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## Import tariff transmission in a production network

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# Import tariff transmission in a production network\*

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## Abstract

We find evidence that US manufacturing sectors experience US import tariffs either as supply-side or demand-side shocks, depending on the location of the sector and the affected products in the US production network. Using local projections in a panel of US manufacturing sectors, we find that US import tariffs – in particular including the 2018-19 tariff hikes – led to sectoral output contractions via two different channels: (1) Tariff increases act as negative supply shocks for sectors that use the affected goods as input in production and thus face rising input costs. (2) Tariff increases act as negative demand shocks for sectors whose customers experience the tariff increase as a negative supply shock and reduce their production. Though the aim of tariffs often is to protect local industries, we do not find evidence of such a protective effect. Overall, our finding suggests that tariffs markedly reduce US manufacturing production and that the role of input-output linkages is key for understanding the transmission of import tariff shocks.

*Keywords:* Import tariffs, sectoral production and prices, input-output-tables, production networks, United States.

*JEL-Classification:* E23, E32, F13.

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# 1 Introduction

The macroeconomic literature has highlighted the importance of sectoral input-output linkages in the transmission of sectoral and aggregate shocks (cf. Carvalho and Tahbaz-Salehi 2019). More recently, it turned to the question on the transmission of trade shocks.<sup>1</sup> Yet, the empirical evidence on the transmission of trade shocks through the domestic input-output network has been scarce. In particular, import tariffs have become a corner stone of US trade policy in recent years.<sup>2</sup> This raises the question, how and through which channels import tariffs affect price and output dynamics of US industries.

Ex ante, higher import tariffs on a given good may be a supply shock for some US sectors and a demand shock for others, depending on the location of the good and the sector in the domestic production network. Import tariffs typically aim at protecting the local industry from foreign competition, potentially raising the demand for goods produced in the protected sectors. At the same time, tariffs imposed on imported intermediate and capital goods raise input costs in sectors that use these goods as input in their production. Importantly, such supply-type repercussions may amplify output losses via the domestic input-output network. If, for instance, car engines face increased import tariffs, cars will likely become more expensive as well, because car production requires engines as intermediate inputs. As cars are capital goods in the production of many other goods, additional cost pressures enter in several locations in the domestic production network. Moreover, other US sectors that supply inputs to US car production – such as, e.g., electronics – will face a lower demand for their products as their customers in the car industry reduce their production due to the tariff increase. We aim to assess the relevance of these intertwined channels empirically.

To disentangle the effects of import tariffs on US industries, we use US input-output data and construct measures of the industries’ potential tariff exposures via linkages in the production network. Specifically, we utilize a panel of 71 US manufacturing industries with data spanning from 2005 to 2020 to compute measures of backward and forward exposure in the domestic production network.

To identify sector-specific tariff shocks, we use tariff information on US imports at the HS-10 product level that we aggregate at the sectoral level. For the sector-specific tariff shocks, we can differentiate between tariffs on intermediate and final goods. The interaction of the identified tariff shocks with backward and forward linkages of a specific industry allows us to trace the transmission of sector-specific tariff shocks within a production network. In addition, we can separate the direct (i.e. horizontal) effect of import tariffs within an industry.

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<sup>1</sup>See, e.g., Caliendo and Parro (2015); Caliendo et al. (2021); Bachmann et al. (2022); Baqaee and Farhi (2024).

<sup>2</sup>The first Trump administration increased import tariffs markedly in 2018 and 2019. Over the course of these years, average import tariffs jumped by close to 2pp. For his second term, president Trump promised additional dramatic imports tariff hikes.

Overall, we find that US import tariffs markedly reduce production of US manufacturing sectors. This effect is significantly amplified by the transmission via input-output linkages in the production network.

More specifically, we find that via the backward exposure of industries to imported inputs, tariff increases are transmitted as negative supply-type shocks. Raising an industry's input costs, tariffs on intermediate imports also raise its producer prices and reduce its output. In addition, our results suggest that the direct effect of a sector-specific tariff shock, which is the estimated effect of an import tariff that hits the own' sectors products, also acts like a supply-type shock. This likely owes to the fact that at the level of sectoral aggregation in which we conduct our analysis, input-output tables reveal strong intra-industry linkages with most sectors being their own key supplier. Finally, our analysis provides evidence that tariff hikes act as negative demand shocks for sectors whose customers experience the tariff increase as a negative supply shock and reduce their demand for the industries goods. Consequently the industry's output declines and its producer prices as well.

Notably, while we find overall negative effects on output, the sign of the sectoral producer price response depends on the channels, via which the sector is exposed to tariff shocks, i.e., the location of the sector and the affected products in the US production network. This findings highlight that the aggregate effect of import tariff shocks on the aggregate price level (such as the US aggregate produce price) crucially depends on the relative importance of upward and downward affected sectors in the domestic production network.

Our results speak to theoretical contributions emphasizing the role of complementarities in the input-output network. In particular, Guerrieri et al. (2022) show in a New Keynesian model that within production networks, a macroeconomic shock that affects one sector negatively on the supply-side can lower demand in other sectors. Our finding of the effect of the forward tariff exposure channel presents novel evidence confirming their theoretical insights. Moreover, we provide evidence for the amplification of supply-type trade shocks in input-output networks (see, e.g., Baqaee and Farhi 2024).

Though the aim of tariffs often is to protect local industries, we do not find evidence of such a protective effect. On the contrary, we find marked negative effects of US import tariffs on US industries production that are amplified in the input-output network.<sup>3</sup>

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<sup>3</sup>As a caveat, we are not tracing out long-run effects of US import tariffs, which are often the focus of trade policy evolutions. Our method is instead designed to study dynamic responses to import tariff hikes.

## Related literature

We are not the first to analyze the effects of US import tariffs on manufacturing output and prices of US industries. Closest to our investigation is the analysis by Flaaen and Pierce (2025). Using a difference-in-difference approach they investigate the effects of the 2018-2019 tariffs via the backward exposure (rising input cost) channel, a protection channel and retaliatory tariffs. In line with these findings, we confirm that US import tariffs markedly raise producer prices of industries via the backward exposure channel. In contrast to our finding, they do not find any significant output effects. Importantly, we add to their study by highlighting the role of forward exposure in the US production network for the transmission of tariff shocks. Barattieri and Cacciatore (2023) study the dynamic employment effects of temporary trade barriers through vertical production linkages and find evidence for marked employment declines in downstream industries that correspond to large input price hikes. We add to this paper by focusing on import tariff shocks as well as taking forward linkages into account. Moreover, our evidence concerns the role of output responses instead of employment, which allows us to characterize supply- and demand-type patterns arising from tariff shocks.

In the theoretical macroeconomic literature, the role of input-output linkages for the transmission of trade shocks has gained much attention in recent years. Caliendo and Parro (2015); Caliendo et al. (2021); Baqaee and Farhi (2019) employ multi-sector models and highlight the importance of input-output linkages and sectoral heterogeneity for the correct assessment of trade shocks on trade, output and welfare. Our empirical results corroborate insight that the effect of tariff rate shocks on industries differ, depending on the goods that are subject to tariffs and the location of the industry in the production network. Our analysis thereby focuses on the transmission of the domestic production network, while we abstract from possible connections of domestic sectors due to linkages in the foreign production networks.

Finally, we contribute to the literature studying the implications of (US) trade policy shocks for the domestic economy (see, *inter alia*, Amiti et al. 2019; Furceri et al. 2019; Lindé and Pescatori 2019; Jacquinet et al. 2022 and Khalil and Stobel 2024). We add to these papers by focusing on role of the domestic production network in the transmission of trade policy shocks.

We proceed as follows: Section 2 presents the data and the data treatment. Section 3 discusses the construction of the tariff exposure measures. Section 4 lays out our econometric approach. Our main results are discussed in section 5. In section 6, we decompose the effect of tariff shocks into the transmission via inter-industrial and inter-industrial linkages. Section 7 concludes.

## 2 Data and concordance

We use data from 2005-2019 on US goods imports and import duties, sectoral industrial production and producer prices, as well as sectoral input-output tables. We retrieve monthly data on the dollar value of imports and calculated duties of US imports at the disaggregated HS-10 level from the US Census District-level reports.<sup>4</sup> Sectoral data on monthly industrial production and producer prices of industries according to the North American Industry Classification System (NAICS) are sourced from the Federal Reserve and from the Bureau of Labor Statistics, respectively. In addition, we use yearly input-output tables by the Bureau of Economic Analysis (BEA) at the 71 industries – 73 commodities level. Details on the data sources are outlined in Appendix A.

To facilitate the investigation of the tariff exposure of US industries, we map the HS-10 product codes covered by tariffs to NAICS industries at the 6-digit industry level employing the concordance tables provided by Pierce and Schott (2012). In calculating industry-specific tariff rates we divide the sum of the calculated duties on products associated with an industry by the sum of the import values of these HS-10 products. As NAICS codes are revised every five years, we concord NAICS6 industry codes from the full observation period (2005-2019) into the 2012-NAICS6 classification. To allow for the construction of tariff exposure measures, which capture industries' exposure via their input and output linkages, we match the 2012-NAICS6 codes to the 412 industries of the 2012-vintage BEA input-output tables. As industrial production series are not available at this disaggregated level, we need to go up the aggregation classification tiers for our purposes. Thus, we utilize the input-output tables at the 73 industry/commodity BEA classification, which are available on a yearly frequency. Details on the concordance are outlined in Appendix B.

Producer prices and industrial production series are available at different NAICS levels. In our analysis, we restrict the universe of industries to those for which we have industrial production series. Further, not all of the commodities in the input-output-tables have import data and tariff rates. This restricts the construction of BEA commodity level tariff rates to 21 non-service commodities.

## 3 Identifying tariff rate shocks and input-output linkages

In the following we outline how we identify tariff rate shocks as well as how we measure backward and forward linkages in the US product network. More details are reported in Appendix C.

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<sup>4</sup>See <https://usatrade.census.gov/>.

### 3.1 Tariff rate shocks

The US administration sets the tariff rates at the disaggregated HS-10 product level. To calculate the tariff rate  $\tau_j$  that is specific to the BEA commodity  $j$  at a higher aggregation level, we sum the import duties on all HS-10 products associated with the BEA commodity  $j$  and divide it by the sum of import values. That is, in our analysis we use an average effective tariff rate, that not only reflects changes in the tariff rate set by the administration, but also composition effects. Such composition effects arise, for instance, if domestic importers reroute imports to other destinations in the light of higher bilateral tariffs.

### 3.2 Input channel - backward exposure measure

Industries are exposed to tariff changes through their input costs. Consider an unexpected rise in the import tariff rate on commodity  $j$ . Then, US industries that use product  $j$  in their production process face a sudden cost shock, the extent of which is determined by the relative importance of the product in their production process (measured by its cost share from total inputs) and the import share in total supply. An industry is thus exposed through all the commodities involved as inputs in its production process. We refer to this as backward exposure to tariffs. More formally, for each commodity  $j$  that industry  $i$  uses, consider

$$BW_{i,j,y} \equiv \frac{use_{i,j,y}}{M_{i,y} + CE_{i,y}} \times \frac{imp_{j,y}}{supply_{j,y}} = USE_{i,j,y} \times IM_{j,y}, \quad (1)$$

where  $use_{i,j,y}$  is the volume of commodity  $j$  used by industry  $i$  as an intermediate input in year  $y$ .  $M_{i,y}$  is the total intermediate use of inputs by industry  $i$  in year  $y$  and  $CE_{i,y}$  is the total compensation of employees paid within industry  $i$  in year  $y$ .  $imp_{j,y}$  is the volume of imports of commodity  $j$  in year  $y$ . and  $supply_{j,y}$  denotes the total supply of commodity  $j$  (i.e., domestic supply plus imports) in year  $y$ .

More compactly written,  $USE_{i,j,y}$  represents industry  $i$ 's use share of commodity  $j$  in its production process in year  $y$ . This term approximates the direct vertical linkage between commodity  $j$  and industry  $i$ .  $IM_{j,y}$  is the import share of commodity  $j$  in its total supply. Since the BEA use tables do not allow the use of commodity  $j$  by industries to be differentiated between use of *domestically* produced and imported  $j$ , we multiply  $USE_{i,j,t}$  by the economy-wide import share of  $j$  (namely  $IM_{j,y}$ ) to obtain a proxy for the backward exposure of industry  $i$  to tariffs on commodity  $j$ ,  $BW_{i,j,y}$ .

The backward exposure measure was introduced in Flaaen and Pierce (2025) and used in Khalil and Weber (2022); Amity et al. (2019); Benguria and Saffie (2019). Different from their analysis,

we here account for the yearly time variation in the input-output linkages. This allows us to captures changes in the exposure to the technology changes (cf. Bown et al., 2020).<sup>5</sup>

### 3.3 Output channel - forward exposure measure

In addition to the backward exposure measure, we introduce a second exposure measure that attempts to measure exposure to tariffs through industries' output linkages in the domestic production network.

The forward exposure measure captures how an industry is exposed to a tariff that affects its customers in other industries. We define for an industry  $i$ , which domestically produces a commodity  $x$  and another industry  $j$  using this commodity as an input

Let the state introduce a tariff hike on the specific product(s) that industry  $j$  produces. This sector is now "protected" by tariffs and if demand were to be redirected from foreign producers toward  $j$ , we could expect its demand of inputs to increase, including  $X$ . If such a protectionary channel were active, industry  $i$  would benefit from the introduction of tariffs on goods produced by industry  $j$  through its product  $x$ 's output linkage. On the other hand, a tariff hike on the products that industry  $j$  produces can also lead to output put contractions in sector  $j$ . As input-output tables reveal strong intra-industry linkages with most sectors being their own key supplier, a tariff shock on  $j$  products can act a negative supply-type shock for  $j$  produced goods.

We use the dollar value of industry  $i$ 's total supply of commodity  $x$  and the total demand of each industry for the good  $x$  and define the the forward linkage between industry  $i$  and industry  $j$  through commodity  $x$  as<sup>6</sup>

$$FW_{i,j,x,y} \equiv \underbrace{\frac{supply_{i,x,y}}{supply_{i,y}}}_{\substack{\text{commodity } x \\ \text{supply share} \\ \text{from industry } i}} \times \underbrace{USE_{j,x,y} \times (1 - IM_{x,y})}_{\substack{\text{industry } i \text{ domestic} \\ \text{demand of commodity } X}} \quad (2)$$

$USE_{x,j,y} \times (1 - IM_{j,y})$  approximates the share of commodity  $x$  that industry  $j$  sources domestically. Multiplying it with the domestic supply share of industry  $i$ , we obtain a proxy for the domestic sourcing of commodity  $x$  by  $j$  that is supplied by industry  $i$ . Taking a weighted average of such commodity-specific linkages over all commodities, we obtain a total linkage between the two industries

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<sup>5</sup>In the regressions, we use a predetermined moving-average to capture structural exposure.

<sup>6</sup>The BEA *make* and *use* tables, unfortunately, do not contain information on how much of an industry  $i$ 's production of  $x$  is used by industry  $j$ .

$$FW_{i,j,y} \equiv \sum_x w_{i,x,y} \times FW_{i,j,x,y} \quad (3)$$

where  $w_{i,x,y}$  is given by commodity  $x$ 's relative importance in industry  $i$ 's total output,  $\frac{\text{supply}_{i,x,y}}{\text{supply}_{i,y}}$

### 3.4 Input-output linkages in 2017

Figure 1 shows the distribution of backward linkages and forward linkages in the US production networks. The heatmaps depict backward and forward exposure normalized by row as  $(\frac{BW_{i,j}}{\max_j BW_{i,j}})$  and  $(\frac{FW_{i,j}}{\max_j FW_{i,j}})$ . The darker the cells, the higher are the exposure of industries to tariffs via input or output linkages. Importantly, most industry's overall exposures are concentrated in a few linkages.

As it turns out, at the level of disaggregation in which we conduct our analysis (71 sectors; mostly NAICS-4 industries), firms in a given industry tend to be important suppliers and customers to other firms in the same industry. Our baseline backward and forward exposure measures contain both intra-industrial and inter-industrial linkages. To check, whether our results are driven only by within-industry linkages, we construct alternative backward and forward exposure measure, which abstract from the intra-industry linkages:  $\widetilde{BW}_{i,y} = \sum_{i \neq j} BW_{i,j,y}$  und  $\widetilde{FW}_{i,y} = \sum_{i \neq j} FW_{i,j,y}$ . In Section 6, we show that our main results hold, when we analyze the tariff exposure only focusing on inter-industry links.

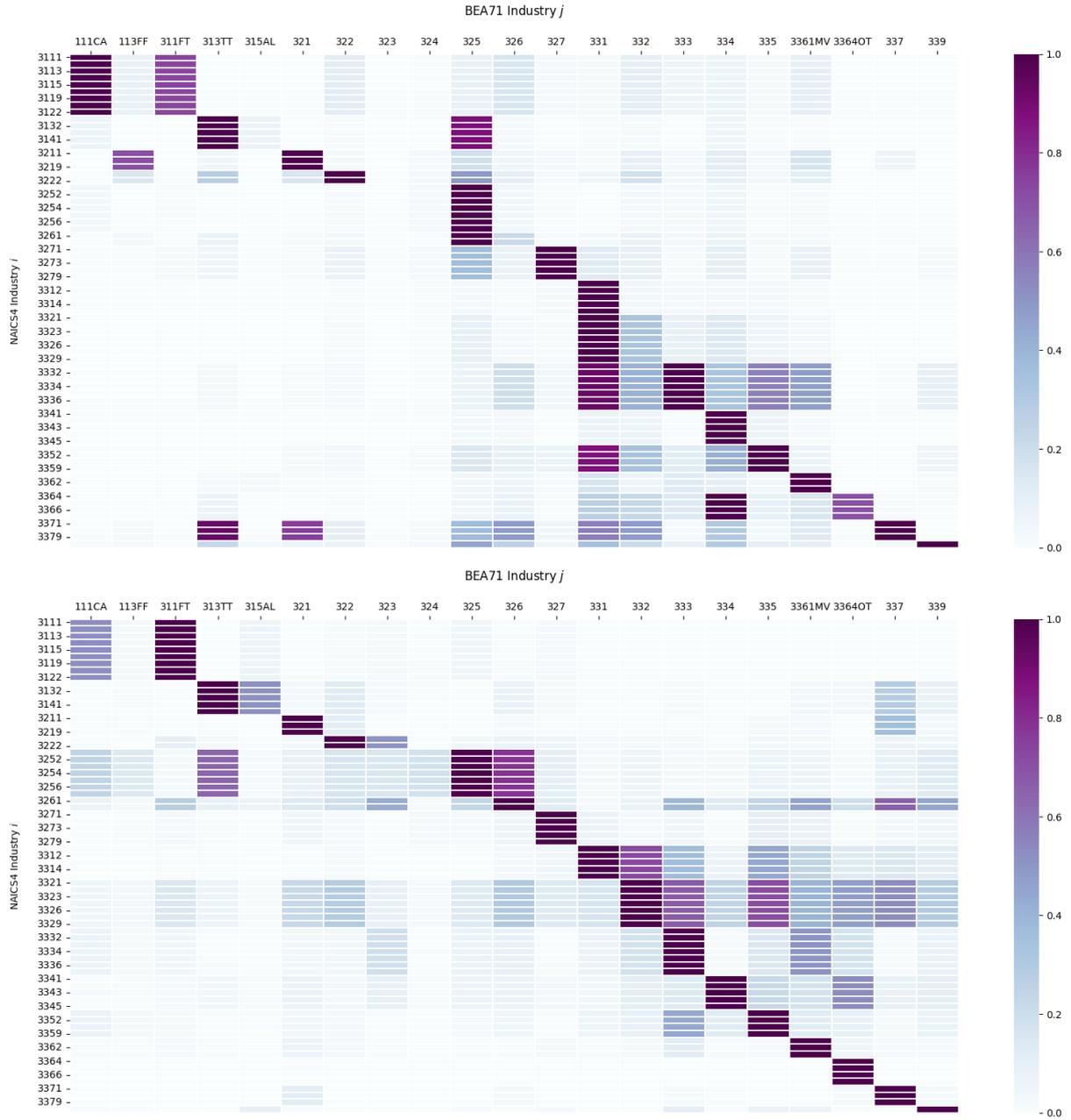
## 4 Empirical strategy

We employ the local panel projections approach by Jordà (2005) to estimate the effect of import tariff changes on production and output prices by industries, taking input-output linkages into account.<sup>7</sup> Let  $\mathcal{Y}_{i,t}$  denote either the log of the producer prices  $PPI$  or the log of the industrial production  $IP$  of NAICS industry  $i$  in month  $t$ . The estimation sample spans  $t = \text{January 2005 to January 2020}$ . Consider the following *panel* local projection specification independently estimated for each  $h = 0, 1, \dots, 17$

$$\Delta_c \mathcal{Y}_{i,t+h} = \alpha^{(h)} + \underbrace{\mu^{(h)} \Delta T_{i,t}}_{\text{Horizontal channel}} + \underbrace{\beta^{(h)} \mathbf{BW}_{i,t} \times \Delta \mathcal{T}_{i,t}^{\text{Input}}}_{\text{Input channel}} + \underbrace{\gamma^{(h)} \mathbf{FW}_{i,t} \times \Delta \mathcal{T}_{i,t}^{\text{Output}}}_{\text{Output channel}} + f_i + \sum_{l=1}^{12} C_{i,t-l} + \varepsilon_{i,t+h}^{(h)} \quad (4)$$

<sup>7</sup>More details on the empirical specification are described in Appendix D

Figure 1: Tariff exposure linkages in the US input-output table



Upper panel: Normalized backward exposure linkages of NAICS industries (y-axes) to BEA commodities (x-axis) in 2017. Lower panel: Normalized forward exposure linkages of NAICS industries (y-axes) to BEA commodities (x-axis) in 2017. Darker cells indicate a higher exposure of industries via production network linkages.

where  $\Delta_c \mathcal{Y}_{i,t+h}$  is the cumulative change between  $t$  and  $t+h$  for either the producer price or industrial production index, both in log.  $\Delta T_{i,t}$  is the monthly change in the tariff rate applied to NAICS4 industry  $i$ .  $\Delta \mathcal{T}_{i,t}^{Input}$  and  $\Delta \mathcal{T}_{i,t}^{Output}$  are monthly changes in the weighted average

input and output tariffs faced by industry  $i$ .  $BW_{i,t}$  and  $FW_{i,t}$  are the aggregate backward and forward exposures defined as  $BW_{i,y} \equiv \sum_j BW_{i,j,y-1}$  and  $FW_{i,y} \equiv \sum_j FW_{i,j,y-1}$  where  $y - 1$  denotes a one-year lag of the exposure measures. This ensures that the exposure measures are pre-determined at date  $t$  and not affected by changes in tariff rates. We control for industry fixed effects  $f_i$ , and for twelve lags of a vector of control variables,  $C_{i,t}$ , which contains  $\Delta\mathcal{Y}_{i,t}$ ,  $\Delta T_{i,t}$ ,  $\mathbf{BW}_{i,t} \times \Delta\mathcal{T}_{i,t}^{Input}$ , and  $\mathbf{FW}_{i,t} \times \Delta\mathcal{T}_{i,t}^{Output}$ . In addition, we control for a wide range of economic conditions, namely the log changes of US real GDP, the S&P Goldman Sachs Brent Crude Index, the US City Average Price for Electricity, the Natural gas future price, the effective Federal Fund Rate, and the US dollar effective exchange rate.<sup>8</sup> The coefficients  $\mu^{(h)}$ ,  $\beta^{(h)}$ , and  $\gamma^{(h)}$ , capture the effects of tariffs on sector  $i$ 's production and producer prices via the horizontal channel, the backward exposure and the forward exposure of an industry.

## 5 Consequences of US import tariff hikes for US production

This section discusses our empirical results on the transmission of sector-specific tariff shocks through the industries' backward tariff exposure, the horizontal channel and the forward tariff exposure.

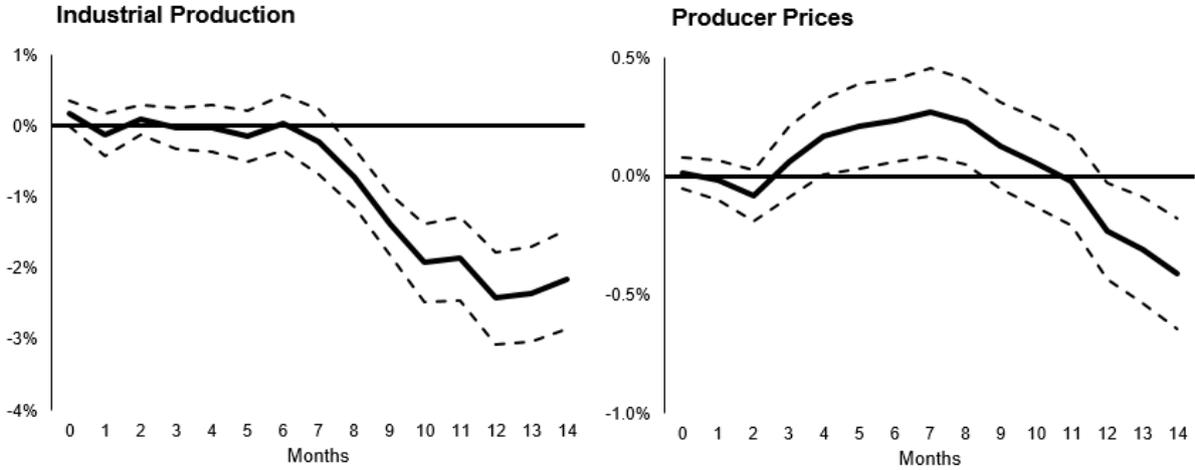
### 5.1 The effect of a tariff via the industry's backward linkages

We find that, via the channel of the backward exposure of industries to imported inputs, tariff shocks affecting suppliers are transmitted as supply-type disturbances (Figure 2). Previous studies show that US pre-tariff import prices did not change after the 2018-19 tariff hikes (cf. Amiti et al. 2019; Fajgelbaum et al. 2020), leading to a near complete pass-through to importers. Thus, tariff hikes affecting industries via their input suppliers directly increase production costs. Our results indicate that these shocks raise average producer prices and lower production. Prices increase after a quarter, pointing at nominal rigidities, and peak at 0.25% seven months after an one percentage point increase of a weighted average input tariff faced by an industry via its backward exposure. Production starts to contract after half a year, eventually decreasing by up to 3%. The sluggish output response may be due to firms depleting their input stocks before adjusting production.

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<sup>8</sup>Montiel Olea and Plagborg-Møller (2021) show that the inclusion of an additional lag of the dependent variable in the LP accounts for the serial correlation in the residuals, validating inference based solely on heteroskedasticity-robust standard errors.

Figure 2: The role of exposure to imported intermediates in the transmission of tariff shocks



Cumulative response in %, weighted average tariff faced by an industry increases by 1pp. Effect of average backward exposure across all industries (taken at 2022 mean). Dashed lines show the 68% confidence bounds, standard errors are clustered at the NAICS4-level.

## 5.2 The effect of a tariff directly on the industry’s goods

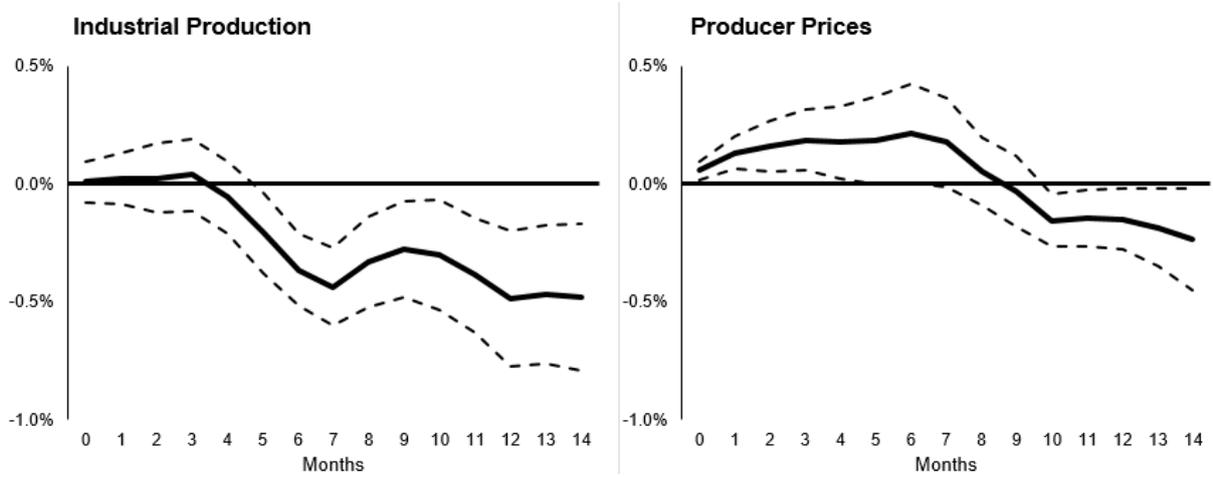
Figure 3 shows the effects of tariff hikes on goods produced in a specific sector on output and producer prices of that sector. We frame this the direct or horizontal effect of tariffs. Interestingly, we find that direct tariff shocks also act as negative supply shocks.

A possible explanation is that US input-output tables reveal strong intra-industry linkages, with most sectors being their own key suppliers and customers. Thus, tariffs on imports intended to protect the production of some firms in this industry, also raise input costs for other firms of firms within that industry. While protectionary effects may exist on a more disaggregated level, at the level of sectoral aggregation in which we conduct the analysis, the contractionary effects from higher input costs within a sector appear to be dominant.<sup>9</sup> This explains why the response via the horizontal channel is at least in the short-term similar to that via the backward channel, with negative effects on output and positive effects on prices.

We find no evidence that tariffs on imported goods protect the domestic industry producing the same goods. This aligns with other findings in the literature on the dynamic implications of protectionist measures for the domestic economy (cf. Flaaen and Pierce 2025 and Barattieri and Cacciatore 2023). While protectionary effects may exist, in our specification, the contractionary effects from higher input costs within a sector appear to be dominant.

<sup>9</sup>There are other possible adverse amplification forces of supply shocks arising from higher input prices that are not related to the production network. One such channel arises from entry and exit (see Bilbie and Melitz 2022 and Khalil and Lewis 2024).

Figure 3: The effects of direct tariff shocks



Cumulative response in %, weighted average output tariff faced by an industry increases by 1pp. Dashed lines show the 68% confidence bounds, standard errors are clustered at the NAICS4-level.

### 5.3 The effect of a tariff via the industry’s forward linkages

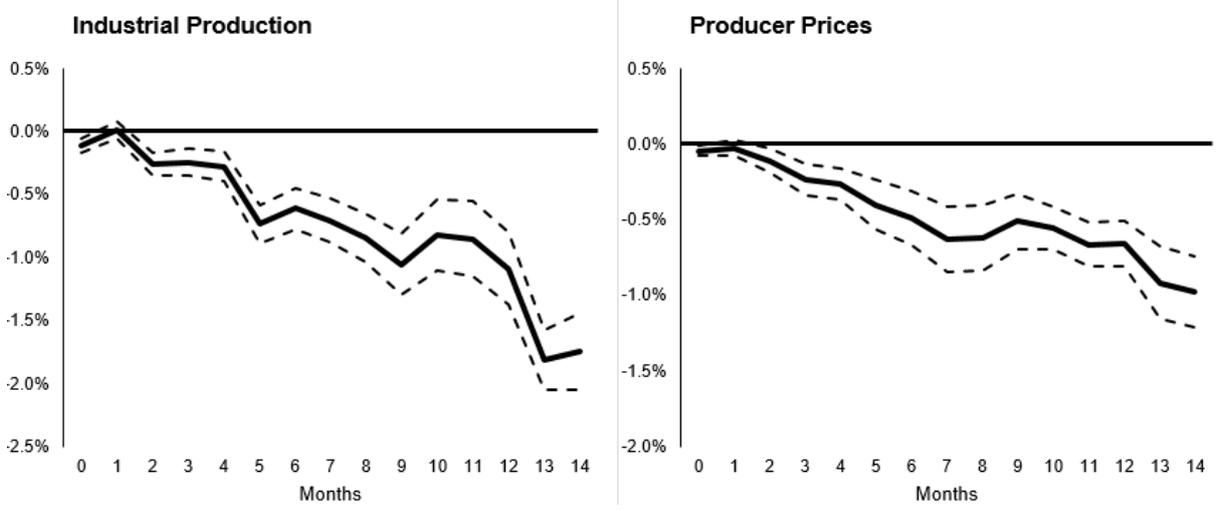
Figure 4 assesses how output and producer price in industries that supply their goods to sectors that experience a tariff shock are affected. In this exercise, we keep in mind that industries facing a tariff shocks directly experience a supply-type disruption (see 3). Thus, the question arises how sectors that have forward linkages to the sector facing a supply-type disruption are hit.

Figure 4 indicate marked negative demand effects as a consequence of tariff shocks in downstream absorbers of an industries output. Our findings indicate that a one-percentage point increase in the average tariff rate on goods produced or used by its customer sectors leads to a 1.5% contraction in the industry’s own output, while producer prices drop by up to 1%. That is, industries, that see the production of their customers drop, face contracting demand for their own goods.

The contraction via the forward channel amplifies the overall production contraction in the economy beyond the initially affected sectors. Our empirical result thus align with recent theoretical contributions. Among others, Guerrieri et al. (2022) stress that a negative supply shock in one sector can reduce output in other sectors, thereby amplifying the initial output contraction.

Notably, US manufacturing sectors that experience US import tariffs as demand-side shocks because of their forward linkages face negative price pressures. This counteracts the typical positive price pressures of import tariff hikes on producer and consumer prices. The findings highlight that the aggregate effect of import tariff shocks on the aggregate price level crucially depends on the relative importance of upstream sectors in the domestic production network.

Figure 4: The role of forward exposure to sectors that face higher tariffs



Cumulative response in %, weighted average output tariff faced by an industry increases by 1pp. Effect of average forward exposure across all industries (taken at 2022 mean). Dashed lines show the 68% confidence bounds, standard errors are clustered at the NAICS4-level.

## 6 Disentangling inter-industry and intra-industry linkages

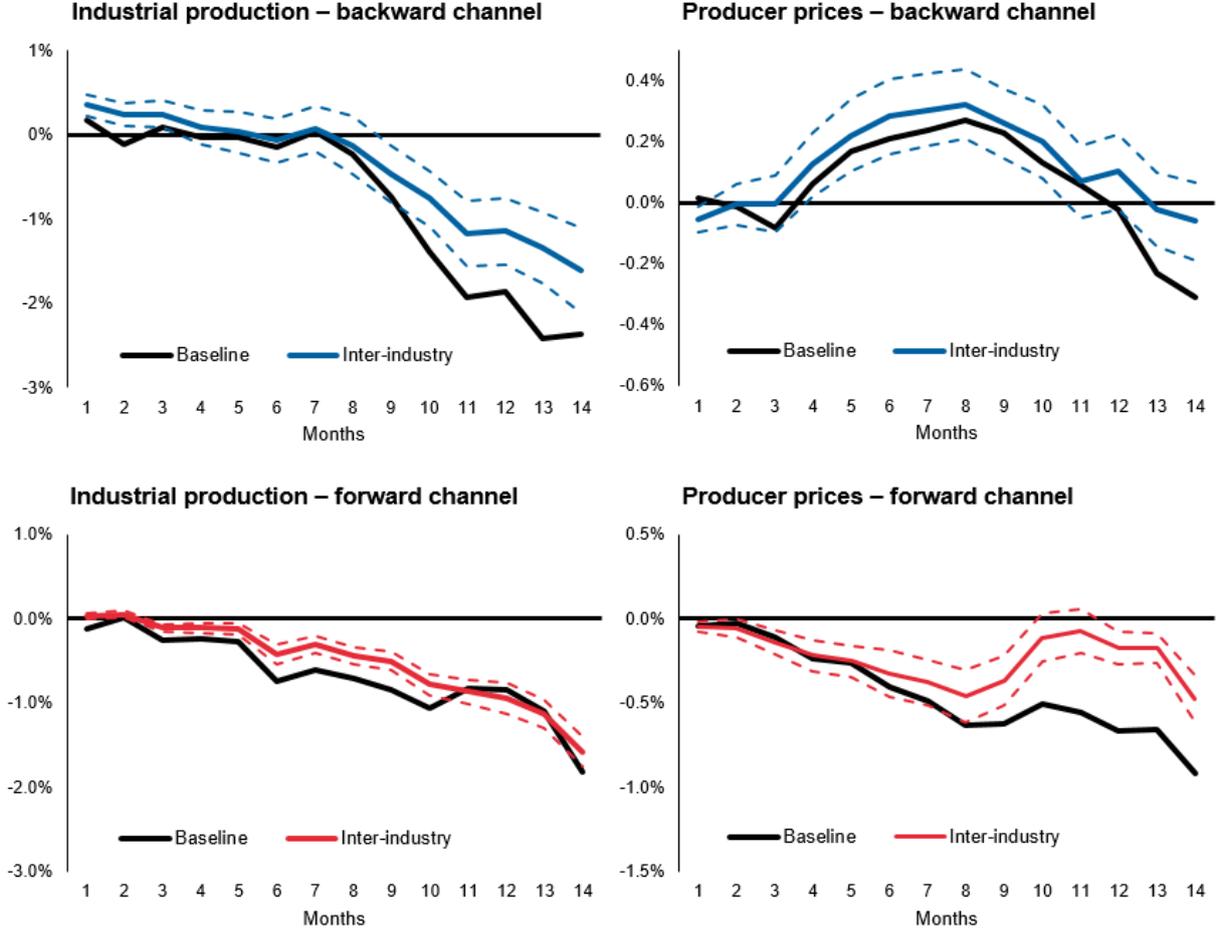
Our results hold, when we focus on inter-industry linkages and omit intra-industry linkages. To determine if strong intra-industry linkages drive our results, we adjust our local projection setting and decompose backward and forward channels into intra- and inter-industry contributions.

We estimate the following  $h$  modified panel local projections to disentangle inter- and intra-industry contributions to the different transmission channels:

$$\begin{aligned} \Delta_c \mathcal{Y}_{i,t+h} = & \alpha^{(h)} + \mu^{(h)} \Delta T_{i,t} + \underbrace{\beta_{intra}^{(h)} BW_{i,i,y-1} \times \Delta \mathcal{T}_{i,t}^{Int} + \gamma_{intra}^{(h)} FW_{i,i,y-1} \times \Delta \mathcal{T}_{i,t}}_{\text{Intra-industry}} \\ & + \underbrace{\beta_{inter}^{(h)} \widetilde{\mathbf{B}\mathbf{W}}_{i,t} \times \Delta \widetilde{\mathcal{T}}_{i,t}^{Input} + \gamma_{inter}^{(h)} \widetilde{\mathbf{F}\mathbf{W}}_{i,t} \times \Delta \widetilde{\mathcal{T}}_{i,t}^{Output}}_{\text{Inter-industry}} + controls + \varepsilon_{i,t+h}^{(h)} \end{aligned}$$

where  $\widetilde{\mathbf{B}\mathbf{W}}_{i,t}$ ,  $\widetilde{\mathbf{F}\mathbf{W}}_{i,t}$ ,  $\widetilde{\mathcal{T}}_{i,t}^{Input}$ , and  $\widetilde{\mathcal{T}}_{i,t}^{Output}$  are the backward and forward tariff exposure measures

Figure 5: Transmission of tariff increases through inter-industry linkages



Cumulative response in %, weighted average tariff faced by an industry increases by 1pp. Average effect of inter-industry exposure measures across all industries (taken at 2022 mean). Dashed lines show the 68% confidence bounds, standard errors are clustered at the NAICS4-level.

excluding the link of the industry  $i$  to itself, and the corresponding tariff rate measures.<sup>10</sup>

$$\widetilde{\mathbf{B}\mathbf{W}}_{i,t} = \sum_{j \neq i} BW_{i,j,y-1} \quad \text{and} \quad \Delta \widetilde{\mathcal{T}}_{i,t}^{Input} = \sum_{j \neq i} \frac{BW_{i,j,y-1}}{\widetilde{\mathbf{B}\mathbf{W}}_{i,t}} \times \Delta \tau_{j,t}^{Int},$$

$$\widetilde{\mathbf{F}\mathbf{W}}_{i,t} = \sum_{j \neq i} FW_{i,j,y-1} \quad \text{and} \quad \Delta \widetilde{\mathcal{T}}_{i,t}^{Output} = \sum_{j \neq i} \frac{FW_{i,j,y-1}}{\widetilde{\mathbf{F}\mathbf{W}}_{i,t}} \times \Delta \tau_{j,t}.$$

Figure 5 shows that the effects of tariff shocks via the backward and forward linkages are not solely driven by intra-industry linkages. Inter-industry linkages appear to be of prime importance for the transmission of tariff increases within the US manufacturing sector. This evidence

<sup>10</sup>For more details, see Appendix B)

corroborates that the role of input-output linkages is key for understanding the transmission of import tariff shocks.

## 7 Conclusion

Input-output linkages are crucial for understanding the transmission of import tariff shocks. We find that tariff rate increases reduce industry-specific production through backward and forward channels arising in a domestic production network. However, the response of an industry's producer price depends on which channel dominates the transmission of the tariff increase.

For aggregate output and prices, our results suggest that intra-industry linkages amplify the contraction of production due to tariff increases. At the same time, the negative demand-type repercussion of tariff shocks for some sector in the domestic production network ought to dampen aggregate price increases. The findings align with recent theoretical literature on shock transmission in production networks. Thus, our results are likely relevant for other supply-type shocks such as supply chain disruptions or energy price shocks. This warrants further examination, which we leave for future research.

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# Appendix

## A Data sources

We start by further describing the data sources and associated measures in Section 2. All data come from publicly available resources.

**Import data at the product level – HS classification:** The Harmonized System (HS) classification is an international commodity classification system developed independently by the World Customs Organization (WCO) specifically used to classify international trade. Simply put, the HS classification starts by assigning products into 99 broad 2-digit classes and then further breaks down each class into more precise product groups (identified by adding digits after the first two). The process of assigning products to a group is solely based on the product physical characteristics. The baseline WCO classification goes down to six digits and this 6-digit dimension, referred to as HS6, is common to all countries and only changed when revised by the WCO. Revisions happen every five years and lead to different HS versions (HS 2002, HS 2007 . . . HS 2022). Countries are also free to further break down the HS6 product groups into more details subgroups at their own discretion. To that end, the US International Trade Commission (ITC) maintains the 10-digit disaggregated HS classification HS10. In addition to revisions every five years of the HS6 basis, the digits 7 to 10 can also be revised, this time annually, by the ITC.

We source data from the US Census Harmonized System District-level reports<sup>11</sup> and focus on imports. Specifically, we obtain at the monthly frequency and at the most disaggregated level (HS10) the following series: Customs Value in US\$ (“The value of goods imported as appraised by U.S. Customs and Border Protection. Excludes freight and duties”), CIF Value in US\$ (“The value of goods imported – cost, insurance, and freight; excludes duties”), Calculated duty in US\$ and Quantity (“The physical volume of imports based on the second quantity measurement”). There also is the possibility to have these series for specific regions or countries<sup>12</sup> and we download data for imports from the European Union and China specifically. The yearly files between 2002 and 2021 then consist of the four aforementioned series for all imported products, identified by their HS10 code. It is noteworthy to mention that the yearly files are unbalanced panels in the sense that for each HS10 product it will only show months where there actually was imports of this product.

For our purposes we also rely on the international product classification by Broad Economic

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<sup>11</sup><https://usatrade.census.gov/>

<sup>12</sup>Instead of US total imports denoted simply as ‘World Total’

Categories<sup>13</sup> (BEC) maintained by the United Nations Statistics Division (UNSD) to further classify imported products by their end use dimension. The BEC classification starts by assigning products to one of eight *Broad Economic Categories*, then the product dimension is determined (Goods or Services). And the third level is what we are interested in: *SNA and end use dimension*. The end use categories are: Intermediate consumption, Gross fixed capital formation, Final consumption. In theory all products have a mixed end use purpose, but specifically when the use is not disproportionately in one category some product will then be labeled as Dual-Use and the UNSD provides proportions of dual use. Examples of dual use goods provided by the UNSD are the following: a personal vehicle as capital good and as final consumption good, or gasoline as intermediate and final consumption. This is specifically the latter case that we do not wish to miss imports from. The UNSD still mentions that the proportions should be determined at the national level but we nonetheless use the provided values.

**Industrial production:** The Federal Reserve System produces Industrial Production (IP) series which aim at measuring the real output of different industries located within the US. These series are identified by their IP codes but *related NAICS industries* codes are also provided. The North American Industry Classification System (NAICS) is a classification system of business activities that uses up to six digits to attribute an establishment to a national industry. The first two digits represent the Sector, digit three the Subsector, digit four the Industry group, digit five the NAICS industry and lastly digit six the National industry. The related NAICS industry associated with each IP code have peculiar features that should be mentioned.

First, depending on the aggregation level of the industry considered by the Industrial Production index, the IP code will be related to a NAICS code between NAICS3 (aggregated) to NAICS6 (disaggregated). For instance, for the industry "Oil and gas extraction" (G211) the related NAICS3 is 211 while for "Crude Oil alone" (G21112) the related NAICS6 is 21112. Second, IP codes can also only be linked to *part of* NAICS industries. For instance, "Natural gas" (N21113G) and "Natural gas liquid extraction" (G21113PQ) both have the same *related NAICS* that is "211130pt.", where pt. stands for *part of*. We directly discard these IP codes as the sole indication *part of* but no proportion/weight makes it impossible to divide any data with this NAICS between the IP-labeled industries. Lastly, some IP codes are also related to an aggregation of multiple NAICS level codes. For instance, the industry "Hydroelectric, renewables, and other" with IP code G221111A4T8 is related to "NAICS 221111,4-8" (where 4-8 stands for digits 4 to 8). This IP series thus represents the aggregate industrial production of NAICS6 industries 221111, 221114, 221115, 221116, 221117 and 221118. We also do not make use of these series as we might not have data for all underlying subcodes and prefer basing the analysis on simple industry levels rather than mixing industries and aggregates.

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<sup>13</sup><https://unstats.un.org/unsd/classifications/Econ>

**Producer price index:** The Producer Price Index (PPI) is a set of indices constructed by the Bureau of Labor Statistics (BLS) measuring the average change over time in prices received by producers for domestically produced products: goods, services and output of construction. The PPIs include a wide range of industries from the following sectors: mining, manufacturing, agriculture, utilities, construction, retail, transportation, and other services sectors. In addition to the industry level PPIs, more disaggregated series at the industry-produced-product level are also available. For instance complementary to the (global) NAICS industry “Petroleum refineries” (NAICS 324110) PPI series, 17 more disaggregated PPI series for this NAICS industry are also available and include: “Petroleum refineries-Primary products”, “Petroleum refineries-Regular gasoline”, “Petroleum refineries-Premium gasoline” . . . The baseline approach that we take is to make use of the simple industry level PPI and not focus on a specific industry-product series.

**Input-output tables – BEA classification:** The Input-Output (IO) Accounts are a series of detailed tables released by The Bureau of Economic Analysis (BEA). They illustrate economic activity by detailing how industries interact with one another. On the one hand, Supply tables show the domestic production of commodities (groups of goods and services) by different industries but also import volumes of these commodities. The Use tables on the other hand, show for each industry its use of different commodities as intermediate inputs in its production process. This notably also includes compensation of employees.

The BEA uses its own classification, based on the NAICS classification, to define *both* commodities and industries. The most important feature is that Input-Output tables identify Industries and Commodities with the exact same codes. We refer to this classification simply as BEA classification. As most classifications, the BEA classification allows for different levels of aggregation: from the most aggregated 23 industries down to the 406 industries, with in-between 73 and 142 levels. The BEA then releases IO-tables on a yearly frequency at the “71 industries – 73 commodities” level and at the “402 industries – 402 commodities” level every five years.

### Summary of available data

- **Imports:** monthly product-level data in the HS classification. Fine-grained level data at the disaggregated HS10 level. Are available: volume of imports (in \$), calculated duties (in \$) and import quantity (physical volume).
- **Input-Output tables:** yearly data for each industry-commodity combination in the BEA classification at the 71 industries – 73 commodities level. Supply tables show for each of the industries their supply (in \$) of each commodity, but also total import volumes by commodity. Use tables show by industry the volume used (in \$) of each commodity in the production process as intermediary inputs.

- **Industrial production:** monthly series available at the IP-code level. These IP codes are related to NAICS codes, with different levels of aggregation depending on the considered IP code.
- **Producer prices:** monthly series available at different NAICS levels (NAICS3-NAICS6 but not evenly) and for some NAICS at disaggregated industry-product level.

## B Concordance between HS-NAICS-BEA classifications

Matching the several data sources that employ different classification schemes requires a number of concordance tasks. The reasoning behind why we would need each of these concordances will be apparent when defining the exposure measures in section C.1. This is a general approach and none of the derived concordances is restricted to the specific sample of sectors used later on in the empirical section.

**HS10 and 20xx-NAICS:** We use the concordance from Pierce and Schott (2012)<sup>14</sup> between US HS10 codes, revised on an annual basis, and NAICS6 codes.<sup>15</sup> As NAICS codes are actively revised every five years, the concordance works by blocs of five years. Considering for instance a code introduced in the 2012 NAICS revision and renamed in the 2017 revision, the concordance file will have HS codes associated to this NAICS between January 2013 and December 2017. Thus, in the process of translating HS-level import data to NAICS-level, we will only have import data using this specific NAICS code only between 2013 and 2017, and not over the full sample. For a simpler case of new codes introduced by the 2017 NAICS revision, NAICS6 codes 211120 "Crude Petroleum Extraction" and 211130 "Natural Gas Extraction" only appear in the import data following the Pierce & Schott concordance starting January 2018. This peculiar inner working of the HS10-NAICS6 concordance by five-year blocs will make it a struggle to build consistent 2017-NAICS time series of customs values and duties over the whole sample. It is also noteworthy to mention that as of summer 2024 the latest Pierce & Schott concordance was for codes of the year 2021 and this would force us to make some assumptions to have a sample encompassing both 2022 and 2023. To avoid confounding results from the pandemic our analysis is, however, limited to data up until 2019.

**20xx-NAICS to 2022-NAICS:** After each NAICS revision the US Census provides concordance tables between old and revised codes that helps tracking changes. The nature of these changes are either a name change, a split or a merge. For instance, in the 2007 revision the

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<sup>14</sup>See [https://sompks4.github.io/sub\\_data.html](https://sompks4.github.io/sub_data.html).

<sup>15</sup>Where "20xx-NAICS6" indicates any of the NAICS6 classification versions from 2002, 2007, 2012, 2017 or 2022

NAICS6 code 111998 "All Other Miscellaneous Crop Farming" is split between NAICS6 111998 "All Other Miscellaneous Crop Farming" and NAICS6 112519 "Other Aquaculture". This example of a splitting code shows that despite the 2002-NAICS6 code 111998 still being present after the 2007 revision, the underlying composition of the NAICS6 code is not the same anymore. Utilizing all concordance files provided by the US Census we construct a NAICS6 tracking matrix that provides for any 20xx-NAICS6 code 2002-NAICS6 to 2022-NAICS6 equivalent(s). The emphasis here being on equivalents since for a forward looking concordance, for instance tracking a 2007 NAICS6 code, the latter might end up being split in the following revisions and we associate to it all codes relevant in this split. This means that a 2007 code might be linked to another 2007 code in the matrix if in any (future) revision the first code end up being split and one of the codes emerging from the split is the second 2007 code. A similar situation happens if we were to try and find the 2002 equivalent of a 2012 code that emerged from a split in the 2007 revision, however in our study this is not relevant.

**20xx-NAICS and BEA67:** Liao et al. (2020) provide a set of utilities for matching products labeled in different international trade classification systems (see R package on *concordance*). This includes the “2012-NAICS6 to 2012-BEA412” concordance that we take as a foundation for the work developed of this section. The concordance matches any 2012-NAICS6 code to one or more of the 2012 disaggregated 412 BEA industries. Going back on the presentation of the BEA classification from A we first note that the effect of the 2017 revision to BEA codes was to collapse the most disaggregated level of the 2012 classification from 412 industries to 406 industries in 2017.

We aim to extend and update this “2012-NAICS6 to 2012-BEA412” concordance to meet the following goal: we wish to match any NAICS6 code of other versions (2002-NAICS6, 2007-NAICS6 or 2017-NAICS6) to at least one 2017-BEA406 industry code. The final purpose is then go up the aggregation level –to use the yearly data from input-output tables– and finally obtain a “20xx-NAICS6 to 2017-BEA71” concordance. To that end we follow the procedure detailed below.

#### **“20xx-NAICS6 & 2017-BEA406” concordance procedure:**

For each of complete release of NAICS6 codes from 2002, 2007, 2017 and 2022 we perform the following procedure:

1. Match each 20xx-NAICS6 code to possibly more than one 2012-NAICS6 using the constructed **NAICS tracking matrix**

2. Use Liao et al. (2020) to convert the obtained 2012-NAICS6 code(s) to 2012-BEA412 equivalent(s)
3. For the few matched 2012 BEA codes among the ones impacted by the 2017 revision adjust to the new version
4. The concordance table “20xx-NAICS6 and 2017-BEA406” is obtained

Further important details on the output of the different steps:

- Step2: in the original work of Liao et al. (2020) the 2012-NAICS6 codes are only effectively matched to 392 out of the 412 different 2012-BEA codes.  
→ Thus, not all 412 2012-BEA codes have (at least) one 2012-NAICS6 equivalent. **Since the revision of BEA codes from the 2012 to the 2017 version does not coincidentally solve this issue**, then neither will all of the 406 2017-BEA codes.
- Step4: considering all possible 20xx-NAICS6 codes, it appears they are ultimately only matched to a total of 389 different 2017 BEA codes out of the 406 available.  
→ Despite this gap we still refer to any of the obtained concordances as “20xx-NAICS6 and 2017-BEA406”.

With the yearly input-output tables only using a more aggregated view, namely the second tier of the BEA classification with 73 codes, the obtained concordances “20xx-NAICS6 and 2017-BEA406” need to go up the BEA classification tiers for our purposes. To that end we make use of the detailed table from the appendix of the 2018 comprehensive update of the Input-Output tables<sup>16</sup> that reads a complete breakdown of the BEA classification from the 23 sectors down to the most detailed 406 industries. It is then straightforward to obtain from the “20xx-NAICS6 and 2017-BEA406” concordances the “20xx-NAICS6 and 2017-BEA73” concordances. More specifically the 389 BEA codes to which the whole of the 20xx-NAICS6 are matched to only cover 67 out of the 73 2017-BEA codes of this aggregation tier. **The sectors not covered are ...** Thus, the final product we obtain from this section are the concordances tables: “20xx-NAICS6 and 2017-BEA73”. We can already see that bits of the data from the 71x73 use/make tables will not be accounted for when translating the BEA industries codes to NAICS6 equivalents.

The latter concordances being solely *many to many* and not *one to many* (or *one to one*) will force us to make assumptions when computing the exposure measures. In this regard we note that, on the one hand 99% of BEA73 codes are associated to more than one 20xx-NAICS6 code. On the other hand a 20xx-NAICS code can also be associated to more than one BEA73 code

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<sup>16</sup>See <https://apps.bea.gov/scb/issues/2018/08-august/pdf/0818-industry-tables.pdf>

but only around 1% of 20xx-NAICS codes are associated with more than one BEA73 code<sup>17</sup>. This issue thus affects mainly the concordance process of BEA labeled data to NAICS6 done in section C.3.

## C Construction of the input-output exposure measures

We remain vague on the classification system used to define industry  $i$  and commodity  $j$  in the following two sections (C.1, C.2) since an entire section is dedicated to this practical issue C.3.

### C.1 Input channel - Backward Exposure measure

An industry is thus exposed through commodities involved as intermediate inputs in its production process, we refer to this as backward exposure.

For each commodity  $j$  that industry  $i$  uses consider:

$$BW_{i,j,y} \equiv \frac{use_{i,j,y}}{M_{i,y} + CE_{i,y}} \times \frac{imp_{j,y}}{supply_{j,y}} = USE_{i,j,y} \times IM_{j,y} \quad (C.1)$$

Where:

- $use_{i,j,y}$  : volume of commodity  $j$  used by industry  $i$  as an intermediate input in year  $Y_t$
- $M_{i,y}$  : total intermediate use of inputs by industry  $i$  in year  $Y_t$
- $CE_{i,y}$  : total compensation of employees paid within industry  $i$  in year  $Y_t$
- $imp_{j,y}$  : volume of imports of commodity  $j$  in year  $Y_t$
- $supply_{j,y}$  : total supply of commodity  $j$  (= domestic supply + imports) in year  $Y_t$

From this definition,  $USE_{i,j,y}$  represents industry  $i$  use share of commodity  $j$  in its production process in year  $Y_t$ . This term approximate the direct vertical linkage between commodity  $j$  and industry  $i$  and by making it time varying we avoid potential measurement errors due to technology changes<sup>18</sup> (Bown et al. (2020)). The evolution of industries' use of different commodities is thus embedded into the computation of the backward exposure measure. Then,  $IM_{j,y}$  is simply the import share of commodity  $j$  in its total supply. Since the BEA use tables do not allow the use of commodity  $j$  by industries to be differentiated between use of *domestically* produced and

<sup>17</sup>For instance the 2002-NAICS code 326299 associated to BEA71 326 and 3364OT

<sup>18</sup>In our robustness checks we asses to what extent this time variation of the backward measure plays a role.

imported  $j$ , we multiply  $USE_{i,j,y}$  by the economy-wide import share of  $j$  (namely  $IM_{j,y}$ ) to obtain a proxy. Finally,  $BW_{i,j,y}$  represents the production process exposure of industry  $i$  to tariffs on commodity  $j$ . This is a direct quantification of the vertical the vertical linkage between industry  $i$  and commodity  $j$ , which had already been introduced in Flaaen and Pierce (2025) and Khalil and Weber (2022) but both lacked the yearly variations<sup>19</sup>. To specifically assess the exposure of industry  $i$  to tariffs imposed on imports of commodity  $j$  coming from a region/country we would simply multiply the aforementioned backward exposure  $BW_{i,j,y}$  and the share of imports of commodity  $j$  coming from the considered region (also obtained from the Customs data).

## C.2 Output channel - Forward Exposure measure

While the concept behind the definition of the backward exposure measure (C.1) had already been considered in other works such as Flaaen and Pierce (2025), ? or Benguria and Saffie (2019) we introduce a second exposure measure that attempts to measure exposure to tariffs through output linkages.

The rationale is the following: an industry  $i$  produces multiple goods  $x$  and particularly one, say  $x$ , that another domestic industry  $j$  uses extensively. Let the state introduce a tariff hike on the specific product(s) that industry  $j$  produces. This sector is now "protected" by tariffs and *if* demand were to be redirected from foreign producers toward  $j$  we *could* expect its demand of inputs to increase, including  $x$ . If such protectionary channel were active, industry  $i$  would thus benefit from the introduction of tariffs on industry  $j$  through its product  $x$  output linkage. While potentially not directly using products in its own production process, an industry can thus still be exposed to tariffs through other industries to which it direct its output.

An impediment to its practical implementation comes from the fact that we cannot identify, from the BEA *make* and *use* tables, the direct linkage between an industry  $i$  domestically producing a commodity  $x$  and another industry  $j$  using this same commodity as an input. Indeed we only have total the dollar value of commodity  $x$  supplied by industry  $i$  and the total dollar value of commodity  $x$  used by  $j$  as an intermediate input. A proxy for the forward linkage between industry  $i$  and industry  $j$  through commodity  $x$  is then defined by:

$$FW_{i,j:x,y} \equiv \underbrace{\frac{supply_{i,x,y}}{supply_{i,y}}}_{\substack{\text{commodity } x \\ \text{supply share} \\ \text{from industry } i}} \times \underbrace{USE_{j,x,y} \times (1 - IM_{x,y})}_{\substack{\text{industry } i \text{ domestic} \\ \text{demand of commodity } x}} \quad (C.2)$$

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<sup>19</sup>Most likely due to two things: smaller time frame considered for their studies and the use of disaggregated I-O tables with 402 industries which are only available on a five-year basis

In this definition  $USE_{x,j,y} \times (1 - IM_{j,y})$  is thus a proxy for the share of commodity  $j$  that industry  $x$  sources domestically, as this specific data is not made available by the I-O tables. Multiplying it with the domestic supply share of industry  $i$  yields a proxy for the the domestic sourcing of commodity  $j$  by  $x$  that is specifically addressed to industry  $i$ .

### C.3 Practical implementation

The PPIs are widely available at the most disaggregated NAICS6 level, however this is not necessarily true for the industrial production series were the number of series available at this disaggregated level strongly shrinks. For the consistency of our results, we include in our sample only industries where output and price series are available. Similarly to Flaaen and Pierce (2025) we conduct our analysis, and subsequent regressions, at the four-digit NAICS industry level "Industry Group" as it appears to be the most disaggregated level where we manage to keep a consistent sample of industries for both output and price series. This is still a significantly disaggregated level to have meaningful variations in the different industry specific measures considered in this study as illustrated (see Figure ?? to ??).

Turning to the exposure measures, since all data that are used in the definitions (C.1) and (C.2) originate from the IO-tables of the BEA, the industry and commodity levels are given by the BEA classification: 71 industries and 73 commodities. However, since we conduct the analysis at the NAICS4 level we specifically convert the industry dimension. In addition as we will be interacting the defined exposure measures with tariff changes we also need to define tariff rates at the BEA commodity level. Hence we need to convert data following two stages:

1. Computing tariff rates at the BEA-commodity level ( $\tau_{j=BEA}$ ) from HS labeled import data
2. Deriving  $USE_{i=NAICS,j=BEA}$  from  $USE_{i=BEA,j=BEA}$  and  $w_{i=NAICS,j=BEA}$  from  $w_{i=BEA,j=BEA}$ , respectively for the backward and forward exposure measures

#### Computing tariff rates at the BEA commodity level<sup>20</sup>

We implement the following procedure:

1. Convert import data labeled with the HS10 classification to 20xx-NAICS6 using Pierce and Schott (2012) concordance.
2. Collapse at the 20xx-NAICS6 level.

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<sup>20</sup>Following Pierce & Schott it is straightforward to obtain the tariff rates at the NAICS industry level.

3. In this step we wish to convert the obtained 20xx-NAICS6 data to BEA67. As previously mentioned, a NAICS6 code might be matched to several BEA67 codes. We take the following stance: for each 20xx-NAICS where we have data from step 2.<sup>21</sup>, we count the number of BEA codes it will be matched with when using the "20xx-NAICS6 and BEA67 concordance" of B and then **evenly allocate** the considered variable (duty or import value) for this NAICS6 between these associated BEA codes. For an imaginary NAICS code N1 that is matched with both BEA codes B1 and B2, the dollar values of duties and import volumes computed for N1 in step 2. are evenly allocated between B1 and B2. This is the assumption mentioned in the last paragraph of B. Such case remains uncommon as <1% of 20xx-NAICS6 codes for every reference year are matched to more than one BEA equivalent.
4. Collapse at the BEA67 level. Again we note that this does not mean that all 67 BEA level commodities will have import data and then tariff rates. In fact converting HS10 product data to BEA commodities yields 27 BEA commodity level tariff rates.

### Computing use and supply share with NAICS industry and BEA commodity dimensions

We implement the following procedure:

1. From the *make* and *use* tables of the BEA, match the industry dimension using the "20xx-NAICS6 and BEA67 concordance" of B. Either 2017-NAICS6 for the case of the IP regression and 2022-NAICS6 for the PPI regression<sup>22</sup>. As mentioned in B a vast majority of BEA67 codes are matched to more than one 20xx-NAICS6 code, we then take the same approach as in the previous procedure: for each BEA67 code, we count the number of 20xx-NAICS6 codes it will be matched with when using the appropriate B concordance and then **evenly allocate** the considered variable (supply or use of  $j$  by  $i$ , where  $i$  is the dimension being converted) for this BEA67 industry between the matched NAICS6 codes.
2. Convert NAICS6 to NAICS4 by looking at the first four digits.
3. Collapse the data at the NAICS4 level.

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<sup>21</sup>The concordance procedures presented earlier make possible the conversion of all NAICS6 codes, but we underline that in reality from the Pierce & Schott concordance of HS10 level data not all NAICS code that exist have associated import data

<sup>22</sup>The use of different concordance tables here is due to the PPI and IP still using different NAICS6 reference years to identify the most disaggregated industries. Even though we later aggregate the data to NAICS4 it is the safest way to ensure we correctly allocate data from NAICS6 to the corresponding NAICS4, as unlikely as it may happen that a NAICS6 revision causes a NAICS4 change

As explained in A the coverage of the PPI and IP series are different at the most disaggregated NAICS6 level but this remains true even at NAICS4. Thus when merging the obtained use and supply share with NAICS4 industry dimension and the actual IP and PPI series, a larger number of PPI series are available. Since we want to maintain a coherent sample across PPI and IP series for the empirical approach we restrict the universe of NAICS4 industries to the NAICS4 industries where we have industrial production series. This restricts the regression analysis to industries classified in Utilities, Construction and mostly Manufacturing.

Table C.1: List of NAICS4 industries forming the sample.

PPI	IP	NAICS4	BEA67 <sup>†</sup>	NAICS4 industry description
3111	G3111	3111	311FT	Animal Food Manufacturing
3112	G3112	3112	311FT	Grain and Oilseed Milling
3113	G3113	3113	311FT	Sugar and Confectionery Product Manufacturing
3114	G3114	3114	311FT	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3115	G3115	3115	311FT	Dairy Product Manufacturing
3118	N3118	3118	311FT	Bakeries and Tortilla Manufacturing
3119	G3119	3119	311FT	Other Food Manufacturing
3121	G3121	3121	311FT	Beverage Manufacturing
3122	G3122	3122	311FT	Tobacco Manufacturing
3131	G3131	3131	313TT	Fiber, Yarn, and Thread Mills
3132	G3132	3132	313TT	Fabric Mills
3133	G3133	3133	313TT	Textile and Fabric Finishing and Fabric Coating Mills
3141	G3141	3141	313TT	Textile Furnishings Mills
3149	G3149	3149	313TT	Other Textile Product Mills
3211	N3211	3211	321	Sawmills and Wood Preservation
3212	G3212	3212	321	Veneer, Plywood, and Engineered Wood Product Manufacturing
3219	G3219	3219	321	Other Wood Product Manufacturing
3221	G3221	3221	322	Pulp, Paper, and Paperboard Mills
3222	G3222	3222	322	Converted Paper Product Manufacturing
3251*	G325@4	3251	325	Basic Chemical Manufacturing
3252*	G325@4	3252	325	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
3253*	G325@4	3253	325	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
3254	G3254	3254	325	Pharmaceutical and Medicine Manufacturing
3255*	G325@4	3255	325	Paint, Coating, and Adhesive Manufacturing
3256*	G325@4	3256	325	Soap, Cleaning Compound, and Toilet Preparation Manufacturing
3259*	G325@4	3259	325	Other Chemical Product and Preparation Manufacturing
3261	G3261	3261	326	Plastics Product Manufacturing

*Continued on next page*

Table C.1 – continued from previous page

PPI	IP	NAICS4	BEA67 <sup>†</sup>	NAICS4 industry description
3262	G3262	3262	326	Rubber Product Manufacturing
3271	G3271	3271	327	Clay Product and Refractory Manufacturing
3272	G3272	3272	327	Glass and Glass Product Manufacturing
3273	G3273	3273	327	Cement and Concrete Product Manufacturing
3274	G3274	3274	327	Lime and Gypsum Product Manufacturing
3279	G3279	3279	327	Other Nonmetallic Mineral Product Manufacturing
3311*	G3311A2	3311	331	Iron and Steel Mills and Ferroalloy Manufacturing
3312*	G3311A2	3312	331	Steel Product Manufacturing from Purchased Steel
3313	G3313	3313	331	Alumina and Aluminum Production and Processing
3314	G3314	3314	331	Nonferrous Metal (except Aluminum) Production and Processing
3315	G3315	3315	331	Foundries
3321	N3321	3321	332	Forging and Stamping
3322	N3322	3322	332	Cutlery and Handtool Manufacturing
3323	N3323	3323	332	Architectural and Structural Metals Manufacturing
3325	G3325	3325	332	Hardware Manufacturing
3326	N3326	3326	332	Spring and Wire Product Manufacturing
3327	G3327	3327	332	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing
3329	G3329	3329	332	Other Fabricated Metal Product Manufacturing
3331	G3331	3331	333	Agriculture, Construction, and Mining Machinery Manufacturing
3332	G3332	3332	333	Industrial Machinery Manufacturing
3333*	G3333A9	3333	333	Commercial and Service Industry Machinery Manufacturing
3334	G3334	3334	333	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing
3335	G3335	3335	333	Metalworking Machinery Manufacturing
3336	G3336	3336	333	Engine, Turbine, and Power Transmission Equipment Manufacturing
3339*	G3333A9	3339	333	Other General Purpose Machinery Manufacturing
3341	G3341	3341	334	Computer and Peripheral Equipment Manufacturing
3342	G3342	3342	334	Communications Equipment Manufacturing

*Continued on next page*

Table C.1 – continued from previous page

PPI	IP	NAICS4	BEA67 <sup>†</sup>	NAICS4 industry description
3343	G3343	3343	334	Audio and Video Equipment Manufacturing
3344	G3344	3344	334	Semiconductor and Other Electronic Component Manufacturing
3345	G3345	3345	334	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
3351	G3351	3351	335	Electric Lighting Equipment Manufacturing
3352	G3352	3352	335	Household Appliance Manufacturing
3353	G3353	3353	335	Electrical Equipment Manufacturing
3359	G3359	3359	335	Other Electrical Equipment and Component Manufacturing
3361	G3361	3361	3361MV	Motor Vehicle Manufacturing
3362	G3362	3362	3361MV	Motor Vehicle Body and Trailer Manufacturing
3363	G3363	3363	3361MV	Motor Vehicle Parts Manufacturing
3364	G3364	3364	3364OT	Aerospace Product and Parts Manufacturing
3365	N3365	3365	3364OT	Railroad Rolling Stock Manufacturing
3366	G3366	3366	3364OT	Ship and Boat Building
3369	N3369	3369	3364OT	Other Transportation Equipment Manufacturing
3371	N3371	3371	337	Household and Institutional Furniture and Kitchen Cabinet Manufacturing
3372*	G3372A9	3372	337	Office Furniture (including Fixtures) Manufacturing
3379*	G3372A9	3379	337	Other Furniture Related Product Manufacturing
3391	N3391	3391	339	Medical Equipment and Supplies Manufacturing

\* PPI series are available at the NAICS<sub>4</sub> level but not the IP - only available for an aggregate, which is chosen and hence appears more than once in the sample.

† NAICS<sub>4</sub>-BEA67 resulting from the underlying NAICS<sub>6</sub>-BEA67 matching exercise of section XXX.

## D Details on the empirical specification

### Notations:

- $\tau_j$  : tariff rate on imports with all end-use in BEA67 industry  $j$ .
- $\tau_j^{Int}$  : tariff rate on imports with intermediate end-use in BEA67 industry  $j$ .
- $\tau_j^{NonInt}$  : tariff rate on imports with non-intermediate end-use in BEA67 industry  $j$ .
- $\tau_j^{Fin}$  : tariff rate on imports with final end-use in BBEA67 industry  $j$ .
- $\tau_j^{Cap}$  : tariff rate on imports with capital end-use in BEA67 industry  $j$ .
- $T_i$  : tariff rate on imports with all end-use in NAICS4 industry  $i$ .

### D.1 Baseline Local Projection setting

Let  $\mathcal{Y}_{i,t}$  denote either the log of the producer prices (*PPI*) or the log of the industrial production (*IP*) of the manufacturing sector NAICS4 industry  $i$  in month  $t$ . The estimation sample spans  $t = \text{January 2005 to January 2020}$ . Consider the following panel local projection specifications independently estimated for each  $h = 0, 1, \dots, 17$ :

$$\Delta_c \mathcal{Y}_{i,t+h} = \alpha^{(h)} + \underbrace{\mu^{(h)} \Delta T_{i,t}}_{\text{Horizontal channel}} + \underbrace{\beta^{(h)} \mathbf{BW}_{i,t} \times \Delta \mathcal{T}_{i,t}^{Input}}_{\text{Input channel}} + \underbrace{\gamma^{(h)} \mathbf{FW}_{i,t} \times \Delta \mathcal{T}_{i,t}^{Output}}_{\text{Output channel}} + \text{controls} + \varepsilon_{i,t+h}^{(h)} \quad (\text{D.1})$$

where  $\Delta_c \mathcal{Y}_{i,t+h} = \mathcal{Y}_{i,t+h} - \mathcal{Y}_{i,t}$  is the cumulative change in  $\mathcal{Y}$  between  $t$  and  $t+h$ .  $\Delta T_{i,t}$  is the monthly change in the tariff rate applied in NAICS4 industry  $i$ .  $\mathbf{BW}_{i,t}$  and  $\mathbf{FW}_{i,t}$  are the aggregate backward and forward exposures defined as:  $\mathbf{BW}_{i,t} = \sum_j BW_{i,j,y-1}$  and  $\mathbf{FW}_{i,t} = \sum_j FW_{i,j,y-1}$ .  $\Delta \mathcal{T}_{i,t}^{Input}$  and  $\Delta \mathcal{T}_{i,t}^{Output}$  are the weighted average monthly changes in the input and output tariffs faced by industry  $i$ , respectively defined as:

$$\Delta \mathcal{T}_{i,t}^{Input} = \sum_j \frac{BW_{i,j,y-1}}{\mathbf{BW}_{i,t}} \times \Delta \tau_{j,t}^{Int}$$

$$\Delta \mathcal{T}_{i,t}^{Output} = \sum_j \frac{FW_{i,j,y-1}}{\mathbf{FW}_{i,t}} \times \Delta \tau_{j,t}$$

We control for a wide range of changes in economic conditions including lags of monthly changes in the dependent variable, industry fixed effects and industries' exposure to changes in the dollar international strength which could be correlated to tariff rates changes and charged price or production. Are included in the baseline specification:

- 12 lags of  $\Delta\mathcal{Y}_{i,t}$
- An industry fixed effect  $f_i$
- 12 lags of the tariff shocks  $\Delta T_{i,t}$ ,  $\mathbf{BW}_{i,t} \times \Delta\mathcal{T}_{i,t}^{Input}$  and  $\mathbf{FW}_{i,t} \times \Delta\mathcal{T}_{i,t}^{Output}$ .
- Lags 0-12 of the monthly changes in the log of the US real GDP
- Lags 0-12 of the monthly changes in the log of different energy prices: the S&P Goldman Sachs Brent Crude Index, the US City Average Price for Electricity and the Natural gas futures price 1st expiring
- Lags 0 to 12 of the monthly changes in the Federal Funds (effective) Rate
- Lags 0 to 12 of the monthly changes in the industry's exchange rate exposure, defined as the product of the share of imports in industry  $i$  intermediate costs and the Wall Street Journal Dollar Index:  $XR_{i,t} = (\sum_j BW_{i,j,y-1}) \times DXY$

## D.2 Inter- and Intra-industry contributions

Let (i) denote the BEA67 correspondance to the NAICS4 industry  $i$  (see Appendix B). We estimate the following  $h$  modified panel local projections to disentangle inter- and intra-industry contributions to the different transmission channels:

$$\begin{aligned}
\Delta_c \mathcal{Y}_{i,t+h} = & \alpha^{(h)} + \mu^{(h)} \Delta T_{i,t} + \underbrace{\beta_{intra}^{(h)} BW_{i,i,y-1} \times \Delta \tau_{i,t}^{Int} + \gamma_{intra}^{(h)} FW_{i,i,y-1} \times \Delta \tau_{i,t}}_{\text{Intra-industry}} \\
& + \underbrace{\beta_{inter}^{(h)} \widetilde{\mathbf{B}\mathbf{W}}_{i,t} \times \Delta \widetilde{\mathcal{T}}_{i,t}^{Input} + \gamma_{inter}^{(h)} \widetilde{\mathbf{F}\mathbf{W}}_{i,t} \times \Delta \widetilde{\mathcal{T}}_{i,t}^{Output}}_{\text{Inter-industry}} \\
& + \text{controls} + \varepsilon_{i,t+h}^{(h)} \tag{D.2}
\end{aligned}$$

where the tilde signals variables computed excluding the corresponding BEA67 industry (**i**):

$$\widetilde{\mathbf{B}\mathbf{W}}_{i,t} = \sum_{j \neq i} BW_{i,j,y-1} \quad \text{and} \quad \Delta \widetilde{\mathcal{T}}_{i,t}^{Input} = \sum_{j \neq i} \frac{BW_{i,j,y-1}}{\widetilde{\mathbf{B}\mathbf{W}}_{i,t}} \times \Delta \tau_{j,t}^{Int}$$

$$\widetilde{\mathbf{F}\mathbf{W}}_{i,t} = \sum_{j \neq i} FW_{i,j,y-1} \quad \text{and} \quad \Delta \widetilde{\mathcal{T}}_{i,t}^{Output} = \sum_{j \neq i} \frac{FW_{i,j,y-1}}{\widetilde{\mathbf{F}\mathbf{W}}_{i,t}} \times \Delta \tau_{j,t}$$