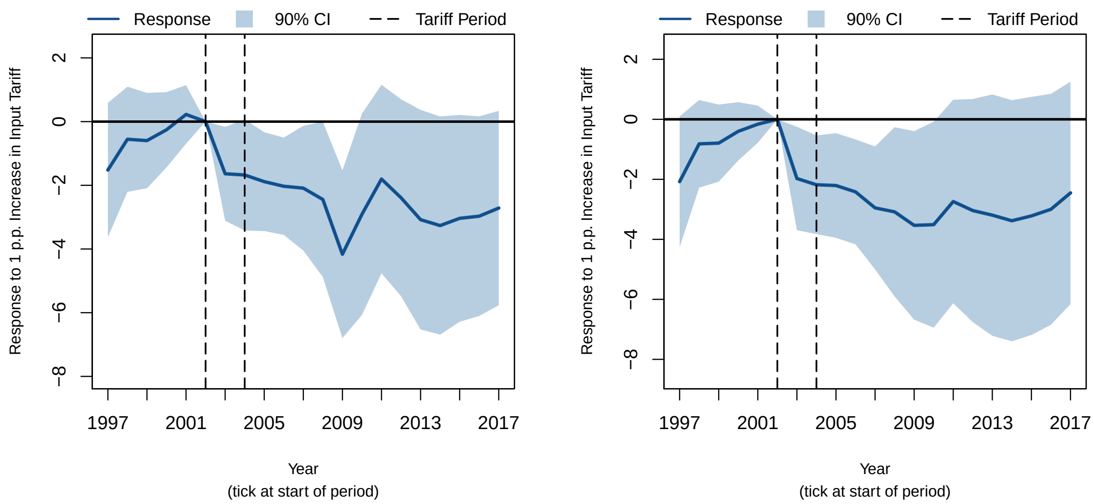
$$y_{d,t} - y_{d,2001} = \alpha_t + \theta_t \Delta\tilde{\tau}_d + \psi_t \alpha^{BEA}_{d,\text{Steel}} + \gamma_t X_{d,2001} + \delta_{n,t} + \varepsilon_{d,t}. \tag{10}$$

Here, the industry d's are NAICS 6 industries, and I control for 3-digit NAICS fixed effects, $\delta_{n,t}$. The results are plotted in Figure 10. The left panel shows the response of the log value of shipments in a downstream industry to a relative 1 p.p. increase in input tariff: Industries that face such an increase suffer an immediate and persistent 2 percent decline in value of shipments relative to pre-tariff levels. Note that the value of shipments variable

[27] To concord HS6 codes to NAICS codes, I again rely on the concordance developed in Pierce and Schott (2012).

Figure 10: Other Results: Value of Shipments and Employment

(a) Value of Shipments (b) Employment



Note. The left panel shows the response of industry value of shipments and the right panel shows the response of employment to an increase in input tariff. Regressions are estimated using equation 10. The shaded regions reflect 90 percent confidence intervals.

also contains exports, so this response reflects a combination of the effect on exports and the effect on production for the domestic economy. Downstream industry employment (right panel) exhibits a similar response: Industries that face a 1 p.p. larger increase in input tariff suffer a persistent decline in employment of about 2 percent relative to pre-tariff levels. The persistence of the employment response is consistent with the findings of Lake and Liu (2021), who find a persistent negative response of downstream industry employment to the Bush steel tariffs at the local level.

5.4 Interpretation and Magnitudes

In this section, I use the reduced form estimates presented above to offer some back-of-the-envelope estimates of the net costs of the Bush Steel tariffs on U.S. industries. Generally speaking, my difference-in-differences empirical specification precludes estimates of the overall costs and benefits of the Bush tariffs. I can, however, use the reduced form coefficients to estimate the scale of the costs and benefits to industries *relative* to a hypothetical industry that did not face the Bush tariffs, and *relative* to pre-tariff levels. In other words, the numbers I report below can be thought of as losses relative to a world that is fixed at the pre-tariff (2001) "steady state."

Specifically, I perform the following exercise: For downstream industries, I use the estimated coefficients plotted in Figures 7a, 10a, and 10b to calculate the losses in exports, value of shipments, and employment in downstream industries due to the Bush tariffs. The coefficients of interest are the θ_t's are estimated from my baseline specification (shown in equation 8), which reflect the percent change in industry d's outcome variable of interest relative to pre-tariff levels due to a 1 p.p. increase in input tariff. In each year, I estimate the total change in exports/shipments/employment relative to 2001 levels attributable to the Bush tariffs as:

$$y_t - y_{2001} = \sum_d \theta_t \times \Delta\tilde{\tau}_d \times y_{d,2001} \tag{11}$$

The results for exports and the value of shipments are shown in the first four columns of Table 2. The first column shows that relative to 2001 levels, the Bush steel tariffs led to a decline in exports of between 10 and 50 billion dollars per year between 2002 and 2009.[28] Annual losses amount to between 1 and 6 percent of downstream industry exports in each year (shown in Column 2).[29] The third column shows that declines in the value of shipments overall were of a similar magnitude of between 20 and 80 billion dollars from 2002 to 2009. Recall that the value of shipments variable also contains shipments that are ultimately exported, so a comparison of the magnitudes in columns 1 and 3 suggests that a large portion of the losses to downstream industries occurred through the export margin, though domestic production was not entirely spared. Declines in the value of shipments accounted for between 0.7 and 1.6 percent of total manufacturing shipments in each year. While it is beyond the scope of this paper to carefully estimate the effects of the Bush steel tariffs on the steel industry itself, columns (5) and (6) show that the estimated losses in downstream industries amounted to about half of *total* shipments in the steel industry (NOT the increase due to the tariffs) and swamped the roughly half billion dollars in tariff revenue that was collected on steel imports (shown in the right-most column) suggesting that the losses may have been large relative to potential gains.

In Table 3, I show the estimates of the downstream industry employment losses, again estimated using equation 11. Column (1) shows that employment losses relative to 2001 levels were between 150 and 250 thousand per year between 2002 and 2009, or between 1 and 2 percent of total manufacturing industry employment in those years (column (2)). This is in line with the employment losses in steel-consuming industries estimated by Francois and Baughman (2003) (roughly 200 thousand) in the immediate aftermath of the Bush tariffs. Notably, these estimated employment losses are larger than the total number of employees in the steel sector (shown in column (3)), and estimates by Lake and Liu (2021) suggest that

[28] I end in 2009 because this is the last year that the θ_t coefficients are estimated precisely.

[29] Losses as a share of total U.S. goods exports are around 1 percentage point per year, on average.

Table 2: Exports and Value of Shipments in Downstream Industries

Year	(1) Δ Exports ($ B)	(2) % Exports	(3) Δ Shipments ($ B)	(4) % Shipments	(5) Steel Shipments (TOTAL, $ B)	(6) Tariff Rev. ($ B)
2001	0	0	0	0	46.0	0
2002	-8.2	-1.4	-25.4	-0.7	47.6	0.3
2003	-14.5	-2.4	-26.1	-0.7	48.7	0.2
2004	-18.9	-2.9	-31.7	-0.8	76.4	0
2005	-39.6	-5.4	-36.9	-0.8	81.5	0
2006	-43.7	-5.5	-40.0	-0.8	92.4	0
2007	-37.1	-4.4	-51.0	-1.0	101.3	0
2008	-46.5	-5.4	-85.0	-1.6	125.3	0
2009	-37.5	-5.8	-45.0	-1.1	63.0	0
2010	-27.6	-3.4	-32.0	-0.7	91.7	0
2011	-11.2	-1.2	-47.1	-0.9	112.9	0
2012	-10.7	-1.0	-64.9	-1.2	112.6	0
Total (02-09)	-246	-3.7	-341.1	-0.8	682.2	0.5

NOTE. Columns (1) and (3) are estimates of the total decline in exports and employment relative to 2001 levels, estimated using equation 11. Columns (2) and (3) scale these estimates as shares of exports and total manufacturing industry shipments. Column (5) shows the aggregate value of shipments in the steel industry (comprised of NAICS 331200 and 331110) taken directly from the NBER CES Database. Column (6) shows the total duties collected on steel products protected by the Bush tariffs while they were in place.

Table 3: Employment in Downstream Industries

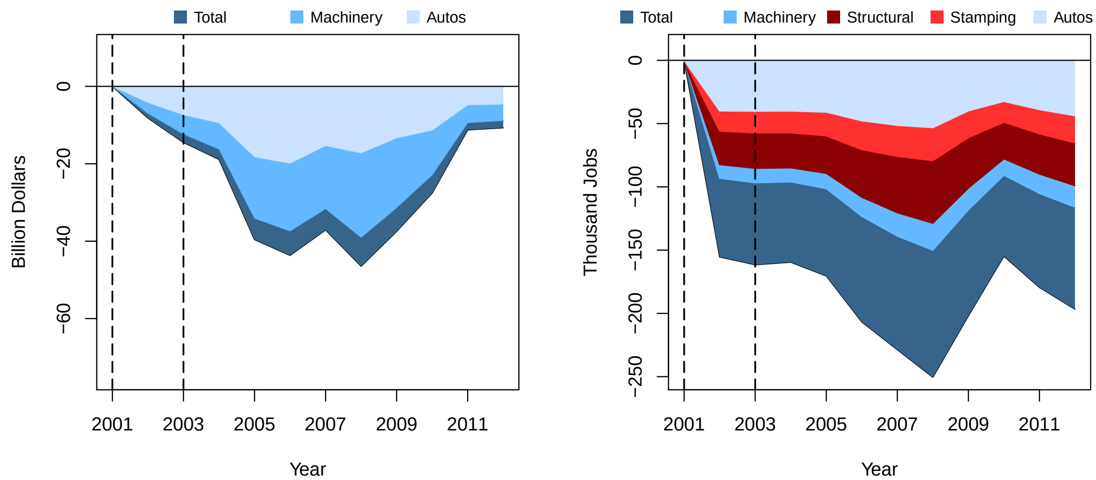
Year	(1) Δ Employment	(2) Pct of Mfg Emp	(3) Steel Industry Employees
2001	0	0	130.3
2002	-153.5	-1.1	120.4
2003	-159.6	-1.3	111.2
2004	-157.6	-1.3	109.3
2005	-168.5	-1.4	101.6
2006	-204.4	-1.7	100.8
2007	-226.0	-1.9	108.5
2008	-247.4	-2.1	109.2
2009	-199.2	-2.0	97.3
2010	-152.7	-1.6	95.3
2011	-177.1	-1.8	101.0
2012	-194.1	-1.9	103.0
Average (02-09)	-168.5	-1.4	109.8

NOTE. Column (1) shows estimates of the total decline in employment relative to 2001 levels, estimated using equation 11. Column (2) scales this as a percent of total manufacturing industry employment. Column (3) shows total employment in the steel industry (comprised of NAICS 331200 and 331110) taken directly from the NBER CES Manufacturing Industry Database.

there were no measurable gains in employment in the steel industry as a result of the Bush tariffs. Again, these results are purely suggestive, but they indicate that the costs of the steel tariffs on downstream industries may have far outweighed the benefits.

Figure 11: Magnitudes by Industry

(a) Exports (b) Employment



Note. The left panel shows a decomposition of estimated export losses relative to pre-tariff levels by 2-digit HS industry. The right panel shows a breakdown of the estimated employment losses relative to pre-tariff levels by 4-digit NAICS industry.

Lastly, breaking the estimated magnitudes down by sector shows where losses in sales and employment were likely concentrated. In Figure 11a, I show that about half of the decline in exports relative to pre-tariff levels was concentrated in the HS Chapter 87, which comprises exports of *Vehicles other than railway or tramway rolling stock, and parts and accessories thereof*, and the remaining losses were largely accounted for by losses in HS Chapter 84—*Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof*. As a percent of exports (not shown) HS 82—*Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal*—suffered the largest losses. Figure 11b shows the breakdown of employment losses by NAICS industry. Again the auto industry (NAICS 3363) and Machinery (NAICS 3339) accounted for a substantial share of the employment losses. The architectural and structural metals (NAICS 3323) and metal stamping (3321) industries also accounted for a large share.

6 Discussion of Potential Mechanisms

In this section, I use a simple model to show that the results presented in Section 5 are consistent with a dynamic trade model featuring relationship-specific sunk costs of importing. Focusing on the downstream industry export market and taking stock of the results presented in Section 5, I found that while the tariffs were in place export prices rose and export quantities fell. This result is intuitive: the increase in input tariffs—an increase in downstream industry marginal costs—leads to a leftward shift of the downstream export supply curve. What happens when the tariffs are removed requires a more complex explanation: Export prices return to pre-tariff levels, suggesting the supply curve shifted back to its pre-tariff location. Export quantities, however, remain depressed. In other words, there is some "missing" demand that downstream exporters are unable to recover immediately following the return to initial conditions. I will show that this sluggish recovery can be generated by a combination of relationship-specific sunk costs and uncertainty about the persistence of the shock.

That sunk costs can generate persistence in exports 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 exchange rate shocks, and more recent papers[30] have embedded sunk costs of exporting into both partial- and general-equilibrium dynamic models to show how they impact trade dynamics. These models have not explicitly been extended to study the impact of temporary, unilateral trade barriers, however, so the goal of this section is to show that a simple model with a relatively standard setup can generate results that align with my reduced form findings.

6.1 Intuition

To see how the persistence of the export response can be explained by the presence of relationship-specific sunk costs of exporting, consider a simple example: in each period, a consumer chooses a source s to purchase a (steel-using) good d from. He can purchase the good from country H at price p_H or from country F at price $p_F = p_H + \varepsilon$, where $\varepsilon > 0$. In this simple example, I assume the consumer is not forward looking. In addition to the price of the good, the consumer faces a relationship-specific sunk cost, κ_t, which is equal to $\bar{\kappa}$ if the consumer wants to *switch* sources relative to the prior period, and 0 otherwise (see equation 12).

$$\kappa_t = \begin{cases} 0, & \text{if } s_t = s_{t-1} \\ \bar{\kappa}, & \text{if } s_t \neq s_{t-1} \end{cases} \tag{12}$$

Assume that the consumer is buying from neither source in the first period, and thus faces the following choice: purchase from H at price $p_H + \bar{\kappa}$ or purchase from F at price $p_F + \bar{\kappa} =$

[30] 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) emphasize the importance of relationship-specific sunk costs. This list is not comprehensive.

Table 4: Simple Sourcing Decision

Period	Price H	Price F	Decision
1	$p_H + \bar{\kappa}$	$p_H + \varepsilon + \bar{\kappa}$	H, if $\varepsilon > 0$
2	$p_H + \tau$	$p_H + \varepsilon + \bar{\kappa}$	F, if $\tau < \bar{\kappa} + \varepsilon$
3	$p_H + \bar{\kappa}$	$p_H + \varepsilon$	F, if $\bar{\kappa} > \varepsilon$

$p_H + \varepsilon + \bar{\kappa}$. The consumer will choose to source from H so long as $\varepsilon \geq 0$. In period 2, suppose that country H imposes a one-period tariff that raises the price p_H to $p_H + \tau$. Now the consumer can either pay the higher cost in H or pay the switching cost $\bar{\kappa}$ to source from F and pay price $p_F = p_H$. The consumer will switch and source from F if $\tau > \kappa + \varepsilon$. Finally, in period 3, the tariff in H is lifted and prices return to their original levels. The consumer can either continue sourcing from country F and pay $p_H + \varepsilon$ or can choose to pay the adjustment cost to source from H and pay p_H. Despite the return to initial conditions in terms of prices, the consumer will continue sourcing from F if $\bar{\kappa} > \varepsilon$. In other words, there is a persistent response to a temporary shock.

This example, which is summarized in Table 4 is oversimplified in many ways. Most importantly, in a dynamic model, we expect the consumer to take into account their expectations about the peristence of the tariff shock and the probability that they may want to switch sources in the future. I will build those features into a slightly more complicated version of the model in the next subsection. However, from this naive example, it is clear that a few features of the model will be important for determining whether the model will generate persistence in response to a temporary shock. First, potential sources must be relatively competitive—ε, in the example, must be small. If the price differential among sources is too large, it is unlikely that a small, temporary shock will induce any switching of sources. Second, the size of the adjustment cost, $\bar{\kappa}$, must be small enough so as not to preclude switching altogether, but large enough to prevent switching back. In the next subsection, I will also show that uncertainty about the persistence of the shock (or the path of future prices) is another key determinant of persistence.

6.2 Model Setup

In the rest of this section I present the full model.

6.2.1 Steel Sector

Steel is produced both at home and abroad. 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 sector-specific composite of home and foreign steel, $M_{d,t}$, and take the price of this composite, P_t^M, as given.

6.2.2 Downstream Manufactured Goods

In each country, there are D downstream producers, each of whom produce a unique good, d. Firm d in country i produces according to the production technology:

$$y_{id,t} = z_{id} L_{d,t}^{1-\alpha_d} M_{d,t}^{\alpha_d}, \tag{13}$$

Where z_{id} is a country × firm specific productivity parameter, L_d is a labor input requirement, M_d is the composite steel input requirement, and α_d is the industry-specific steel-intensity. Downstream goods are sold at unit cost:

$$p_{id,t} = \frac{1}{z_{id}} \left(\frac{P_{id,t}^M}{\alpha_d} \right)^{\alpha_d} \left(\frac{W_{i,t}}{1-\alpha_d} \right)^{1-\alpha_d}, \tag{14}$$

Where $P_{id,t}^M$ is the price the downstream producer pays for the steel composite and $W_{i,t}$ is the wage rate in country i. Downstream producers take the price of the steel composite as given, and pay that price, augmented by a tariff rate set by their country's government. Therefore, the price that downstream proudcer d faces for steel inputs, $P_{id,t}^M$ is given by:

$$P_{id,t}^M = (1 + \tau_{id,t}) P_t^M, \tag{15}$$

where $\tau_{id,t}$ is the steel tariff rate faced by downstream industry d in country i 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 country, i, there are two states of the world: $w_{i,t} \in \{\ell, h\}$. Tariffs on steel depend on the state of the world: $\tau_{id,t} \in \{\tau_{id}^\ell, \tau_{id}^h\}$, with a transition matrix given by:

$$\Pi = \begin{bmatrix} \pi_{\ell,\ell} & \pi_{\ell,h} \\ \pi_{h,\ell} & \pi_{h,h} \end{bmatrix} \tag{16}$$

where, for example, $\pi_{\ell,h}$ is the probability of transitioning from state ℓ to state h. I assume tariffs are set independently in both countries. In the simulations that I perform, I feed in a fixed path for tariffs such that they are in place for two periods (matching what happened during the Bush steel tariffs if a period is assumed to be one year). Thus, the transition matrix, Π, does not govern persistence of the actual shock, but does govern agents expectations about the persistence of the shock. For example, an agent is completely uncertain about the persistence of the shock if $\pi_{\ell,\ell} = \pi_{\ell,h} = \pi_{h,\ell} = \pi_{h,h} = 0.5$. In this case, the agent believes that there is a 50 percent chance of being in either the low state or the high state in each period.

6.2.3 Dynamic Sourcing Problem

Consumers in country i consume a CES bundle of the differentiated manufactured products. Consumers choose one source for each differentiated product d, and, in particular, choose the cheapest source for each product, subject to one friction: They must pay an adjustment cost, κ_t in order to form a new relationship with a supplier. For example, if a consumer buys good d from country H in period $t-1$, they must pay a one-time fixed cost of κ_t to purchase good d from country F in period t. κ_t is also subject to idiosyncratic shocks.[31]

In each period, consumers in each country choose a source, s, for each good, d, to minimize expected future costs:

$$C_{i,d}(s,\kappa,\tau) = \min_{s'} \left[p_{s',d}(\tau) + \kappa \times \mathbf{1}(s' \neq s) + \beta \mathbb{E}_i \left[C_{i,d}(s',\kappa',\tau') \right] \right] \quad (17)$$

As equation 17 shows, conusmers minimize the cost of the good today, taking into account switching costs if relevant— $p_{s',d}(\tau) + \kappa_t \times \mathbf{1}(s' \neq s)$—plus the entire path of expected future costs, including the possibility that the consumer may want to switch sources again down the line—$\beta \mathbb{E}_i \left[C_{i,d}(s',\kappa',\tau') \right]$.

6.3 Calibration and 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 country and by a firm in the Foreign country. Each good has three characteristics: (i) a tariff on inputs in the high tariff state of the world that is drawn uniformly from one of six possible tariff rates ranging from 0 to 15 percent (the same range as the $\Delta\tilde{\tau}_d$ in the data); (ii) an indicator for whether the firm gets fixed cost relief ($\kappa_t = 0$ with 2 percent probability); (iii) a productivity parameter, δ, which equals the relative price ($p_F - p_H$) of good d between the producer in H and the producer 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 σ. In my baseline, I set $\delta = 0.01$ and $\sigma = 0.01$ in order to match the data, and show counterfactual simulations that adjust these values. In the baseline, the chosen values of δ and σ mean that, on average, Home country producers are *slightly* more productive and charge lower prices than the Foreign producers, but the two countries are highly competitive. I show how the results vary with these parameters in Section 6.4. Note that in partial equilibrium, the prices drawn serve as a summary statistic for τ_{id}, α_d, and z_{id} in equation 14, since the other

[31] The idiosyncratic shocks are here solely to help bring the system back to the initial steady-state. This is similar to the common imposition that firms face an exogenous "death shock."

elements of the equation are fixed. In period 0, consumers purchase each good from the country that charges the lower price. In period 1, the import tariff rate on steel is shocked in the Home country, and in period 3, the tariffs are removed.

Consumers in each country believe that tariffs in their own country follow a two-state Markov process with transition matrix given by:

$$\Pi = \begin{bmatrix} 0.79 & 0.21 \\ 0.76 & 0.24 \end{bmatrix} \tag{18}$$

This transition matrix is calibrated such that consumers believe that in their own country, tariffs will stay in place for two years, on average, and tariffs will be put in place every 15 years. I consider this to be the "correct" expectation about tariff policy, in that it generates expectations about the persistence of the tariff shock that match the simulated shock that I feed in for the simulation.[32]

In the other country, consumers are less certain about tariff policy. They still believe that tariffs will be put in place every 15 years, but once the tariffs are in place, consumers believe there is a 40 percent chance they will remain high the following period. The calibration for the transition matrix is given by Π^*, below.

$$\Pi^* = \begin{bmatrix} 0.79 & 0.21 \\ 0.60 & 0.40 \end{bmatrix} \tag{19}$$

These parameters are chosen to match my empirical results, but can be thought of as a middle ground between complete uncertainty about the persistence of the shock (all transition probabilities equal to 0.5) and the "correct" expectations (given by Π). This asymmetric uncertainty can be thought of as driven by frictions in information or salience of a foreign country's trade policies to domestic downstream consumers. An individual buying a car in Japan may not internalize the fact that the price of a Ford is being driven, in part, by the U.S. tariffs on steel. Counterfactual simulations in Section 6.4 show how the results vary with the choice of the transition matrix.

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_t is equal to 0.1 on average, but is subject to idiosyncratic shocks

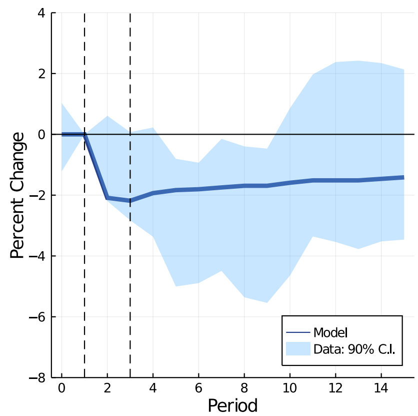
[32] The expected number of periods that a high- or low-tariff period will last, conditional on entering, is:

$$d = 1 + 2 \times p_{i,i} + 3p_{i,i}^2 + ... = \sum_{t=1}^{\infty} t p_{i,i}^{t-1} = \frac{1}{(1 - p_{i,i})^2} \rightarrow p_{h,h} = 1 - \frac{1}{\sqrt{d}}$$

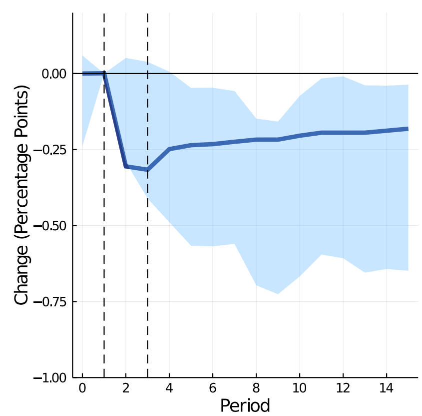
This means that for the baseline calibration of Π, the average low-tariff duration is 15 periods and the average high-tariff duration is 2 periods.

Figure 12: Model-Simulated Regression Results

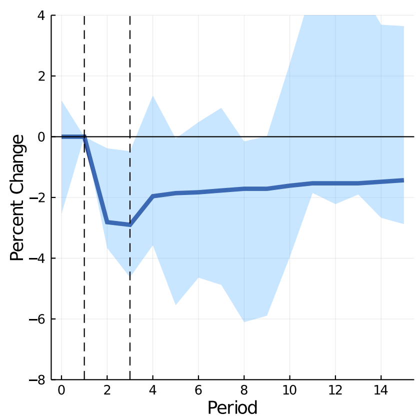
(a) Exports



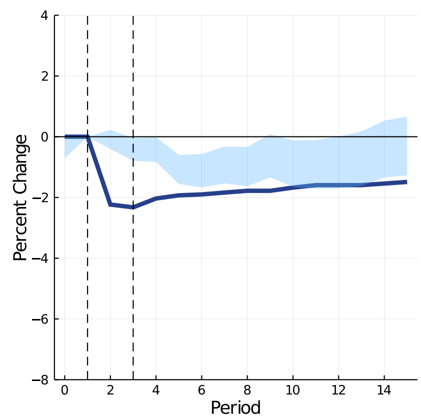
(b) Export Quantities



(c) Export Share



(d) Number of Exporting Firms



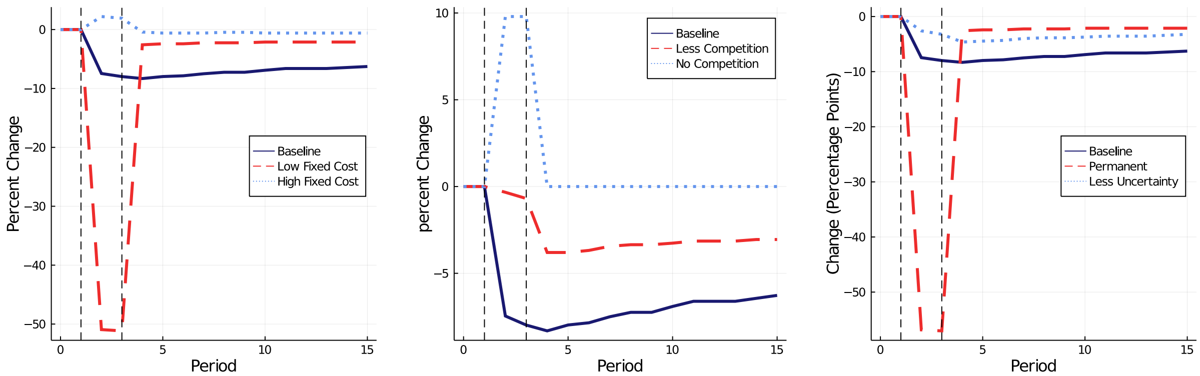
NOTE. The figures above show the model-simulated analogs to the regressions presented in Figure 7. Confidence intervals from the reduced form results are shown against the simulated point estimates.

such that it equals 0 in each period with 2 percent probability. This is equivalent to 10 percent of current period prices (or costs for the consumer) or 0.1 percent of lifetime costs. I show sensitivity to the choice of fixed cost in Section 6.4. Consumers in each country start off with an initial endowment. Initial endowments are set such that the Home country accounts for 30 percent of world demand, calibrated to match the U.S. share of world GDP in the year 2000.

Tariff rate increases for the two-period tariff shock are uniformly distributed between 0 and 15 p.p.—the same range as the increase in the scaled tariff rate that is my primary variable of interest in the data. Figure 12 shows the model-simulated analogs to the baseline regressions presented in Section 5.1. Specifically, I regress changes in industry-level exports, export quantities, export shares, and the number of exporting firms (the extensive margin), relative to pre-tariff levels on industry tariff rates. This is analogous to the empirical speci-

Figure 13: Counterfactual Simulations: Path of Aggregate Exports

(a) Fixed Costs (b) Price Competition (c) Uncertainty



NOTE. The figures above show counterfactual simulations of aggregate exports. The left panel shows variations in the fixed cost parameter. The middle panel shows variations in the degree of price competition. The right panel shows variations in beliefs about the persistence of the tariff shock.

fication shown in equation 8. I plot the point estimates from the model-generated regression against the confidence intervals estimated in reduced form. For nominal exports, export quantities, and export shares, the point estimates from the model lie squarely within the confidence intervals estimated in the data. The model overestimates the extensive margin changes relative to the data, however recall that in the data I am unable to observe the *true* extensive margin, only a proxy, which explains this discrepancy.

6.4 Counterfactuals

In Figure 13, I show the model-simulated response of exports for serveral counterfactual scenarios. Rather than the regression estimates shown in Figure 12, which show relative effects, the impulse responses are shown for aggregate variables. In all panels, the baseline model is shown by the solid navy blue line. In response to the tariff shock, aggregate exports suffer a peak decline of around 7.5 percent relative to pre-tariff levels, and responses in the baseline case are highly persistent.

In Figure 13a I show two counterfactual simulations where I vary the size of the fixed switching cost. In the "Low Fixed Cost" scenario—depicted by the red dashed line—I set the switching cost to near zero (specifically 0.01, compared to 0.1 in the baseline). In this case, because it is essentially frictionless to move between sources, there is a much steeper drop in exports—to nearly 50 percent below their pre-tariff levels—when the tariff hits. In contrast to the baseline, however, exports revert nearly back to pre-tariff levels immediately once the tariffs are lifted. (Had we set the switching cost to 0, exports would revert all the way back to pre-tariff levels.) Again, since it is nearly costless to transition between suppliers, most consumers are able to immediately return to their preferred source under the initial conditions. The blue dotted line represents the “High Fixed Cost” counterfactual. Here, the fixed cost is raised to 0.25, making it too costly for any consumer to shift sources when the tariffs hit. As a result, nominal exports actually rise slightly during the tariff period (because prices increase), and immediately revert to pre-tariff levels. Thus, to generate the persistence found in the data, fixed costs must be high enough to create a barrier, but not too high to prevent the switching of sources altogether.

In Figure 13b, I show the export response under two counterfactual scenarios with varying degrees of price competition. In the baseline, again depicted by the solid navy blue line, the Home and Foreign countries are extremely competitive—meaning neither has a strong comparative advantage. The Home country is, on average, only slightly more productive (the mean price differential is 1 percent). In the first counterfactual scenario, labeled “Less Competition” and depicted by the red dashed line, I increase the average price differential between the Home and Foreign country from 1 percent in the baseline to 5 percent, thereby increasing the Home country’s relative advantage. In this scenario, the export response is more muted than in the baseline: There are fewer goods for which consumers find it profitable to switch sources even after the tariff shock occurs. In the third counterfactual scenario, labeled “No Competition” and shown by the light blue dotted line, I increase the gap even further, to 25 percent. In this scenario, the Home country has a strong comparative advantage in production of all goods, and therefore no consumer switches sources after the tariffs are put in place. As a result, (nominal) exports rise while the tariffs are in place, as consumers pay higher prices, and immediately revert to their pre-tariff levels once the tariffs are removed. As these counterfactuals show, to generate a persistent response of the magnitude I find in the data, downstream firms in competing countries must be highly competitive when it comes to prices.

The last set of counterfactuals, shown in Figure 13c, illustrate the importance of uncertainty about the persistence of the tariff shock in generating persistence. In the first counterfactual scenario, labeled “Permanent” and depicted by the red dashed line, consumers instead believe that the current state of the world will be permanent (e.g., if tariffs are high, they will be high forever). Here, the response of exports resembles the case where there are no fixed costs: to the consumers, there is no uncertainty, so it is always worth it to switch to the best source in the period in question—there is no option value of waiting. The next counterfactual, labeled “Less Uncertainty” and depicted by the light blue dotted line shows the case where there is no asymmetry between consumers’ beliefs about tariff policy in their own country versus the foreign country. Consumers have the “correct” expectations that in both countries, tariffs will arise every 15 years on average and be in place for two years. Here, because consumers are relatively certain that tariffs will be short-lived, the export response is moderated slightly: fewer consumers decide to switch sources, as they are more willing to wait for the tariffs to be removed to avoid paying the switching costs. Importantly, there is still persistence in the scenario, in that the consumers who do switch are slow to return. Uncertainty about future prices is what creates a value in being slow to adjust, and is therefore an important driver of persistence in the model.

7 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 new 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: The global market share of U.S. downstream industries remained depressed long after the tariffs were removed. Due in large part to this persistence, back-of-the-envelope calculations suggest that losses to downstream industries as a result of the Bush steel tariffs likely swamped any short-term gains to the steel industry.

Using a simple dynamic trade model, I then show that the presence of relationship-specific sunk costs and uncertainty about future tariff policy 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 countries 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 these persistent spillover effects into account can lead to a substantial underestimate of the costs of imposing unilateral trade barriers on an upstream industry.

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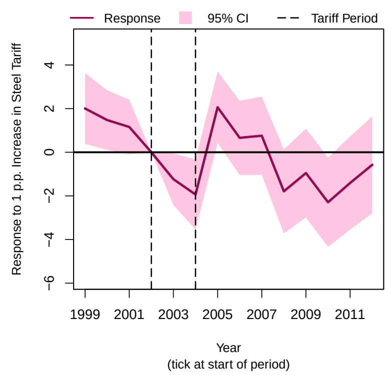
Appendix: For Online Publication

A1 Steel Industry Response

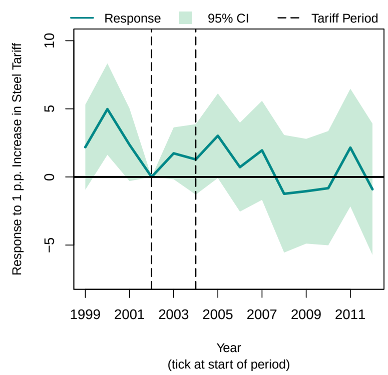
The impulse responses plotted in Figure 14 show that changes in U.S. steel imports in response to the tariffs were entirely driven by changes in imports in countries that were *not* exempt from the steel tariffs. Imports and import unit values from exempt countries (shown in the right three panels) display no measurable impact from the Bush tariffs.

Figure 14: Effect of Higher Statutory Rates on Steel Imports and Import Prices

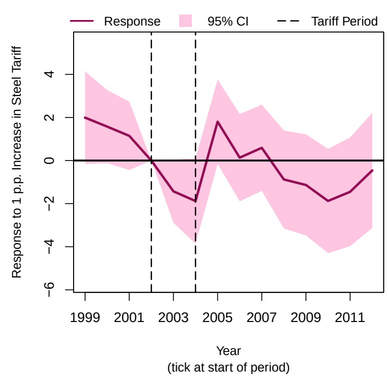
(a) Non-Exempt: Import Values



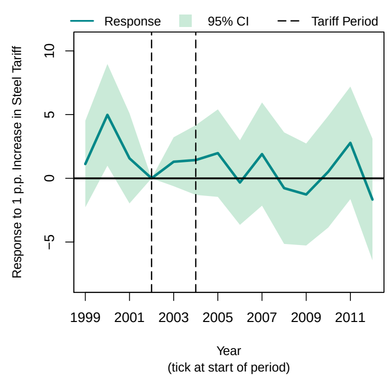
(b) Exempt: Import Values



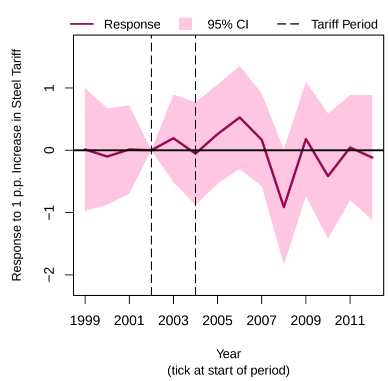
(c) Import Quantities



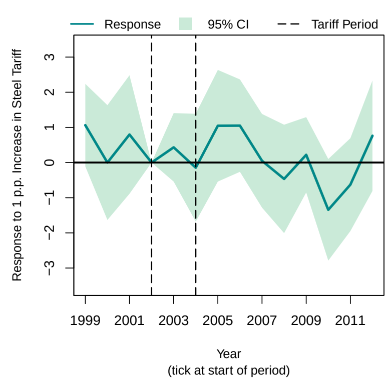
(d) Import Quantities



(e) Import Prices



(f) Import Prices



A2 Cost Share Measure as a Scaling Factor

As discussed in Section 3.3, a drawback of my baseline approach is that I scale the steel tariff variable using steel cost shares calculated from the more aggregated BEA input-output table. Note that if the exclusion requests covered the universe of steel inputs, using this more aggregated cost-share measure would be innocuous. However, this is not the case. The steel products accounted for in the exclusion requests represent only roughly 70 percent of the steel products represented in the BEA input-output table, and I have no way of knowing which products are "missing" from which industries. To try to alleviate concerns about this measure, I show in this Appendix that using the BEA cost share measure scales the response in the expected manner, but does not appear to otherwise distort the results from using the unscaled tariff as my independent variable of interest.

Recall my baseline specification, shown below:

$$y_{d,t} - y_{d,2001} = \alpha_t + \theta_t \Delta\tilde{\tau}_d + \psi_t \alpha^{BEA}_{d,\text{Steel}} + \gamma_t X_{d,2001} + \delta_{h,t} + \varepsilon_{d,t}. \tag{20}$$

The independent variable is $\Delta\tilde{\tau}_d$, which is the increase in the tariff rate on steel inputs $\Delta\tau_d$, scaled by the industry's steel cost share $\alpha^{BEA}_{d,\text{Steel}}$. Because I am also controlling for $\alpha^{BEA}_{d,\text{Steel}}$ on its own, multiplying the steel cost share with the tariff should (roughly) serve as a scaling factor. Instead of providing the response of an outcome variable to an increase in the tariff rate on steel for an industry with the average steel cost share, it governs the response of an industry to an increase in the cost (or tariff on) inputs. If the steel cost share measure is specified correctly (or at least, as long as the error is not correlated with the tariff shock in a distortionary way), the point estimates from my baseline specification (θ_t) should simply be a scaled version of the point estimates of the regression below ($\hat{\theta}_t$), where the independent variable of interest is $\Delta\tau_d$ rather than $\Delta\tilde{\tau}_d$.

$$y_{d,t} - y_{d,2001} = \alpha_t + \hat{\theta}_t \Delta\tau_d + \psi_t \alpha^{BEA}_{d,\text{Steel}} + \gamma_t X_{d,2001} + \delta_{h,t} + \varepsilon_{d,t}. \tag{21}$$

Specifically, the average steel cost share for downstream industries that faced a non-zero steel tariff in my sample is 0.14. That means it would take a roughly 7 ($= 1/0.14$) percentage point increase in the tariff rate on steel to cause a 1 percentage point increase in the scaled steel tariff rate. Thus, we should see that the coefficient on the scaled tariff rate (my baseline) is roughly 7 times larger than the coefficient on the unscaled tariff rate (e.g., $\theta_t \simeq 7\hat{\theta}_t$). Furthermore, because the exclusion requests cover only around 70 percent of all steel inputs contained in the BEA cost share measure, I am likely *overestimating* $\Delta\tilde{\tau}_d$ (assuming the missing 30 percent of potential steel inputs faced 0 tariff). Thus, we should scale down $\Delta\tilde{\tau}_d$ to $\Delta\tilde{\tau}_d \times 0.7$.

Table 5 shows the results of running the following specification:

$$y_{d,t} - y_{d,2001} = \alpha_t + \theta\Delta\tilde{\tau}_d + \psi\alpha^{BEA}_{d,\text{Steel}} + \gamma X_{d,2001} + \delta_h + \varepsilon_d, \quad (22)$$

where y is either U.S. export shares or log U.S. exports in downstream industry d and δ_h are HS4 digit fixed effects. This is essentially the same as my baseline regression, but I pool the years 2002 through 2005 and report the average coefficient, θ. In the first two columns of Table 5, I run the regression using my baseline, scaled $\tilde{\tau}_d$ for export shares (column (1)) and log exports (column (2)). In columns (3) and (4), I show the results for the same regression, when I instead use the unscaled tariff variable, $\Delta\tau$, multiplied by 7. The estimates are in the same ballpark, but, as expected, are higher than my baseline. In the rightmost two columns, I further scale my baseline independent variable, $\tilde{\tau}_d$ down by 0.7. Comparing columns (3) and (5), we see that the point estimates are within each other's confidence intervals. The same is true for columns (4) and (6).

In sum, these results suggest that despite being an imperfect measure for my purposes, the aggregate cost share measure is doing little more than scaling the results (and likely leading me to underestimate the effect of the steel tariffs on downstream industry outcomes). This should alleviate any concern that the error term in the cost share measure is correlated in the tariffs in some way that is obscuring my baseline results in a more distortionary way. In Figure 15, I show the local projection for my baseline (scaled tariff) and the unscaled tariff variable to show that the dynamic path is not distorted by the BEA cost share measure. I multiply the unscaled tariff by 5, which is roughly equivalent to multiplying by 7 and scaling down the cost share measure by 0.7.

A2.1 Input-Output Relationships Over Time

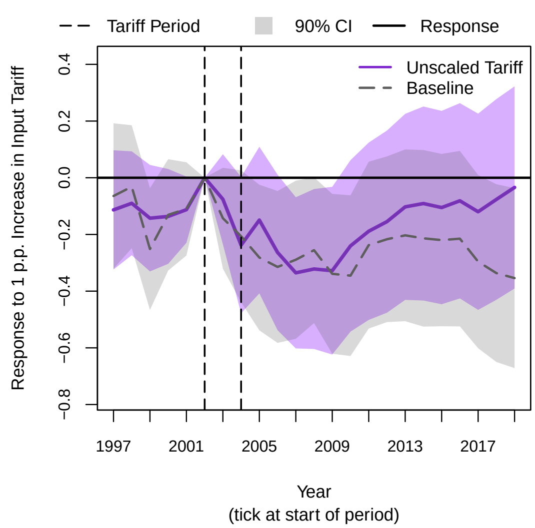
Because the exclusion requests that underlie the steel-specific input-output table were filed in 2018, I assume that steel input-output relationships in 2018 are a reasonable representation of steel input-output relationships in 2002. A comparison of the input-output tables published by the Bureau of 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.

Table 5: Scaled Coefficients: $\Delta\tau_d$ vs $\Delta\tilde{\tau}_d$

	(1) Δ Share	(2) Δ Value	(3) Δ Share	(4) Δ Value	(5) Δ Share	(6) Δ Value
Δ Costs	-0.285**	-3.250***				
	(0.136)	(1.013)				
$\Delta\tau$ x 7			-0.542**	-5.427***		
			(0.253)	(1.888)		
$\Delta\tau$ x 0.7					-0.407**	-4.642***
					(0.194)	(1.448)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HS4 FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1587	1587	1587	1587	1587	1587
R^2	0.252	0.279	0.253	0.278	0.252	0.279

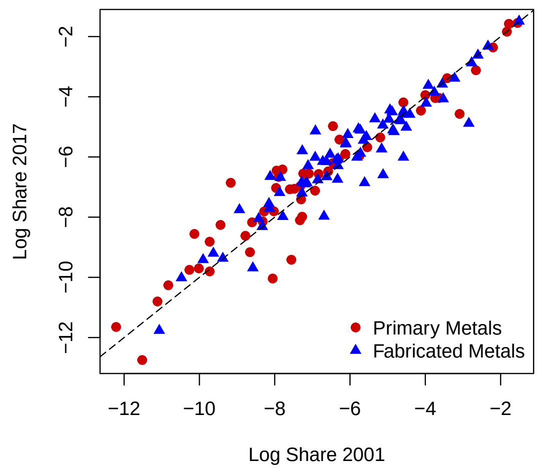
Standard errors in parentheses
Additional Controls: Industry Steel Cost Share, Exempt Share of Steel Inputs
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 15: Scaled vs Unscaled Export Shares



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 16 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.

Figure 16: Change in Metal Share of Input Costs: 2001-2017



A3 Robustness Exercises

A3.1 Alternative Difference-in-Differences Specification

In this section I present a few sets of robustness exercises for my primary results. First, I show that my baseline local projection specification gives quantitatively similar point estimates to a pooled difference-in-differences specification. Specifically, I reestimate the results using the specification shown below:

$$\Delta y_{d,t} = \sum_t \theta_t \mathbf{1}(T=t)\Delta\tilde{\tau}_d + \sum_t \psi_t \mathbf{1}(T=t)\alpha^{BEA}_{d,\text{Steel}} + \gamma_t \sum_t \mathbf{1}(T=t)X_{d,2001} + \delta_h + \varepsilon_{d,t} \quad (23)$$

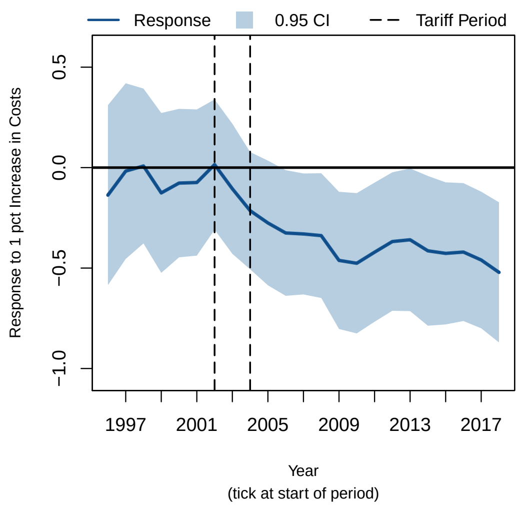
This is similar to my baseline specification except that instead of estimating the specification separately in each year, I pool the data and interact a year dummy with my main variable of interest, $\Delta\tilde{\tau}_d$. Instead of HTS Section $\times$ year fixed effects, which is what I have in my baseline, I include year and HS4 code fixed effects (separately) in this version. The results, shown in Figure 17, are very similar to my baseline results.

A3.2 Controlling for China's Export Share

To assuage concerns that my findings are being driven in part by the rapid growth in Chinese manufacturing (a.k.a. the "China Shock"), which started around the same time as the Bush steel tariffs were put in place, I rerun my baseline specification controlling for the change in China's export share in downstream industry d relative to 2001. The results,

Figure 17: Robustness: Pooled Regression with HS4 Fixed Effects

(a) U.S. Export Share



(b) U.S. Export Value

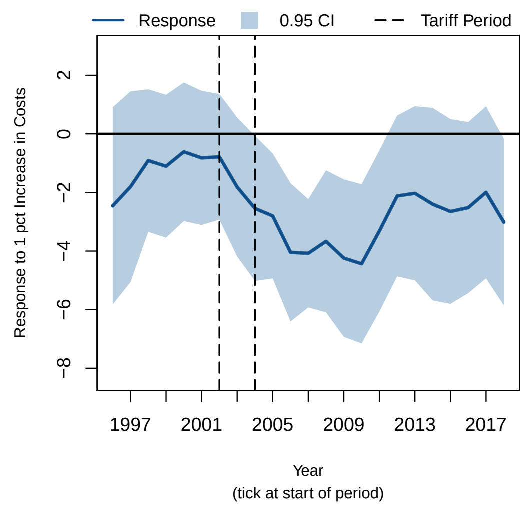
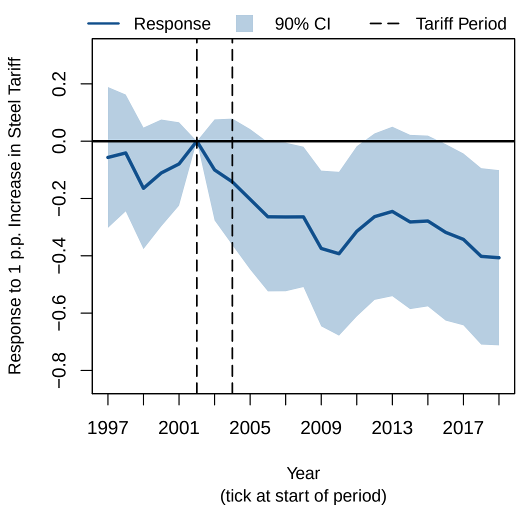
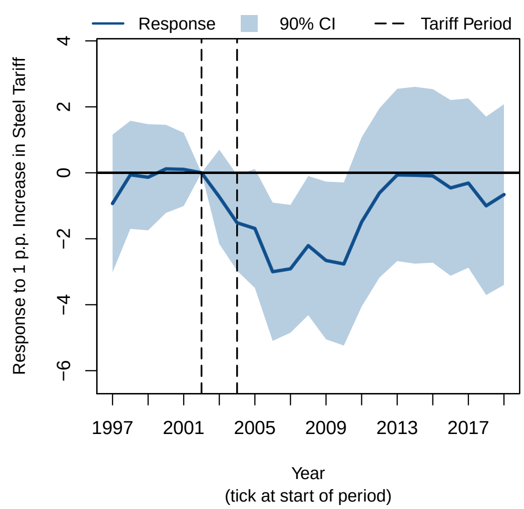


Figure 18: Robustness: Controlling for China's Export Share

(a) U.S. Export Share



(b) U.S. Export Value



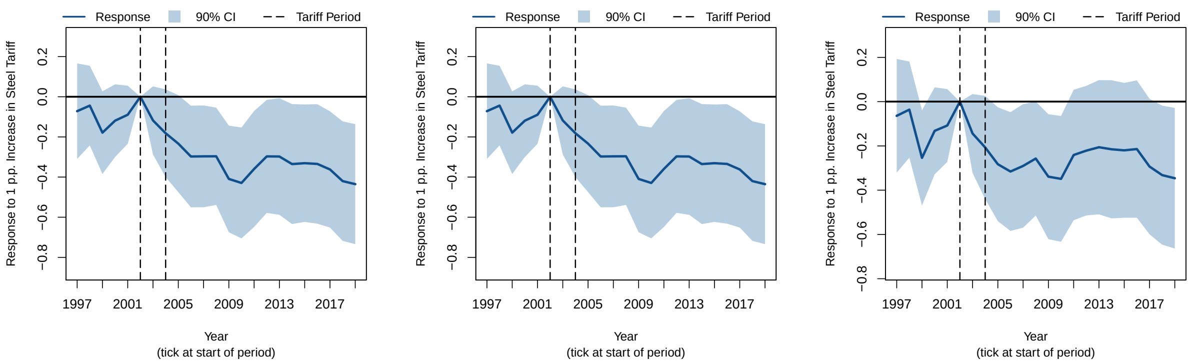
shown in Figure 18, are virtually identical to my baseline, confirming that growth in Chinese manufacturing is not driving my findings.

A3.3 Inclusion of Zeros

In my baseline, I include industries for which $\Delta\tilde{\tau}_d = 0$, but only if they are sub-industries of HS2 Chapters where there is at least one industry with $\Delta\tilde{\tau}_d > 0$. Figure 19 shows that my results (shown below for U.S. export shares) are robust to this choice. In the left panel I include all industries, the middle panel shows my baseline, and in the right panel I restrict

Figure 19: Robustness: Inclusion of Industries with $\Delta\tilde{\tau}_d = 0$

(a) All Zeros (b) Baseline (c) Only $\Delta\tilde{\tau}_d > 0$



the sample to only include industries for which $\Delta\tilde{\tau}_d > 0$. The choice of sample does not meaningfully change my results.

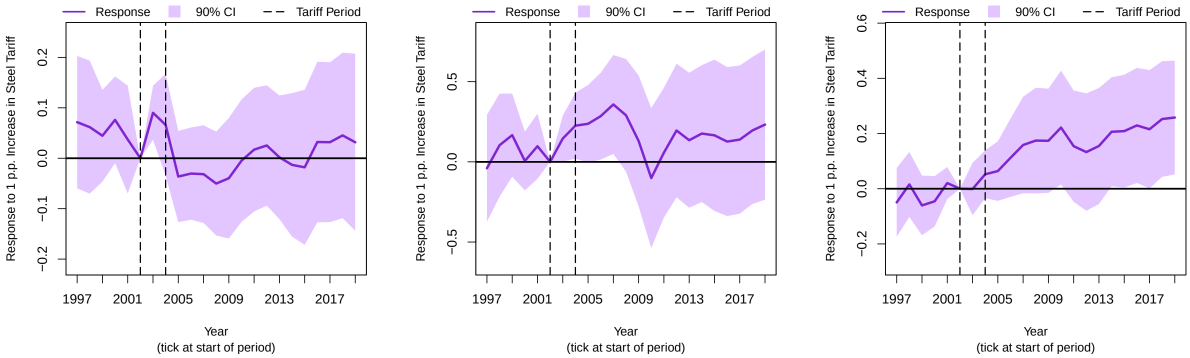
A4 Which Countries Gained Market Share?

In this paper, I show that the U.S. lost global market share in downstream industries because of the Bush steel tariffs. A natural question is, which countries benefitted? The simple theoretical model I present in Section 6 suggests that market share should shift to the top competitors of the United States, meaning the countries producing similar products for a close price. In 2001, the United States was the top exporter of the downstream products in question, meaning that total exports of these products from the United States was higher than any other country. I collect data on the export shares of the other nine countries that round out the top 10—Germany, Japan, France, Italy, Canada, United Kingdom, China, Belgium, and South Korea. I then estimate my baseline specification, but replacing the U.S. export share on the left-hand side with the foreign country's export share.

I find no impact of the tariffs on the export shares of Belgium, China, Italy, and Canada. For the remaining countries, responses, shown in Figure 20, are divided into threetypes. The left panel shows that Japanese downstream export shares exhibited a sharp, but transitory increase in downstream industries that faced higher input tariffs in the U.S. Specifically, a 1 p.p. increase in input tariff in the U.S. leads to a relative increase in the Japanese industry's export share of 0.1 p.p. Japanese export shares return to pre-tariff levels immediately after the tariffs are removed. In the middle panel, I plot the response of the combined export shares of three European countries: Germany, the UK, and France. Export shares in these countries rise on impact of the tariffs, and remain elevated relative to pre-tariff levels until 2009. In the right panel, the South Korean export share exhibits yet another response. Upon impact of the tariffs, South Korean export shares are slower to take off, however, they remain

Figure 20: Export Shares of Top Competitors

(a) Japan (b) Germany, France, UK (c) South Korea



elevated for the longest, failing to return to pre-tariff levels by the end of the sample period.

These results suggest that one country alone is not responsible for taking over the market share lost by U.S. producers, but several countries at different times. Further exploration into how and why global sourcing patterns were reconfigured in this way is a question requiring further research.