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

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Motivation

+ Globally integrated supply chains complicate traditional cost-benefit analysis of tariffs.

+ **Protection comes at a cost**: tariffs on upstream products raise input costs for downstream manufacturers.

+ Tariffs/emergency safeguards often justified as **temporary measures**.

+ Little is known about the **long-term behavior** of these spillover effects.

This Paper

+ **Measurement:** Create a **new steel-specific input output table** to study the steel tariffs levied by George W. Bush in 2002-2003.
  - Constructed using publicly available Trump-tariff exclusion requests.
+ New empirical evidence that **temporary upstream tariffs have persistent impacts** on downstream industries.
  - Downstream industries that face higher tariffs suffer persistent declines in exports and lose global market share.
  - Relative declines in output and employment as well.
  - Consistent with models featuring relationship-specific sunk costs of trade.
+ Back-of-the-envelope calculations show the importance of taking dynamic downstream impacts into account when evaluating costs and benefits of tariffs.

Literature

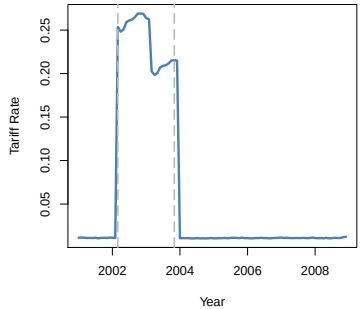
+ **Empirical Impacts of Trade Policy:** Primarily short-term in nature. Amiti et al. (2019), Cavallo et al. (2019), Fajgelbaum et al. (2020), Flaaen et al. (2020), Flaaen and Pierce (2021), Handley et al. (2020), Bown et al. (2020), Lake and Liu (2021), Alessandria et al. (2021a)
+ **Steel Tariffs:** Correlative or cross-country evidence. Francois and Baughman (2003), Read (2005), Blonigen (2016), Cox and Russ (2020)
+ **Input Tariff Liberalization, Transmission of Input Shocks:** Amiti and Konings (2007), Goldberg et al. (2010), Topalova and Khandelwal (2011), Blaum et al. (2018), Boehm et al. (2019), Auer et al. (2019)
+ **Sunk Costs, Policy Uncertainty, and Hysteresis:** Baldwin (1988), Baldwin and Krugman (1989), Dixit (1989), Roberts and Tybout (1997), Bernard and Jensen (2004), Das et al. (2007), Atkeson and Burstein (2010), Burstein and Melitz (2013), Alessandria and Choi (2014), Bernard et al. (2018),Caldara et al. (2019), Alessandria et al. (2021b), Xu (2021)

Policy Setting: Background on the Bush Steel Tariffs

Background: The Bush Steel Tariffs

- Effective March 20, 2002; 3-year phase out.
- 171 steel products (HS8), 13 categories of steel.
- 8 to 30 percent on top of existing rates.
- Eliminated in December 2003.

Figure: Trade-Weighted Average Steel Tariff Rate



Primary Empirical Challenge

Typical regression to estimate the effect of tariffs through supply chains has the following general form:

$$\text{Outcome}_i = \alpha + \beta \text{Exposure}_i + \varepsilon_i$$

where the key independent variable is a measure of how **exposed** an industry is to the input tariff.

Common approach is to measure **exposure** is to use input-output tables (e.g., from the BEA):

$$\text{Exposure}_i = \frac{\text{Steel Use}_i}{\text{Intermediate Input Costs}_i}$$

Primary Empirical Challenge

The Problem: Input-Output tables tend to be very broad, while tariff policy can be highly specific.

+ Tariffs are applied at the HS8-digit level.
  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.

+ I-O category for steel—*Iron and Steel Mills and Ferroalloy Manufacturing*—is a compilation of roughly 300 HS8 digit products.

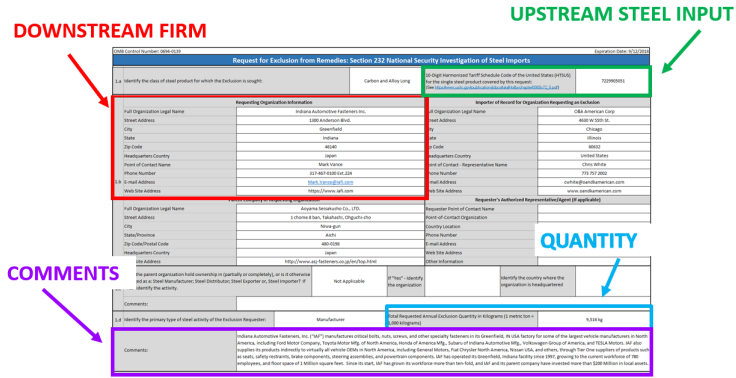
+ Using the aggregate exposure measure is ok if:
  - Tariffs are applied uniformly to the entire BEA category.
    Not the case for the Bush steel tariffs.
  - Or, all downstream industries use all types of steel in the same proportions.
    Not a good assumption...think soup cans vs automobiles.

New Steel-Specific Input-Output Table

Steel-Specific Input-Output Table

Data: Exclusion requests filed in response to Trump's steel tariffs.

+ Firms filed OMB Form 064-0139 for **individual 10-digit steel products**.
+ Publically available from Regulations.gov



Steel-Specific Input-Output Table

Exclusion-requesting firm is a **downstream user** of specific **upstream steel input**.

+ 73,824 requests with 5,685 unique descriptions.
+ Map to roughly 700 downstream industries (HS6).

Coverage: Consider a product "covered" if one or more exclusion requests have been submitted for it.

+ Of the HS8-digit products contained in BEA's "Iron and Steel Mills and Ferroalloy Manufacturing" category, requests cover 90 percent of steel imports.
+ Of the products covered by the Bush steel tariffs, requests cover 95 percent of imports.
+ At the HS4-digit level (i.e., "covered" defined as having an exclusion request for a product in a given HS4 category), 100 percent coverage of the BEA category (and the Bush tariffs).

Constructing Steel-Input Weights

The requests allow me to identify which *types* of steel are used by which industries:

+ First, identify the set Ω_d of steel inputs, s, by downstream industry d.
  An input enters Ωd if there is an exclusion request filed for that input that I map to industry d.

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+ Calculate the weights, $\omega_{s,d}$, for each input s in Ω_d^s:

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

  - p_s is the import unit value of steel product s in 2001 ($ per kg).
    Source: Import data.
  - $Q_{s,d} = \sum_i \bar{Q}_{i,s,d}$ is the sum of the average consumption of product s in 2015-2017 reported by firms that filed a request for input s mapped to downstream industry d.
    Source: Exclusion requests.

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    Source: Exclusion requests.
+ Reassuringly $\omega_s = \sum_d \omega_{s,d}$ is highly correlated with import shares of s.

Steel-Specific Input-Output Table

In constructing the weights, $\omega s, d$, I am able to break up total steel use of downstream industries into the *shares* spent on each steel type.

A few examples:

Metal Cans
(BEA Steel Cost Share: 15%)

- + Tin Mill Products (89%)
- + Coated Steel (11%)

Appliances
(BEA Steel Cost Share: 10%)

- + Cold-Rolled Stainless (48%)
- + Hot-Rolled Stainless (47%)
- + Other (5%)

Architectural Structures
(BEA Steel Cost Share: 20%)

- + Hot-Rolled Steel (90%)
- + Other (10%)

Because different steel products were taxed differently under the Bush Steel Tariffs (e.g., Tin Mill Products—30%, Cold-Rolled Stainless—0%), these weights are crucial for understanding an industry's true exposure.

Measure Validation: Comparison with ITC Report

Industry	Coated	Cold-rolled	Hot-rolled	Hot Bar	Cold Bar	Pipe	Tin mill	Other
Motor Vehicles	64	26	5	0	0	4	0	1
ITC, 2002–03	72	16	11	1	0	0	0	0
Motor Vehicle Parts	19	8	3	28	3	19	0	20
ITC, 2002–03	8	7	6	25	1	1	1	51
Steel Barrels & Cans	11	0	0	0	0	0	89	0
ITC, 2002–03	8	0	0	0	0	0	83	9
Household Appliances	2	49	47	0	0	0	0	3
ITC, 2002–03	33	47	2	0	1	0	1	16

NOTE. White rows show breakdowns constructed from the steel-specific input-output table. Blue-shaded rows show ITC (2002–03) benchmark data from the U.S. International Trade Commission's Table D–1. Each value represents the share (in percent) of total steel use by the given downstream industry attributed to that steel product category. In the rows constructed from my input-output table, the "other" category can be broken down into semi-finished products, wire, plate, railway, rebar, razor blade, and high-speed steel. The ITC "other" category includes reported purchases in which firms did not separate data by product purchased, so cannot be fully broken into component parts.

Constructing the Bush Tariff Exposure Variable

Last Step: Constructing the exposure variable that I will use in my regressions.

+ **Average change in tariff rate faced by downstream industry d on steel** as a result of the Bush Tariffs:

$$\Delta\tau_d = \sum_{s \in \Omega_d} \omega_{s,d} \Delta\tau_s$$

where $\Delta\tau_s$ is the legislated increase in tariff on steel product s. ▸ Distribution of Tariff Variables

+ **Input cost increase due to Bush steel tariffs**:

$$\boxed{\Delta\text{Costs}_d = \ln(1 + \Delta\tau_d) \times \alpha^{\text{BEA}}_{steel,d}}$$

+ **Proof of Concept:** Constructed exposure measure is predictive of increases in the price of materials for downstream industries. ▸ More.

Estimation Strategy and Results

Estimation: Dynamic Specification

Local projection approach (Jordà, 2005; Dube et al., 2022):

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

Details:

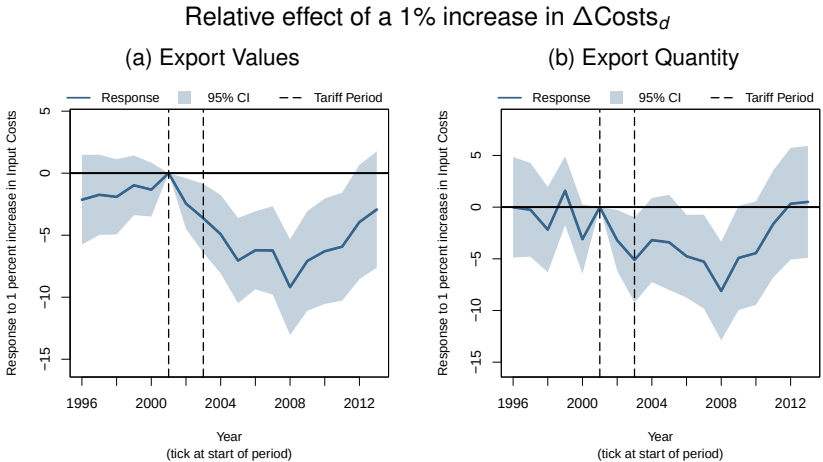
- $\Delta Costs_d =$ change in input costs due to Bush steel tariffs.
- $\alpha^{\text{BEA}}_{d,\text{Steel}}$ = industry d's steel cost share.
- $\delta_{h,t} =$ HTS Section fixed effects.
- $\mathbf{X}_{d,2001}$ contains share of steel inputs imported from exempt countries in 2001 and change in Chinese export shares relative to 2001.
- Standard errors clustered by HS4 industry.

▸ Threats to Identification

Results

Relative Decline in U.S. Exports

Industries for which the steel tariffs increased input costs by relatively more, suffered *persistent relative declines in exports*, driven by export quantities (noisy).

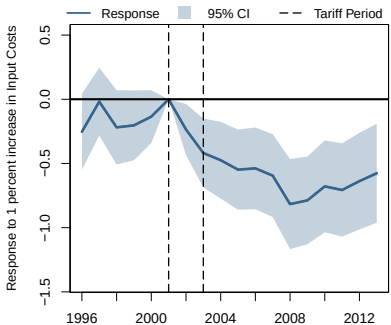


U.S. Loses Global Market Share

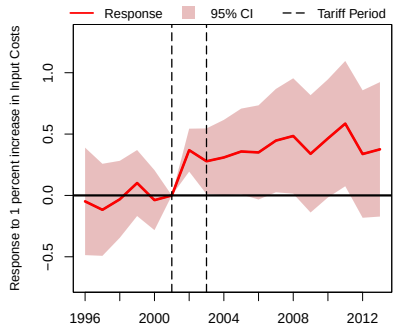
Higher input tariffs → persistent relative decline in U.S. share of world exports.

\+ Top 3 competitors[1] (Germany, Japan, France) see relative increases.

(a) U.S.



(b) Top 3 Competitors



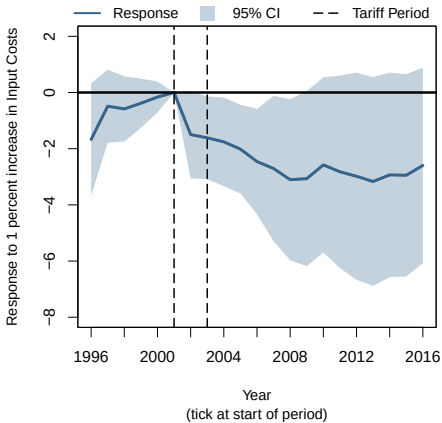
[1] Based on total exports in 2001.

Other Results: Value of Shipments and Employment

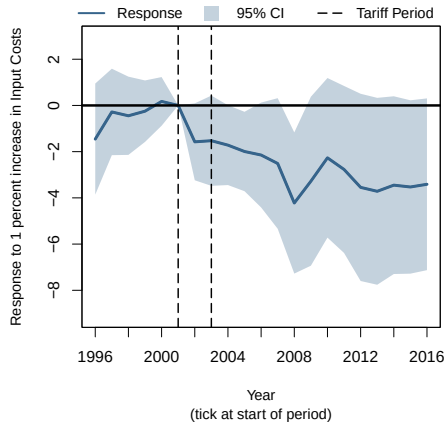
Using data from NBER CES Mfg Industry Database (NAICS 6):

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

(a) Value of Shipments



(b) Employment



Intuition Behind Persistence

Persistence can be explained by standard models incorporating **relationship-specific sunk costs**. ▸ Toy Model

- \+ Steel tariffs raise input costs for U.S. downstream industries, causing their prices to rise relative to foreign competitors. ▸ Anecdotal Evidence
- \+ Large enough price increases $\rightarrow$ customers willing to pay "relationship-specific cost" to find a new source.
- \+ When tariffs are removed, it may not be worth it for customers to pay the cost again to switch back to U.S. suppliers.

Two (somewhat) testable implications:

- \+ Changes in exports should be driven by extensive margin changes.
- \+ Relationships for products requiring relationship-specific investments should be "stickier" (less likely to move in response to the tariffs).

Testable Implications: Extenstive Margin

No firm-level data, so I **proxy for extensive margin** using the most detailed industry-level data available:

+ Customs district-level U.S. exports from Schott (2008).
+ Define a "Trade relationship" as a (district $\times$ product $\times$ country) triplet.
  e.g., A golf cart exported from Savannah, GA to Japan
+ 47 customs districts, and in 2001 the mean (median) 10-digit product had 120 (172) trade relationships.
+ Baseline local projection with log number of trade relationships on the LHS.

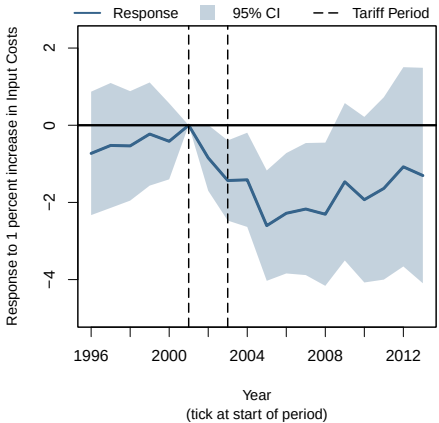
Define **specificity** as in Nunn (2007) using the Rauch (1999) classification:

+ Differentiated goods require a relationship-specific investment.
+ Other goods (sold on an organized exchange or referenced priced) do *not*.

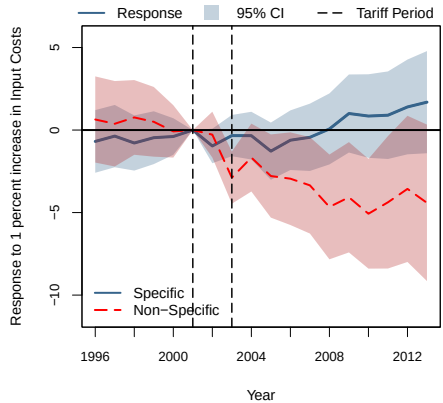
Evidence Points to Extensive Margin

Relatively large decline in the number of “trade relationships” for industries that suffered relatively large increases in input costs.

(a) Number of Trade Relationships



(b) Specific vs Non-Specific



Conclusion

+ Case study of the Bush steel tariffs using a **new method for identifying highly detailed input-output relationships**.
+ Temporary upstream steel tariffs have **persistent negative impacts** on downstream industries.
+ Persistence of export response is consistent with models featuring relationship-specific costs of trade.
+ Costs of upstream tariffs will be understated if downstream and dynamic effects are not taken into account. Back-of-the-Envelope Calculation

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Reported Distress in Downstream Industries

> *A.J. Rose has been able to grow and add jobs because we manufacture high quality products that a limited few can do. Now, however, with the steel 201 tariffs everything has changed... These additional tariffs are a disaster for our business. They make us much more vulnerable to foreign competition, which is not crippled by artificially inflated raw material prices. In fact, one of our major customers has recently contacted us to let us know that they will be resourcing 11 of the current jobs we run for them to overseas suppliers with savings that they are telling us of 38 to 42 percent on finished goods that they can import from Brazil and Asia. — CEO of A.J. Rose Manufacturing*

Source: Hearing Before the Committee on Small Business, July 2002

▸ Full Testimony ▸ Return

Reported Distress in Downstream Industries

> *These increases in steel have already cost us a substantial amount of business. For example, soon after the 201 tariffs were put into effect, G.R. Spring and Stamping lost a major contract with a well-established customer...This company went to a Canadian company for the purpose of this product. This Canadian company is now able to purchase its steel for 30 percent less than we can, and this cost advantage was directly reflected in their bid...The reality of our market is that we cannot pass the additional cost of these tariffs to our customers. — VP and GM of G.R. Spring and Stamping*

Source: Hearing Before the Committee on Small Business, July 2002

▸ Full Testimony ▸ Return

Reported Distress in Downstream Industries

Our service center provider that supplies 25 percent of our steel requirements increased the price of delivered steel by as much as 48 percent despite our contract. We of course have relied on these contracts with our suppliers and based our pricing to our own customers accordingly. My customers will not pay the increased prices...the bottom line is that my business is in danger if I cannot get steel and must continue to pay the increased prices. Unless things change rapidly, my company will lose business to foreign competition now that our international competitors have a built in cost advantage and a ready supply of steel.— President, Wren Industries, Inc.

Source: Hearing Before the Committee on Small Business, July 2002

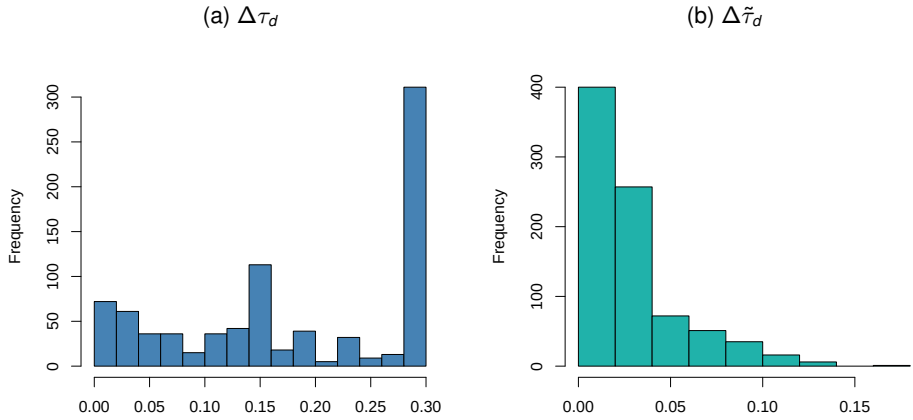
▸ Full Testimony ▸ Return

WSJ: March 6, 2002

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.

▸ Article ▸ Return

Distribution of Tariff Variables



NOTE. The left panel shows the distribution of the change in tariffs that 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.

Return

Proof of Concept and Threats to Identification

Key Questions for Evaluation:

1. **Matching:** Am linking right inputs to the right industries?
2. **Timing:** Are I-O relationships in 2017 good proxy for 2002?

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Exercise: Changes in steel tariffs for matched inputs predict changes in price of materials in downstream industries.

Data:

+ Price index of manufacturing industry (downstream) material costs, $p_{d,y}$.
  Source: NBER CES Mfg Industry Database
+ Change in steel tariffs faced by downstream industry, $\Delta\tau_d$, from my IO table.

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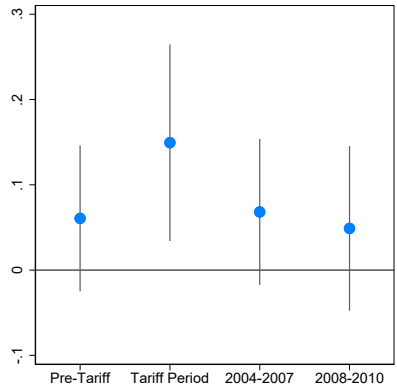
$$p^{mc}_{d,y} - p^{mc}_{d,2001} = \alpha + \sum_t \gamma_t \mathbf{1}(y \in P_t)(\Delta\tau_d) + \sum_t \theta_t \mathbf{1}(y \in P_t)(\alpha^{BEA}_{\text{Steel},d}) + \delta_y + \delta_n + \varepsilon_{d,y} \quad (1)$$

Proof of Concept

Timing: Change in **steel tariffs** for matched inputs predicts **temporary increase in the price of materials downstream**:

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



NOTE. The Pre-Tariff period runs from 1995-2001 and the Tariff Period runs from 2002-2003, when the Bush Steel Tariffs were in place.

Proof of Concept

Matching: Placebo test shows that steel-specific IO table is predictive, while randomized mapping of steel inputs to downstream industries is not.

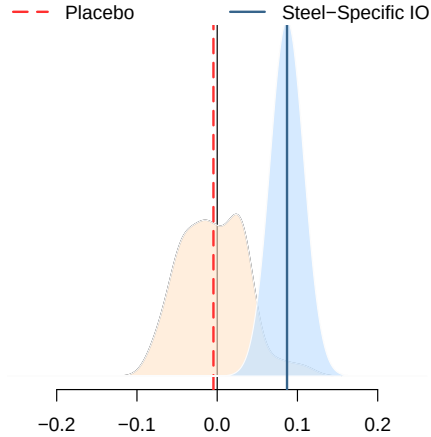
+ Pooled version of same specification for 2002-2003:

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

+ **Baseline:** Use τ_d constructed from steel-specific IO table.
  Plot coefficient, γ, and asymptotic distribution.

+ **Placebo:** Randomly assign steel inputs to downstream industries ($100\times$).
  Plot kernel density of estimated γ's.

Proof of Concept



NOTE. This figure shows estimates of γ 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.

Return

Why So Persistent? A Toy Model

The presence of relationship-specific sunk costs of exporting can explain the persistence of the export response.

Consider a simple example:

- In each period, a consumer chooses a source, $s \in \{H, F\}$, 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 addition to the price of the good, the consumer faces a relationship-specific sunk cost, κ_t:

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

Why So Persistent? A Toy Model

Consider the choices the consumer will make in Periods 1-3:

+ **Period 1:** Choose initial supplier.
+ **Period 2:** H imposes a tariff that raises prices from p_H to $p_H + \tau$.
+ **Period 3:** H removes the tariffs, prices return to original levels.

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 $\bar{\kappa} > \varepsilon$

+ We can generate a permanent switch from H to F.
+ In a richer model with forward-looking consumers, need some uncertainty about future trade policy, but the intuition is largely the same.

Return

Evidence Points to Extensive Margin

Anecdotal evidence from the time confirms businesses were concerned about losing customers.

Quotes from businesses testifying before Congress:

+ *"These additional tariffs are a disaster for our business. They make us much more vulnerable to foreign competition."* ▸ A.J. Rose

+ *"Soon after the 201 tariffs were put into effect, [we] lost a major contract with a well-established customer."* ▸ G.R. Spring and Stamping

+ *"Unless things change rapidly, my company will lose business to foreign competition."* ▸ Wren Industries

▸ Return

The Back-of-the-Envelope

The “missing intercept” problem applies, so we can’t calculate aggregate effects.

To get a sense of magnitudes, however, we can calculate changes in downstream industries relative to a *hypothetical industry that did not face the Bush tariffs*, and relative to pre-tariff levels.

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

+ Where y is exports/employment/value of shipments.
+ θ_t are the associated coefficients at time t from the local projections.
+ Summing over downstream industries, d.
+ Comparison to an economy fixed at the pre-tariff (2001) steady state.

The Back-of-the-Envelope

Key Point: Typical cost benefit analysis (contemporaneous effects) misses a lot!

Table: 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
Total (02-09)	-246	-3.7	-341.1	-0.8	682.2	0.5

The Back-of-the-Envelope

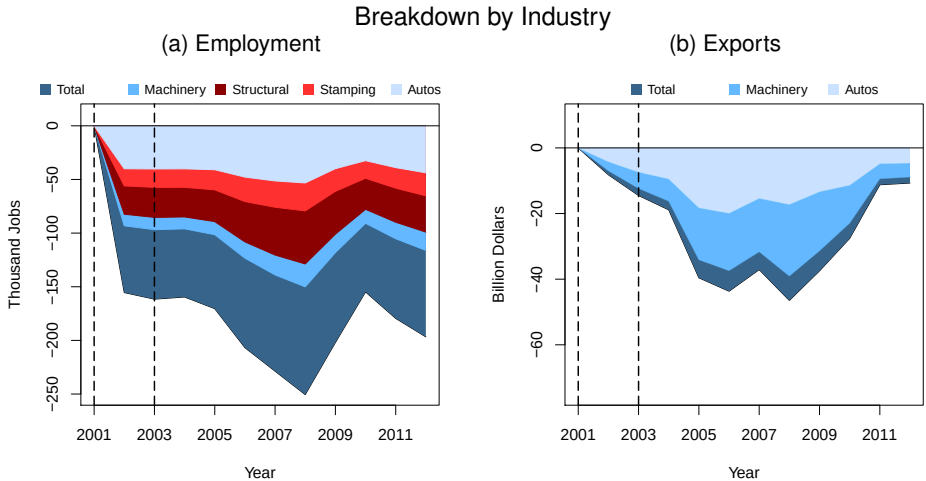
Magnitude of the *changes* in downstream-industry employment exceed the total number of employees in the steel industry.

Table: 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
Average (02-09)	-168.5	-1.4	109.8

The Back-of-the-Envelope

Finally, we can break these changes down by sector. No surprises here.



Threats to Identification

Endogeneity of trade policy challenges identification of tariff impacts, particularly along supply chains.

Trefler (1993), Gawande et al. (2012), Bown et al. (2020)

Potential Sources:

1. **Counter-Lobbying** by downstream industries.
   - Anecdotal evidence: tariffs seen as a gift to the steel industry. Quote

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Potential Sources:

1. **Counter-Lobbying** by downstream industries.
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2. **Omitted variables** (e.g., productivity shock by foreign input suppliers or domestic downstream producers).
   - No significant pre-trends in main results.
   - **Identifying assumption**: Variation in τ_d is exogenous.

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