The Propagation of Tariff Shocks via Production Networks*

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Abstract

Imports feature at all stages of production as well as in final consumption, and this is key to how tariff shocks play out. If imposed on imports in upstream sectors, import tariffs lower domestic output in downstream sectors; if imposed downstream, they raise upstream production. The aggregate effect of tariffs can be recessionary or expansionary—depending on the strength of upstream and downstream effects. Tariffs raise inflation no matter what, but how persistently they do so also depends on the network structure. We establish these results in a New Keynesian small open-economy model with an input-output network and provide supporting evidence based on US import tariffs. Simulating the "liberation day" tariff package, we find it highly stagflationary.

Keywords: Tariffs shocks, business cycle, upstream sectors, downstream sector, input-output network, monetary policy, inflation

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1 Introduction

How do import tariffs affect the business cycle, particularly output and inflation dynamics? Addressing this question is challenging because tariffs do not impact the economy uniformly. They are often imposed on specific goods or trading partners. And even when tariffs are applied uniformly to all imports, their implications differ by sectors due to varying levels of import intensity. Moreover, sectors are also heterogeneous in the extent to which they rely on imports as inputs or compete with them in the goods markets. More broadly, tariffs propagate through domestic supply chains, potentially generating spillover effects that extend beyond the directly targeted sectors.

In this paper, in order to study the propagation of tariff shocks and their aggregate effect, we put forward a New Keynesian multi-sector model of a small open economy. It features an input-output network and imported goods at all stages of domestic production. We show analytically that sectoral import tariffs propagate within the network in both directions: downstream and upstream. A tariff imposed upstream lowers output in downstream sectors, as imported inputs become more expensive. A tariff imposed downstream, by contrast, boosts output upstream by shielding the domestic supply chain from foreign competition. To provide evidence on how tariffs propagate through the domestic supply chain, we construct a measure of effective sectoral tariffs using US customs data. As predicted by the model, tariffs reduce output in downstream sectors while increasing output in upstream sectors. We also document a statistically significant increase of downstream prices, but no significant effect on upstream prices.

The aggregate effect of import tariffs depends on a) their sectoral distribution and b) on the structure of the domestic production network. Intuitively, sectoral tariffs can be expansionary or contractionary, depending on whether upstream or downstream propagation dominates. For a quantitative assessment, we calibrate the model to capture key features of the US economy and expose it to a tariff shock. First, assuming a uniform tariff, we find that it induces a sharp contraction in output and a persistent increase in inflation. Instead, the same tariff raises output and has a only a short-lived inflationary impact in the absence of production network. Second, we simulate the "Liberation Day" tariffs proposed by the Trump administration. Their effect is similar to the uniform tariff, but their inflationary impact is stronger still because they disproportionately affect upstream sectors: They reduce US GDP by about 1%, while raising consumer price inflation by approximately 1.5 percentage points.

Our results—that the aggregate impact of tariff shocks depends on its sector of origin—have important implications for monetary policy because the nature of the shock changes with the sector of origin along the supply chain. Tariffs imposed on upstream sectors producing intermediate goods represent a negative supply shock and are highly stagflationary: they reduce output and raise inflation due to downstream propagation of production costs throughout the network. This creates a monetary policy tradeoff—stimulating the economy to mitigate the recessionary impact raises inflation further, while tightening to control inflation deepens the recession. In contrast, as the tariff shock originates further down the supply chain, the role of downstream propagation diminishes, and the stagflationary impact weakens. When tariffs target sectors closer to final use, they act as positive domestic demand shocks, raising both domestic output and prices. Their impact can be contained more easily by monetary policy.

Our model extends the New Keynesian small open economy workhorse model à la Gali and Monacelli (2005) to a multi-sector environment with a fully specified input-output network. It differs from the related framework by Qiu et al. (2025) in that we consider a fully dynamic model. Goods used for intermediate inputs and final consumption are bundles of domestically produced and imported sectoral goods, allowing imported inputs to matter at all stages of production and to be partially substituted by domestic counterparts. Sectors differ in their use of intermediate inputs, trade openness, and importance in household consumption. We allow for time-varying, sector-specific import tariffs and study their short-run effects, notably how they propagate through the network. For our model simulation, we assume feedback rule for monetary policy that adjusts interest rate in response to domestic inflation.

To establish the determinants of sectoral tariff propagation, we analytically solve the model under assumptions that yield tractability—flexible prices and linear disutility of labor. We show that tariffs imposed on upstream sectors reduce output and raise prices in downstream sectors. Conversely, tariffs in downstream sectors increase output in upstream sectors, provided domestic and imported goods are sufficiently substitutable. We illustrate these results using a numerical three-sector example with a vertical production chain: A tariff in the middle sector raises output in the upstream and middle sectors while reducing it in the downstream sector. In larger and more realistic production networks, any given sector can be simultaneously upstream and downstream relative to any other sector, resulting in a more complex tariff propagation in both directions.

We then turn to US data to assess whether there is empirical support for the patterns of sectoral tariff propagation predicted by our model. We begin by constructing a monthly sector-level effective tariff measure for the period 2002M1–2024M12 using US Census Bureau data on imports and estimated duties. Then we estimate tariff propagation patterns following the approach of Acemoglu et al. (2016). Specifically, we calibrate the input-output matrix based on the Use Tables of the Bureau of Economic Analysis to measure the upstream and downstream proximity between pairs of sectors and construct a sector-specific time series of upstream and downstream tariff exposures for all sectors in the sample. Based on local projections, we estimate the response of sectoral output to changes in upstream and downstream tariff rates. As predicted by the model, output increases in sectors upstream and decreases in sectors downstream after an increase in tariffs. Estimating the response of sectoral prices, we find an increase in prices downstream, but no significant response for other directions of propagation.

Having established evidence that supports the model predictions on tariff propagation, we use the model to analyze the aggregate effects of tariffs. We calibrate the model to the US production network at the disaggregated level allowing for 63 sectors, incorporating sector-specific input-output linkages, labor shares, consumption shares, trade openness, and price stickiness. This allows us to generate quantitative predictions for the effects of actual or hypothetical tariff packages, accounting for the structure of the US economy. We examine two policy scenarios and compare their effects in the calibrated model with what would happen in the absence of an input-output network. First, we consider a 10 percent import tariff uniformly imposed on all imports. This scenario allows us to isolate the role of the production network for the propagation of tariffs: Any difference in the overall effect relative to what we find in the absence of a network is caused by input-output linkages. And the difference turns out to be fundamental. In the baseline, GDP, measured in terms of value added, falls by more than 1 percent, while it rises mildly in the absence of the network; inflation increases persistently in the baseline while undershooting quickly after an initial increase in the absence of the network.

Second, we simulate the effect of the "Liberation Day" tariffs, announced by the US government in April 2025. In this case, tariffs are not uniform. While these tariffs prima facie vary primarily across trading partners, they effectively vary across sectors, too. Intuitively, a high tariff on imports from a country that mostly exports textiles to the US and a low tariff on imports from a country that mainly exports machinery to the US results in a higher effective tariff rate on textiles than on machinery. We compute the sector-specific tariff rates implied by the "Liberation Day" tariffs, using sectoral import shares from all US trading partners, and find that they vary substantially across sectors. Yet their impact on GDP is similar to that of the uniform tariff scenario—testifying to the importance of network propagation for the aggregate effects of tariffs. However, the "Liberation Day" tariffs induce a stronger inflation response because in this case tariffs increase disproportionately in upstream sectors.

The paper is organized as follows. In the remainder of the introduction, we place the paper in the context of the literature and outline its contribution. Section 2 presents the structural model used to study tariff propagation across sectors. Section 3 outlines the theoretical patterns of tariff propagation and documents corresponding evidence in US data. Section 4 provides a quantitative analysis of tariff scenarios. Section 5 concludes.

Related literature. Our paper relates to several strands of the literature. First and foremost, it contributes to recent work on the short-run impact of tariffs in economies with imported intermediate inputs. Bergin and Corsetti (2023, 2025) and Auclert et al. (2025) show that tariffs are generally recessionary. Kalemli-Özcan et al. (2025) find that in a production network economy, tariffs, while contractionary, can be deflationary or inflationary, depending on the strength of demand effects. We contribute to this literature by analyzing tariff propagation through the domestic production network using both a structural model and US data. We show that downstream linkages cause recessionary effects, while upstream propagation can be expansionary.

Second, in this way, our paper complements the empirical literature on how import tariffs propagate through domestic production chains. Blonigen (2016); Cox (2021) document that steel-related trade protection harms downstream sectors, while Flaaen and Pierce (2019) show that manufacturing tariffs reduce employment due to higher input costs. Barattieri and Cacciatore (2023) find large negative effects of tariffs on downstream employment but minimal short-term benefits for protected sectors. Bown et al. (2024) provide evidence of negative downstream employment effects alongside positive long-run gains for protected sectors. Rodríguez-Clare et al. (2025) show that tariffs can stimulate domestic manufacturing.

Third, there is a large empirical literature on the effects of tariffs on sectoral and aggregate economic activity. Tariffs have been found to reduce output, productivity, consumption, and exports in the medium run Furceri et al. (2018); Waugh (2019); Handley et al. (2020), with retaliation often amplifying these effects Fajgelbaum et al. (2020); Autor et al. (2024). While some studies find benefits for protected sectors, these are typically outweighed by broader welfare losses (Fajgelbaum et al., 2020; Autor et al., 2024). Protectionism has also been shown to act as a negative supply shock, lowering output and raising inflation across countries (Barattieri et al., 2021), and harming economic activity globally (Chor and Li, 2024). We complement this evidence by emphasizing the role of production networks in the propagation of tariff shocks.

Fourth, we contribute to the literature on the effects of tariffs on prices. While some argue tariffs have not historically been inflationary in the US (Batra, 2001), recent evidence suggests mixed price effects—often offset by trade diversion (Flaaen et al., 2020)—with import prices rising and export prices falling (Cavallo et al., 2021). We add to this by analyzing how tariffs propagate through production networks to influence domestic prices.

Fifth, there is related but distinct work on the objectives and effectiveness of trade protection (e.g., Hume, 1742; Lerner, 1936; Krugman, 1985; Marris, 1987). More recent work has explored the political economy rationale for trade protection (Ossa, 2014) and how optimal tariffs are influenced by production and trade network structures (Erbahar and Zi, 2017; Antràs et al., 2024; Blanchard et al., 2025). Another line of research considers trade protection as a tool for business cycle stabilization through fiscal devaluations, though its practical effectiveness is debated (Farhi et al., 2014; Erceg et al., 2023). Obstfeld (2025) reviews common fallacies in tariff policy aimed at reducing the US trade deficit, and Itskhoki and Mukhin (2025) examine optimal tariffs when policy goals include supporting manufacturing jobs and improving the trade balance. A related strand studies how monetary policy interacts with tariffs in aggregate economies, highlighting the benefits of inflation targeting during trade wars (Auray et al., 2024) and the rationale for expansionary policy when tariffs suppress imports (Bianchi and Coulibaly, 2025). In contrast to this literature, which focuses on motivations for and policy responses to tariffs, our work emphasizes tariff propagation through production networks.

Lastly, we relate to the broad literature on shock propagation trough production networks. Acemoglu et al. (2012, 2016); Carvalho (2014); Barrot and Sauvagnat (2016) investigate the transmission of microeconomic shocks to macroeconomic outcomes. Baqaee and Farhi (2019, 2020); Bigio and La'o (2020) develop methodologies to assess the effects of sectoral shocks on the misallocation and productivity. Carvalho et al. (2021) explores the effects of the 2011 Japan earthquake on production networks. Pasten et al. (2020); Ghassibe (2021) analyze the propagation of monetary policy shocks within input-output network economies.

2 Model

We study the propagation of sector-specific import tariffs using a dynamic New Keynesian model of a small open economy with a production network and sectoral imports and exports. The model allows for sector-specific import tariffs, along with an arbitrary degree of substitutability between imported and domestic varieties at each stage of production and in final consumption. Goods produced in each sector can be used either as intermediate inputs in any sector or for final consumption. Domestic prices are subject to a Calvo-type nominal rigidity. We now describe the model setup in detail.

2.1 Model description

2.1.1 Households

A representative domestic household consumes a bundle of domestic and imported sectoral goods and supplies labor to the N domestic sectors. International financial markets are complete, allowing the household to trade a full set of state-contingent assets across countries. The household maximizes expected lifetime utility

$$\max_{\{C_t, L_t\}} E_t \sum_{t=0}^{\infty} \delta^t \{\log C_t - \sum_{i=1}^{N} \frac{L_{t,i}^{1+\phi}}{1+\phi}\},$$

where C_t is household consumption and $L_{t,i}$ is the labor supplied to domestic sector i. The parameter $\delta < 1$ is the discount factor, and $\varphi > 0$ is the inverse of the Frisch elasticity. The household's budget constraint is given by

$$P_t^c C_t + E_t\{Q_{t,t+1}, B_{t+1}\} \leq B_t + \sum_{i=1}^{N} W_{t,i} L_{t,i} + T_t,$$

where P_t^c is the consumer price index (CPI), B_t is the nominal payoff in period t from a portfolio purchased in period $t-1$, $Q_{t,t+1}$ is the one-period-ahead stochastic discount factor, $W_{t,i}$ is the wage paid in sector i, and T_t is a lump-sum transfer.

The consumption basket C_t is a composite of sector-specific goods:

$$C_t = \prod_{i=1}^{N} \left(\frac{C_{t,i}}{\beta_i} \right)^{\beta_i},$$

where $\sum \beta_i = 1$. The sector-specific consumption good, in turn, is a composite of domestic and imported (foreign) varieties:

$$C_{t,i} = \left((1-\gamma_i) \cdot [C^D_{t,i}]^{\frac{\eta-1}{\eta}} + \gamma_i \cdot [C^F_{t,i}]^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{1}$$

where $0 \leq \gamma_i \leq 1$ is the sector-specific steady-state share of imports in consumption (openness), and $\eta > 0$ is the elasticity of substitution between domestic and imported varieties. Later, we show that the patterns of tariff propagation strongly depend on this elasticity. $C^F_{t,i}$ denotes the quantity of sectoral imports for consumption, while $C^D_{t,i}$ is assembled by competitive firms that produce the aggregated domestic sector-i good from a continuum of domestic varieties, as defined below.

Optimality conditions. Defining the nominal interest rate as $R_t \equiv \frac{1}{E_t Q_{t,t+1}}$, the Euler equation is given by

$$\delta R_t \mathbb{E}_t \frac{C_t P^c_t}{C_{t+1} P^c_{t+1}} = 1 \; . \tag{2}$$

Sectoral labor is supplied according to

$$L^{\phi}_{t,i} C_t = \frac{W_{t,i}}{P^C_t} \tag{3}$$

and expenditure minimization for the final consumption good implies that sectoral consumption demand satisfies

$$\frac{P^c_{t,i} C_{t,i}}{P^c_t C_t} = \beta_i \; , \tag{4}$$

where $P^c_{t,i}$ is the price of the sector-i good defined in (1). Hence, β_i is the share of sector-i good consumption in total consumption.

The optimal choice between domestic and foreign goods yields the demand functions

$$C^D_{t,i} = (1-\gamma_i) \left(\frac{P_{t,i}}{P^c_{t,i}} \right)^{-\eta} C_{t,i} \tag{5}$$

for the domestic good with price $P_{t,i}$, and

$$C^F_{t,i} = \gamma_i \left(\frac{(1+\tau_{t,i})\mathcal{E}_t P^\star_{t,i}}{P^c_{t,i}} \right)^{-\eta} C_{t,i} \tag{6}$$

for the foreign good, where $P^\star_{t,i}$ is the world price of good i (in foreign currency), $\mathcal{E}_t$ is the nominal exchange rate, and $\tau_{t,i}$ is an import tariff in sector i. Hence, $(1+\tau_{t,i})\mathcal{E}_t P^\star_{t,i}$ is the domestic price of imports in sector i.

Expenditure minimization also implies that the sector-i *consumer* price is given by

$$P^c_{t,i} = \Big((1-\gamma_i) \cdot [P_{t,i}]^{1-\eta} + \gamma_i \cdot [(1+\tau_{t,i})\mathcal{E}_t P^\star_{t,i}]^{1-\eta} \Big)^{\frac{1}{\eta-1}} , \tag{7}$$

and the price of the final consumption good (CPI) is given by

$$P^c_t = \prod_i \left[P^c_{t,i} \right]^{\beta_i} . \tag{8}$$

2.1.2 Risk sharing

We assume complete international financial markets and, as a result, full risk sharing with the rest of the world. This yields the link between the domestic and foreign interest rates R_t and $R^\star_t$ (UIP condition):

$$E_t \left\{ Q_{t,t+1} \left(R_t - \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} R^*_t \right) \right\} = 0$$

As shown, for example, in Galí (2015), full risk sharing, together with identical initial conditions in the home country and the rest of the world, implies that domestic consumption relative to consumption in the rest of the world, C^*_t, is given by:

$$\frac{C_t}{C^*_t} = \frac{\mathcal{E}_t P^*_t}{P^c_t} . \tag{9}$$

2.1.3 Firms

Domestic production in a sector i is carried out by a continuum of monopolistically competitive firms denoted $k \in [0,1]$. Each firm produces output according to a constant-returns-to-scale production technology, combining sectoral labor with intermediate inputs:

$$Y_{t,i,k} = A_{t,i}\left(\frac{L_{t,i,k}}{\alpha_i}\right)^{\alpha_i}\prod_{j=1}^{N}\left(\frac{X_{t,i,j,k}}{\omega_{i,j}}\right)^{\omega_{i,j}(1-\alpha_i)},$$

where $Y_{t,i,k}$ denotes the output of firm k in sector i, $L_{t,i,k}$ is the amount of labor employed by the firm, and $X_{t,i,j,k}$ is is the quantity of good j used as an intermediate input. $A_{t,i}$ is sector-specific total factor productivity. The parameter α_i is the sectoral labor share in total costs, and $\omega_{i,j}$ is the share of input j in the total intermediate input cost of sector i.

The optimal choice of inputs yields the demand functions for sectoral labor and for intermediate inputs produced by sector j:

$$W_{t,i}L_{t,i,k} = \alpha_i MC_{t,i}Y_{t,i,k} \tag{10}$$

$$P^x_{t,j}X_{t,i,j,k} = (1-\alpha_i)\omega_{i,j}MC_{t,i}Y_{t,i,k}\,, \tag{11}$$

where $P^x_{t,j}$ is the price of intermediate good j, and $MC_{t,i}$ denotes the marginal costs common to all firms in sector i, given by

$$MC_{t,i} = \frac{\overline{A_i}}{A_{t,i}}W_{t,i}^{\alpha_i}\prod_{j=1}(P^x_{t,j})^{(1-\alpha_i)\omega_{i,j}}\,, \tag{12}$$

with $\bar{A}_i$ as a normalizing constant. Thus, marginal costs increase with wages and intermediate input prices, and decrease with sectoral productivity.

The input bundle of sector-j goods used in sector-i production is defined analogously to the sectoral consumption bundle in (1):

$$X_{t,i,j} = \left((1-\gamma_j)\cdot[X^D_{t,i,j}]^{\frac{\eta-1}{\eta}} + \gamma_j\cdot[X^F_{t,i,j}]^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}},$$

where $X^D_{t,i,j}$ and $X^F_{t,i,j}$ denote the quantities of domestically produced and imported sector-j goods used in sector-i production, respectively. The corresponding demand functions for these goods are:

$$X^D_{t,i,j} = (1-\gamma_j)\left(\frac{P_{t,j}}{P^x_{t,j}}\right)^{-\eta}X_{t,i,j} \tag{13}$$

and

$$X^F_{t,i,j} = \gamma_j \left(\frac{(1+\tau_{t,j})\mathcal{E}_t P^\star_{t,j}}{P^x_{t,j}} \right)^{-\eta} X_{t,i,j} \,, \tag{14}$$

and domestic varieties are aggregated into $X^D_{t,i,j}$ analogously to equation to (15).

Sectoral labor and intermediate goods are aggregated across firms according to $L_{t,i} = \int_k L_{t,i,k}$ and $X_{t,i,j} = \int_k X_{t,i,j,k}$.

Perfectly competitive aggregating firms collect firm-specific output within each domestic sector into a domestic sectoral good – used both for consumption and as an intermediate input – via the following CES function:

$$Y_{t,i} = \left(\int_0^1 Y_{t,i,k}{}^{\frac{\epsilon-1}{\epsilon}} dk, \right)^{\frac{\epsilon}{1-\epsilon}} , \tag{15}$$

where $\epsilon > 1$ denotes the elasticity of substitution between varieties. This implies that the domestic *producer* price in sector i is given by

$$P_{t,i} = \left(\int_0^1 P^{1-\epsilon}_{t,i,k} \, dk \right)^{\frac{1}{1-\epsilon}} \,. \tag{16}$$

Price setting. Since domestic producers are monopolistically competitive, each firm sets its own output price. Price setting is subject to Calvo price rigidity: in any given period, a fraction $1 - \lambda_i$ of firms in sector i reset their prices. Thus, λ_i captures sector-specific price stickiness. Firms that reset their prices choose a new price to maximize the expected stream of future profits generated while the price remains in effect:

$$\max_{\{P^f_{t,i}\}} E_t \sum_{s=t}^{\infty} Q_{t,s} \lambda_i^{s-t} (P^f_{t,i} Y_{s,i,k} - (1-\overline{\tau}) MC_{s,i} Y_{s,i,k})$$

where $P^f_{t,i}$ is the new price chosen by firms that reset their prices in period t, and $\bar{\tau}$ is a subsidy that offsets monopolistic markups in the steady state. The demand faced by each firm is given by

$$Y_{t,i,k} = \left(\frac{P_{t,i,k}}{P_{t,i}} \right)^{-\varepsilon} Y_{t,i} \,.$$

The optimal price chosen by firms that reset their prices is given by

$$P_{t,i}^{f} = \frac{E_t \sum_{s=t}^{\infty} Q_{t,s} \lambda_i^{s-t} P_{s,i} Y_{s,i} MC_{s,i}}{E_t \sum_{s=t}^{\infty} Q_{t,s} \lambda_i^{s-t} P_{s,i} Y_{s,i}} \tag{17}$$

and the sectoral domestic price index evolves as a weighted average of unchanged and newly set prices:

$$P_{t,i}^{1-\varepsilon} = \lambda_i \left(P_{t-1,i} \right)^{1-\varepsilon} + (1 - \lambda_i) \left(P_{t,i}^{f} \right)^{1-\varepsilon} . \tag{18}$$

2.1.4 Foreign demand and trade

Let $Y_{t,i}^{*}$ denote the total world demand for domestically produced good i. We impose the following structure on foreign demand for domestic good i:

$$E_{t,i} = \left(\frac{\mathcal{E}_t P_{t,i}^{*}}{P_{t,i}(1 + \tau_{t,i}^{e})} \right)^{\eta^{*}} \cdot Y_{t,i}^{*} , \tag{19}$$

where $E_{t,i}$ is the quantity of good i exported, $P_{t,i}^{*}$ is the price of good i in foreign currency, η^{*} is the elasticity of demand for exports and $\tau_{t,i}^{e}$ is a sector-specific export tax.

The total export across sectors, expressed in domestic currency is given by

$$EX_t = \sum_{i=1}^{N} (1 - \tau_{t,i}^{e}) P_{t,i} E_{t,i},$$

while total imports are given by

$$IM_t = \mathcal{E}_t \sum_{i=1}^{N} (1 + \tau_{t,i}) P_{t,i}^{*} (C_{t,i}^{F} + \sum_{j=1}^{N} X_{t,j,i}^{F}).$$

2.1.5 Policy and equilibrium

Monetary policy controls the domestic nominal interest rate and sets it in response to observable economic conditions:

$$R_t = f(\pi_t, y_t ...). \tag{20}$$

A fiscal authority pays a production subsidy $\bar{\tau}$ and collects revenues from import tariffs and export taxes. The net balance is then returned to or extracted from households via lump-sum transfers:

$$T_t = \sum_{i=1}^{N} \tau_{t,i} \mathcal{E}_t P^*_{t,i} (C^F_{t,i} + \sum_{j=1}^{N} X^F_{t,j,i}) + \tau^e_{t,i} P_{t,i} E_{t,i} - \bar{\tau} Y_{t,i} MC_{t,i} \ . \tag{21}$$

In equilibrium, all markets clear. This implies that domestic output in each sector is either consumed domestically, exported, or used as an intermediate input:

$$Y_{t,i} = C^D_{t,i} + \sum_{j=1}^{N} X^D_{t,j,i} + E_{t,i} \ . \tag{22}$$

2.1.6 Exogenous processes

We assume that total factor productivity and both import and export tariffs in each sector follow AR(1) processes in logs:

$$\begin{aligned} \log(A_{t,i}) = a_{t,i} &= \rho_a a_{t-1,i} + \varepsilon^a_{t,i} \\ \tau_{t,i} &= \rho_\tau \tau_{t-1,i} + \varepsilon^\tau_{t,i} \\ \tau^e_{t,i} &= \rho_{\tau^e} \tau^e_{t-1,i} + \varepsilon^{\tau^e}_{t,i} \end{aligned}$$

This specification reflects the empirical observation that tariff changes are often implemented abruptly and then gradually phased out – typically due to trade agreements or shifts in policy regimes.

2.2 Steady state, definitions, log-linearization

We log-linearize the model around a steady state in which all import and export tariffs are zero, trade is balanced in each sector, and all prices and the exchange rate are normalized to one.

Notation. Let us introduce the following steady-state notation. Column vectors of the form $[X_1, ..., X_N]'$ are denoted by bold letters, such as $\boldsymbol{X}$. The log-deviation of a variable X from its steady-state value is denoted by a lowercase letter, so that $x_t = \log(X_t) - \log(X)$, where X without a time subscript refers to the steady-state value. The matrix I_X is a diagonal matrix with the elements of $\boldsymbol{X}$ on the diagonal, and $\mathbf{1}$ denotes a column vector of ones.

Steady-state shares. We define several steady-state shares that are used throughout our analysis and in the calibration. The input-output matrix Ω collects the intermediate input shares in sectoral output, such that $\Omega_{ij} = (1-\alpha_i)\omega_{ij} = \frac{X_{ij}}{Y_i}$. The domestic product share in intermediate and consumption goods is given by $\frac{C_i^D}{C_i} = \frac{X_{ji}^D}{X_{ji}} = 1-\gamma_i$. The ratio of sectoral domestic consumption to aggregate consumption is $\frac{C_i^D}{C} = (1-\gamma_i)\beta_i$, while the ratio of sectoral imported consumption to aggregate consumption is $\frac{C_i^F}{C} = \gamma_i\beta_i$. We also denote the ratio of sectoral exports to aggregate consumption by $d_i \equiv \frac{E_i}{C}$.

Let us also define sectoral sales shares in aggregate consumption as $\xi_i = \frac{Y_i}{C}$, often referred to as Domar weights. Using the sectoral market-clearing condition, we can derive the vector of sales shares as:

$$\boldsymbol{\xi} = L' \cdot [(I - I_\gamma) \cdot \boldsymbol{\beta} + \boldsymbol{d}]$$

where $L = [I - \Omega(I - I_\gamma)]^{-1}$ is the Leontief inverse matrix relevant in this context. Having obtained an expression for the Domar weights, we can express key sectoral output shares as follows. The share of sector i output used for consumption is given by $\frac{C_i}{Y_i} = \frac{\beta_i}{\zeta_i}$; the share of sector i output used as an intermediate input in sector j production is $\frac{X_{j,i}}{Y_i} = (1-\alpha_j)\omega_{j,i}\frac{\zeta_j}{\zeta_i}$.

We log-linearize the model around the steady state and solve the resulting system of linear rational expectation equations using the QZ decomposition method (Klein, 2000).

3 Trade shock propagation: theory and evidence

In this section, we first characterize the propagation of tariff shocks through the domestic production network theoretically. We then bring our theoretical results to the data and document the empirical patterns of sectoral tariff propagation in the US.

3.1 Theoretical analysis

Various trade policies, including import tariffs, generally affect the terms of trade. It is therefore instructive to examine how terms-of-trade shocks propagate through the domestic production network. We define the sector-i terms of trade as

$$s_{t,i} = (e_t + p_{t,i}^\star + \tau_{t,i}) - p_{t,i} \;, \tag{23}$$

where $p_{t,i}$ is the domestic price of good i, e_t is the nominal exchange rate, $p^{\star}_{t,i}$ is the world price of good i, and $\tau_{t,i}$ is the import tariff. thus, $e_t + p^{\star}_{t,i} + \tau_{t,i}$ is the import price in domestic currency, inclusive of tariffs.

We now examine the propagation of changes in sectoral terms of trade to sectoral domestic outputs and prices within a simplified model that allows for analytical treatment. For this section, we impose the following simplifying assumptions: (i) monetary policy controls domestic final spending, $m_t = p^c_t + c_t$; (ii) the disutility of labor is linear ($\phi = 0$), implying that all sectoral wages satisfy $w_{t,i} = m_t$; (iii) markups $\boldsymbol{\mu}_t$ are treated as exogenous rather than being endogenized through price rigidity. These assumptions allow us to theoretically characterize the mechanisms by which terms-of-trade shocks affect the domestic economy.

Under assumptions (i)–(iii), and in the absence of other shocks, the relationship between tariffs and the terms of trade is given by:

$$\boldsymbol{s_t} = (I - [I + \hat{L}\Omega I_\gamma]^{-1}\hat{L}\Omega I_\gamma) \cdot \boldsymbol{\tau_t} \; . \tag{24}$$

That is, the patterns of propagation of terms-of-trade changes also characterize the propagation of tariff shocks, while focusing on the terms of trade allows for a clear additive separation between downstream and upstream propagation. The proposition below characterizes the propagation of terms-of-trade changes to domestic sectoral output:

Proposition 1 (Sectoral terms-of-trade propagation)**.** Domestic sectoral output and sectoral terms of trade are linked as

$$\boldsymbol{y_t} = (\eta - 1) \cdot (U + O) \cdot \boldsymbol{s_t} - D \cdot \boldsymbol{s_t} \; , \tag{25}$$

where the matrix $U = I_\xi^{-1} L'(I - I_\gamma)\Omega' I_\xi \cdot [I_\xi^{-1} I_{1-\gamma} I_\beta + I] I_\gamma$ captures *upstream propagation* through the transposed Leontief inverse $L' = [I - (I - I_\gamma)\Omega']^{-1}$ satisfying $L'(I - I_\gamma)\Omega' = L' - I$. The diagonal matrix $O = I_\xi^{-1} I_{1-\gamma} I_\beta I_\gamma$ captures the impact of terms-of-trade changes within the *own sector*. Finally, $D = \hat{L}\Omega \cdot I_\gamma$ is the matrix capturing *downstream propagation* of terms-of-trade changes through yet another Leontief inverse $\hat{L} = (I - \Omega)^{-1}$, which satisfies $\hat{L}\Omega = \hat{L} - I$.

The result outlined in Proposition 1 is intuitive. Sectoral terms of trade propagate both upstream and downstream to affect sectoral domestic output. When tariffs are imposed on upstream industries, they lead to reduced output in downstream sectors. This occurs because intermediate inputs include imported goods, which become more expensive due to the tariffs. The resulting increase in input costs raises production expenses and leads to lower output in the downstream sectors.

However, as long as $\eta \neq 1$ a second direction of tariff propagation emerges: the own-sector impact and upstream propagation. If imported and domestic varieties are sufficiently substitutable, that is, $\eta > 1$, this propagation leads to an increase in domestic output in response to a tariff in a sector where the tariff is imposed as well as in upstream sectors. Domestic output in the own sector increases because the tariff shields the domestic industry from foreign competition. The output in upstream sectors also rises because the tariff protects not just the own sector but the entire domestic supply chain – a shift towards domestic production increases demand for domestic intermediate inputs, boosting output upstream.

Next, we establish the propagation of sectoral terms-of-trade onto sectoral domestic prices in the following Corollary:

Corollary 1 (Terms-of-trade effect on domestic good prices)**.** Terms-of-trade shock affect domestic prices via

$$\boldsymbol{p}_t = D \cdot \boldsymbol{s_t} \ . \tag{26}$$

Under our assumptions, sectoral terms-of-trade propagate to domestic prices only in the downstream direction, through the increased costs of imported intermediate inputs. Note that sectoral consumption prices can be expressed as $\boldsymbol{p^c_t} = \boldsymbol{p_t} + I_\gamma \boldsymbol{s_t}$. Hence, these prices are influenced both directly — through more expensive imports — and indirectly —through higher domestic prices resulting from increased production costs.

The important question in tariff policy is whether tariffs lead to an expansion or a recession.To analyze this question, we define GDP as the aggregate real value added – that is, nominal value added deflated by the GDP deflator. The following corollary establishes the effect of terms-of-trade shocks on GDP:

Corollary 2 (Terms-of-trade propagation on GDP)**.** The link between sectoral terms of trade and aggregate final output is

$$y_t^{GDP} = (\eta - 1) \cdot \boldsymbol{\hat{\xi}'} \cdot (U + O) \cdot \boldsymbol{s_t} - \boldsymbol{\hat{\xi}'} \cdot D \cdot \boldsymbol{s_t} \tag{27}$$

where $\hat{\xi}_i = \frac{VA_i}{VA}$.

The effect of sectoral terms-of-trade changes on GDP is twofold. First, if domestic and imported varieties are substitutes (i.e., $\eta > 1$), the direct and upstream effects are positive: trade protection shifts consumption toward domestic goods, increasing domestic output. However, in the presence of a production network (i.e., D is non-zero), this positive effect is mitigated by an increase in production costs. Higher input prices make domestic goods more expensive, which reduces the incentive to substitute away from imported goods. Which effect dominates is ultimately a quantitative question, dependent on the specific structure of the production network.

3.2 Three-sector example

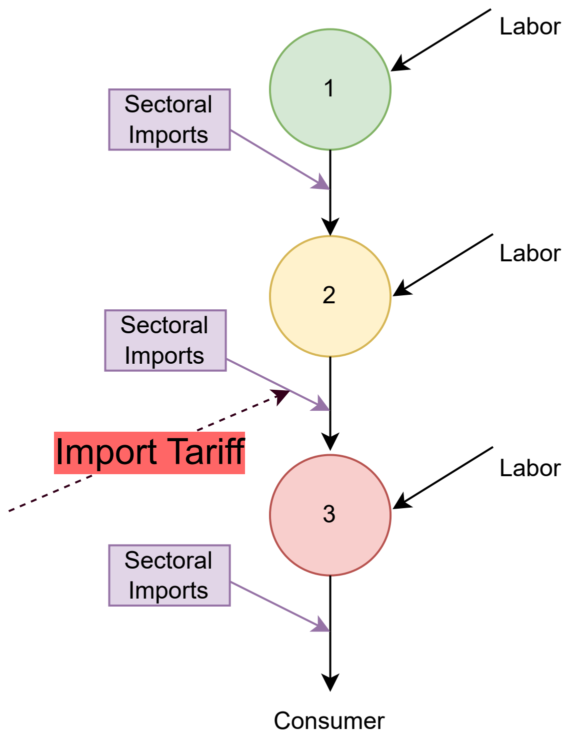
We now illustrate graphically the propagation of sectoral tariffs within a three-sector example economy depicted in Figure 1. This is a vertically integrated supply chain economy in which both imported and domestic inputs are used in production. The domestic inputs are sourced from sectors located upstream in the supply chain. The three-sector vertical production network is sufficiently deep, for our purposes, to capture both upstream and downstream propagation of shocks. To illustrate the propagation mechanism, we consider an import tariff imposed on Sector 2. In this case, downstream propagation affects Sector 3, while upstream propagation influences Sector 1. Sector 2 is referred to as the "own sector" in this example.

Figure 2 illustrates the response of sectoral output to a tariff shock in Sector 2. The middle panel shows the own-sector effect in Sector 2: output increases as the tariff shields the domestic industry from foreign competition. The left panel captures upstream propagation: output in Sector 1 rises because the tariff in Sector 2 shifts production toward the domestic supply chain, boosting demand for Sector 1's output. The right panel shows downstream propagation: output in Sector 3 falls as the imported input from Sector 2 becomes more expensive due to the tariff, raising production costs.

3.3 Empirical evidence

We now turn to documenting the empirical patterns of tariff propagation through the domestic production network in the US. To this end, we construct time series of upstream and downstream tariff exposure for each sector, based on its input-output linkages to sectors where the tariff is imposed. Guided by our theoretical results, we then estimate an empirical specification to capture the propagation of tariffs across the production network.

Figure 1: Three-sector example: vertical supply chain economy



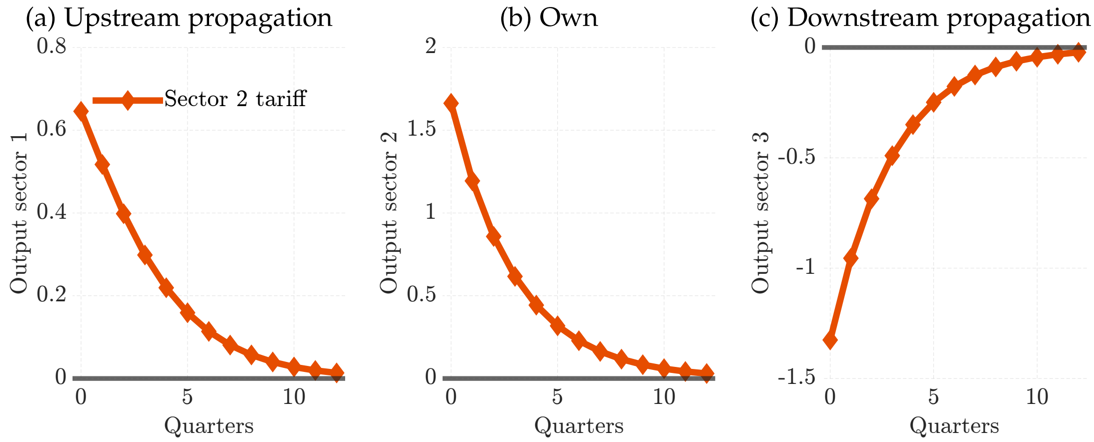
Notes: This figure depicts a three-sector vertical chain economy, in which sector-specific imported inputs are used at all stages of production. An import tariff is imposed on Sector 2.

3.3.1 Data

Tariffs. We construct sectoral tariff measures following the approach of Poilly and Tripier (2025). For this, we extract data on US imports and duties from the US Census Bureau using USA Trade Online. Using Harmonized System (HS) data, we collect (i) "Customs Value (Gen)" – the value of imported goods as reported by US Customs and Border Protection, expressed in US dollars; and (ii) "Calculated Duty" – the estimated import duties, also expressed in US dollars. Both series are extracted at the 10-digit disaggregation level for all countries of origin. The data is collected at a monthly frequency and then aggregated to quarterly values. The time span covers January 2002 (the earliest available period for monthly data) to December 2024.

Output and prices. We retrieve sectoral output and price data from the US Bureau of Economic Analysis. Specifically, we use the "Real Gross Output by

Figure 2: Propagation of a tariff shock in a three-sector vertical chain economy



Notes: This figure shows sectoral output responses to a tariff shock in Sector 2 in a three-sector vertical chain economy. Trade openness is set to 0.4 in each sector. Sectoral labor shares are (1,0.6,0.6). All remaining parameters follow those reported in Table 1. All responses are expressed as percentage deviations from the steady state.

Industry" table, which provides seasonally adjusted real output (measured in 2017 US dollars) for 66 industries (excluding government). For prices, we use the "Chain-Type Price Indexes for Intermediate Inputs by Industry". Both data series are available at a quarterly frequency, covering the period from Q1 2005 to Q3 2024.

Input-output data. To construct the input-output matrix, we employ the data from the Use Tables by the US Bureau of Economic Analysis. The table we use provides information on the usage of commodities by 66 US industries for the year 2023, expressed in US dollars.

Harmonizing data. We harmonize sectoral import and tariff data with output and price data in two steps. First, using the USITC DataWeb mapping, we map imports and tariffs from 10-digit HTS codes to North American Industry Classification System (NAICS) codes and then convert NAICS codes into the BEA system. We focus on BEA2 industry codes, the highest available level of disaggregation for output. As a result, we obtain non-zero import tariff data for 23 sectors, along with sectoral output and price data for 66 sectors.

3.3.2 Methodology

We estimate the patterns of tariff shock propagation following the methodology of Acemoglu et al. (2016). To this end, we begin by constructing upstream and downstream proximity matrices. These matrices capture the intensity of direct and indirect input-output linkages between sectors, allowing us to quantify upstream and downstream exposure of each sector to tariff changes originating in other sectors. We then construct measures of upstream and downstream tariff exposure by weighting sectoral tariff changes by the corresponding entries in the proximity matrices.

Downstream propagation. First, we construct the use matrix Ω, where $\Omega_{ij} = \frac{P_j X_{ij}}{MC_i Y_i}$, that is the share of input j in the total cost of output i. The Leontief inverse of Ω, defined as $\hat{L} = (I - \Omega)^{-1}$, captures the downstream propagation. Specifically, $\hat{L}_{ij}$ reflects the importance of sector j as a direct and indirect supplier to sector i.

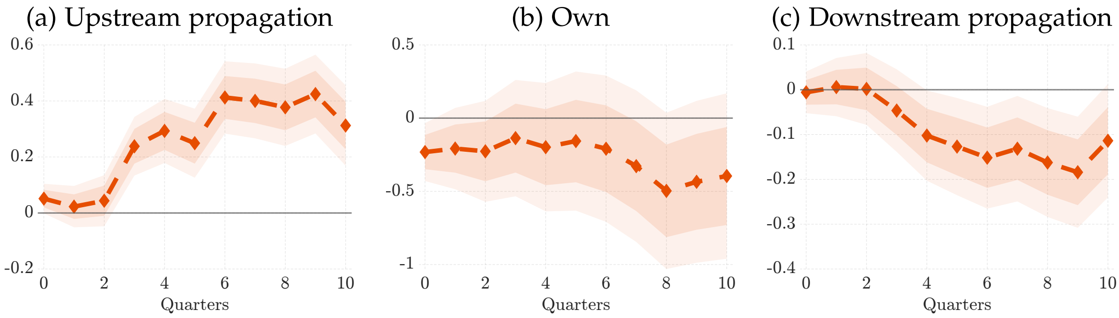
Upstream propagation. Next, we build the sales matrix $\tilde{\Omega}$, such that $\tilde{\Omega}_{ij} = \frac{P_j X_{ji}^D}{P_i Y_i}$ is the share of domestic good i's sales to sector j in the total sales of good i. Leontief inverse of this matrix, $\tilde{L} = (I - \tilde{\Omega})^{-1}$, captures upstream propagation, with $\tilde{L}_{ij}$ reflecting the importance of sector j as a direct and indirect buyer of good i.

Upstream and downstream tariff exposure. Given the vector of sectoral tariff changes $\boldsymbol{\Delta\tau_t}$, the effective measure of tariff exposure to the upstream sectors relevant to a focal industry is captured by $(\hat{L} - I) \cdot \boldsymbol{\Delta\tau_t}$. Specifically,the upstream tariff exposure for sector i is given by $X_{t,i}^D = \sum_j (\hat{L}_{ij} - 1_{i=j}) \cdot \Delta\tau_{t,j}$, where $1_{i=j}$ is an indicator function equal to 1 if $i = j$, and 0 otherwise. Similarly, the exposure to downstream tariffs is captured by $(\tilde{L} - I) \cdot \boldsymbol{\Delta\tau_t}$, where the downstream exposure for sector i is summarized as $X_{t,i}^U = \sum_j (\tilde{L}_{ij} - 1_{i=j}) \cdot \Delta\tau_{t,j}$. Finally, the tariff exposure to the own sector tariff is given by $X_{t,i}^O = \Delta\tau_{t,i}$.

Upstream/downstream propagation of tariffs. Having constructed our effective measures of upstream, downstream, and own-sector exposure to tariff changes, we now turn to estimating how tariffs propagate to sectoral domestic output. Proposition 1 establishes the upstream, downstream, and own-sector directions of tariff propagation on output. Guided by this result, we estimate an empirical specification aiming to capture all three aspects of propagation. To estimate the dynamic responses, we employ a local projection methodology and estimate the following specification:

$$Y_{t+h,i} - Y_{t-1,i} = \beta_O^h X_{t,i}^O + \beta_D^h X_{t,i}^D + \beta_U^h X_{t,i}^U + \gamma_i + \gamma_t + X_{t,ij} + \epsilon_{t,ij}^h \tag{28}$$

Figure 3: Propagation of tariffs on domestic sectoral output



The dark shaded area represents the 67% confidence interval; the light shaded area is the 90% confidence interval.

for $0 \leq h \leq H$. Here, $Y_{t+h,i}$ is sectoral output at horizon h, and $X^O_{t,i}$, $X^D_{t,i}$, and $X^U_{t,i}$ denote the own, upstream, and downstream exposure to tariff changes for sector i, respectively. Note that the subscripts D and U indicate the *direction* of propagation, not the origin of the tariff change. The terms γ_t and γ_i denote time and sector fixed effects, and $X_{t,ij}$ is a vector of other controls (including lagged output $Y_{t-1,i}$). The coefficients $\{\beta^h_D\}^H_{h=1}$ capture the downstream propagation of tariffs, $\{\beta^h_U\}^H_{h=1}$ the upstream propagation, and $\{\beta^h_O\}^H_{h=1}$ the effect of tariffs within the sector itself.

Additionally, we estimate the propagation of tariffs on sectoral domestic prices using the specification implied by Corollary 1:

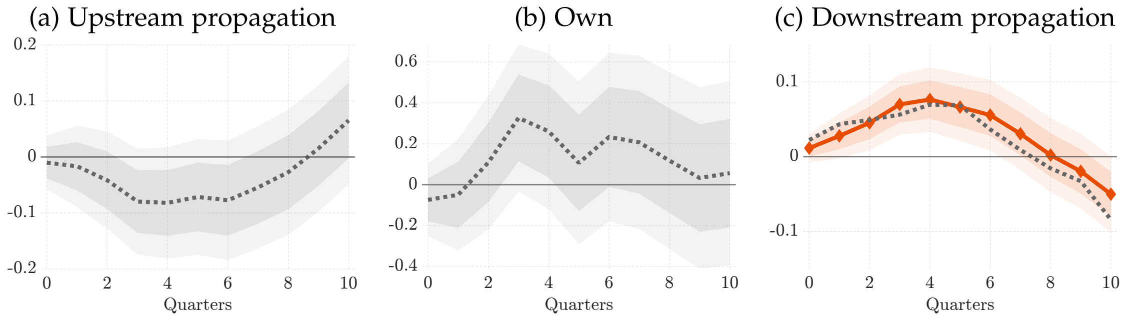
$$P_{t+h,i} - P_{t-1,i} = \beta^h_D X^D_{t,i} + \gamma_i + \gamma_t + X_{t,ij} + \epsilon^h_{t,ij} \tag{29}$$

where $P_{t+h,i}$ denotes the price level in sector i at horizon h. Note that, unlike the estimations for output, the baseline specification for prices excludes upstream and own-sector tariff propagation, in accordance with our theoretical result. We then augment our baseline specification to include all three directions of propagation — own, upstream, and downstream — to mirror the specification used for output.

3.3.3 Estimation results

Figure 3 shows the estimated propagation of tariffs to domestic sectoral output. Panel (c) shows that, in line with our theoretical predictions, downstream tariff propagation leads to a decline in sectoral output. Specifically, a one percentage point increase in the effective upstream tariff leads to a gradual decline in output, peaking at approximately 0.2% after 6 to 8 quarters.

Figure 4: Propagation of tariffs on domestic sectoral prices



Notes: **Solid red line** in Panel (c) plots the effect of downstream tariff propagation on prices using the specification that includes only downstream propagation. The confidence bands in Panel (c) correspond to this baseline specification. The **dotted grey lines** depict the estimated price responses in the alternative specification that includes all directions of propagation. Confidence bands in Panels (b) and (c) correspond to this alternative specification. The dark shaded area represents the 67% confidence interval, while the light shaded area indicates the 90% confidence interval.

Panel (a) of Figure 3 shows the empirical upstream propagation of tariffs. A one percentage point increase in effective tariffs in downstream sectors leads to a gradual increase in sectoral output, peaking at approximately 0.4% after five quarters. This positive response is consistent with the theoretical prediction that upstream sectors may benefit from increased domestic demand when tariffs are imposed on downstream industries.

Finally, Panel (b) reports the effect of tariffs imposed within the sector itself. We do not find statistically significant evidence of own-sector tariff propagation to output. One possible explanation is that the sectoral classification is not sufficiently disaggregated; as a result, the “own” sector may include both upstream and downstream industries, making it difficult to isolate the true own-sector effect in the data.

We now turn to estimating the downstream producer price response to an imposed tariff, as specified in Equation 29. We then complement this baseline estimation with an alternative specification that includes upstream and own-sector directions of propagation, which are not dictated by our theoretical results.

The solid line in Panel (c) of Figure 4 depicts the estimated downstream tariff propagation to prices under the baseline specification. Consistent with our theoretical predictions, an increase in upstream tariffs leads to higher prices in sectors that rely on the tariffed inputs for production. A one percentage point increase in the effective tariff measure results in nearly a 0.1 percent rise in downstream prices, and this effect is statistically significant. This finding is consistent with the theoretical mechanism: imported inputs become more expensive, raising the cost of domestic production and, in turn, pushing domestic prices upward.

We then extend the specification to include upstream and own-sector propagation, mirroring the approach used in our output analysis. The thin dotted lines in Panels (a)–(c) of Figure 4 display the results from this alternative specification. We do not find statistically significant effects for these additional directions.

4 Quantitative analysis

We now turn to a full-fledged version of our model presented in Section 2, incorporating sticky prices, non-linear labor supply, and endogenous markups. Using a calibrated version of this model, we quantitatively examine the effects of tariffs. We consider two quantitative experiments: (1) a 10% uniform tariff applied across all sectors, and (2) a set of sectoral tariffs reflecting the distribution proposed under the "Liberation Day" scenario announced by the U.S. government in April 2025 (and subsequently retracted).

Next, we describe the calibration of the model parameters and the tariff distribution.

4.1 Model calibration

Model parameters. To calibrate the sectoral structure of the model, we use the Bureau of Economic Analysis Input-Output Accounts Data. For the intermediate input shares $\omega_{i,j}$, labor shares α_i, and consumption shares β_i, we rely on the 2023 "Use Table", which covers 71 industries. Following Baqaee and Farhi (2020), we exclude the government, scrap, and noncomparable imports sectors and assume that each industry produces exactly one commodity. We drop sectors whose output is neither used in final consumption nor as intermediate inputs by any other industry, leaving us with 63 sectors. For each of the remaining sectors, we compute the input share of each commodity, yielding $\omega_{i,j}$. We then use the field "Compensation of employees" for each industry to calibrate sectoral labor shares α_i as the share of compensation of employees in total costs (defined as compensation plus the expenditure on all intermediate

Table 1: Parametrization of three-sector vertical economy

Parameter	Description	Value
η	Import elasticity	2
η^*	Export elasticity	2
δ	Discount factor	0.96
φ	Inverse Frisch elasticity	2
ρ_τ	Tariff shock persistence	0.7
ϕ_π	Inflation feedback Taylor rule	1.5

inputs). Next, we calibrate the consumption shares β_i using each sector's share of "Personal consumption expenditure" in the total value of personal consumption across all sectors. To calibrate sectoral trade openness γ_i, we divide the "Imports of goods and services" from the 2023 import matrix (before redefinition) by the total domestic use of products – that is, the difference between "Total use of products" and "Exports of goods and services", as reported in the Use Table for each commodity.[1]

We base our calibration of sectoral price stickiness λ_i on the estimates for monthly price adjustment frequencies from Pasten et al. (2024). See Appendix for details on how we aggregate these frequencies to the level of 2-digit BEA codes. We convert the monthly adjustment probabilities θ_i into quarterly price stickiness λ_i by setting $\lambda_i = (1 - \theta_i)^3$. The remaining model parameters are calibrated as shown in Table 1.

Monetary policy. As the baseline monetary policy, we assume that the central bank follows a Taylor rule, which, after log-linearization, takes the form

$$i_t = \phi_\pi \pi_t^{PPI},$$

where $\phi_\pi = 1.5$, and π_t^{PPI} is producer price inflation. We define π_t^{PPI} as the linear combination of sectoral domestic inflations, computed using Domar weights.

Tariff package calibration. We compute the sectoral tariff rates implied by the tariff package announced by the US government on April 2, 2025. Although the package has since been revised and largely withdrawn, it illustrates how tariffs that are uniform at a country level can still result in heterogeneous effective sectoral tariff rates.

[1]Due to symmetry between the domestic economy with the rest of the world, steady state export shares are set equal to import shares.

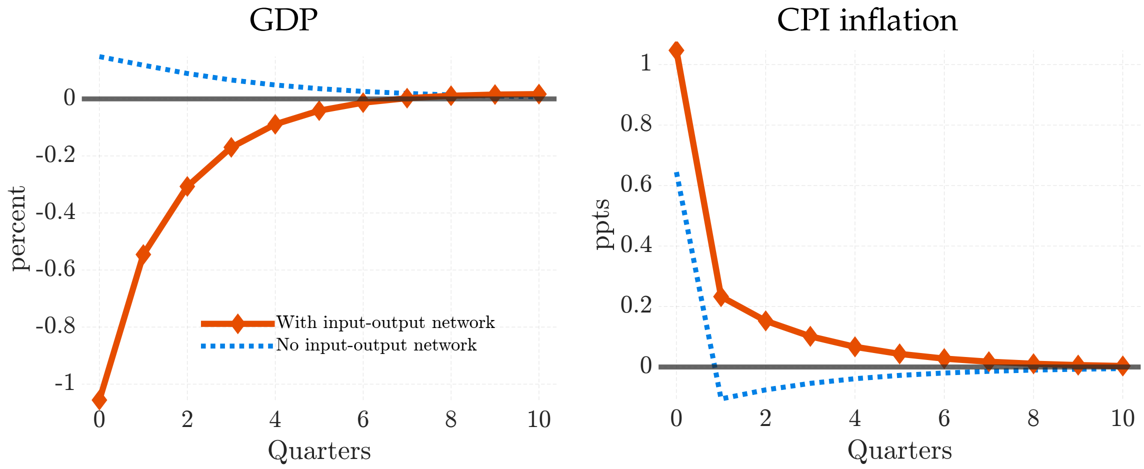
Table 2: Effective sectoral tariffs implied by the "Liberation Day" package

BEA2 sector	Description	Tariff rate
315AL	Apparel and leather and allied products	31.72%
337	Furniture and related products	30.45%
313TT	Textile mills and textile product mills	27.28%
334	Computer and electronic products	25.88%
339	Miscellaneous manufacturing	24.54%
335	Electrical equipment, appliances, & components	24.54%
326	Plastics and rubber products	24.32%
332	Fabricated metal products	22.54%
327	Nonmetallic mineral products	21.46%
333	Machinery	21.01%
3364OT	Other transportation equipment	17.80%
322	Paper products	17.62%
113FF	Forestry, fishing, and related activities	17.14%
3361MV	Motor vehicles, bodies and trailers, and parts	16.48%
311FT	Food and beverage and tobacco products	16.19%
111CA	Farms	13.13%
331	Primary metals	12.15%
323	Printing and related support activities	11.62%
212	Mining, except oil and gas	7.20%
321	Wood products	6.78%
325	Chemical products	5.92%
324	Petroleum and coal products	0.73%
211	Oil and gas extraction	0.00%

To compute the sectoral imports structure across US trading partners, we use Harmonized System (HS) District-level Data from the US Census Bureau. We consider imports ("`Customs Value (Cons)($US)`") from all countries of origin in 2024 at the 10-digit level. For each of the 32,583 commodities, we compute the share of each country of origin in the overall imports of that commodity. We then multiply these shares by the country-specific tariff rates reflecting the "Liberation day" policy. The list of these rates is provided in Table C.5 in the Appendix. For all countries not listed in Table C.5 (except Belarus, Cuba, North Korea, and Russia), we apply a baseline tariff of 10%. For all exempted commodities listed in Appendix II of Executive Order 14257 [2], we subsequently set the tariff rate to zero. This yields effective tariff rates for all commodities at the 10-digit level. Finally, we use the mapping from 10-digit HTS codes to 23 BEA2 industry codes, as described in Section 3.3. When aggregating multiple units to a higher level, we weigh them by their import shares. As shown in Table 2,

[2] Accessed via https://www.whitehouse.gov/wp-content/uploads/2025/04/Annex-II.pdf

Figure 5: Aggregate effects of a uniform 10% import tariff



Notes: This figure shows the aggregate impulse responses to the imposition of a 10% import tariff on all sectors in the quantitative model. Red solid lines with markers denote responses under the full production network; blue dashed lines are responses when no intermediate inputs are used in production. Responses are in percent/ppts deviations from the steady state.

the resulting effective tariff rates exhibit significant variation across the 23 BEA2 sectors.

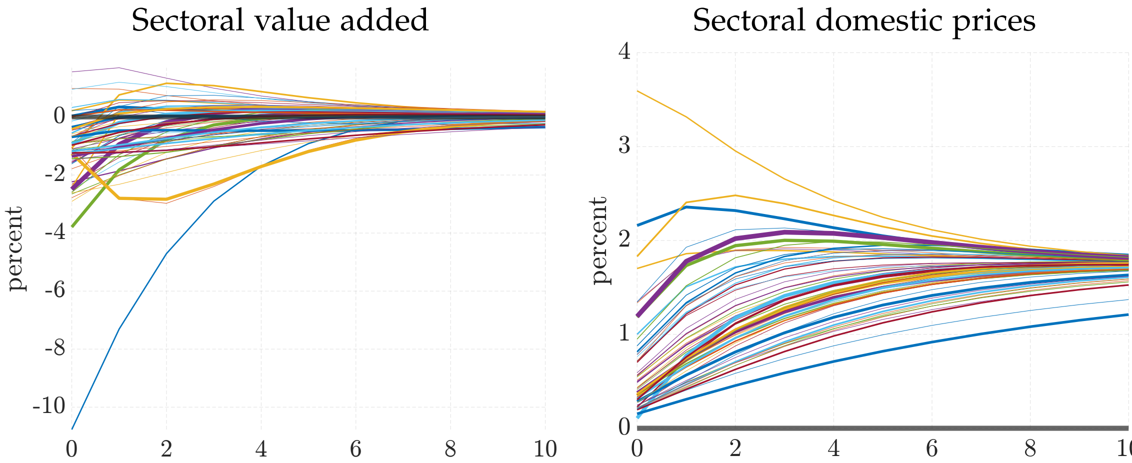
4.2 Quantitative results

We begin by examining the model prediction for the responses of domestic output (GDP) and inflation (CPI) to a uniform tariff shock.[3] As shown in Figure 5 (red line), GDP falls while inflation rises, indicating that the uniform tariff shock is *stagflationary*. The decline in domestic output primarily reflects the downstream propagation of tariffs through the domestic production network: higher import tariffs in upstream sectors raise input costs for downstream producers, driving up domestic prices and reducing output.

To illustrate the role of production network linkages in shaping the economy's response to tariffs, we consider a counterfactual version of the economy in which the domestic production network is suppressed by setting the input–output matrix to zero. We then repeat the same quantitative experiment—imposing a 10% uniform tariff—on the counterfactual version of the economy.As shown in Figure 5 (blue line), in the absence of a production network, domestic output increases in response to a uniform tariff. Without the production

[3]GDP is computed as aggregate real value added, calculated by summing sectoral nominal value added and deflating the result by the GDP deflator. CPI inflation is computed as the change in the price of the aggregate consumption good.

Figure 6: Sectoral effects of uniform 10% tariff



Notes: This figure shows the sectoral impulse responses to the imposition of a 10% import tariff on all sectors in the quantitative model. Left panel: real value added (nominal VA deflated by the GDP deflator) for each sector. Right panel: domestic sectoral prices. Each line represents one sector; line width is proportional to the sector's Domar weight.

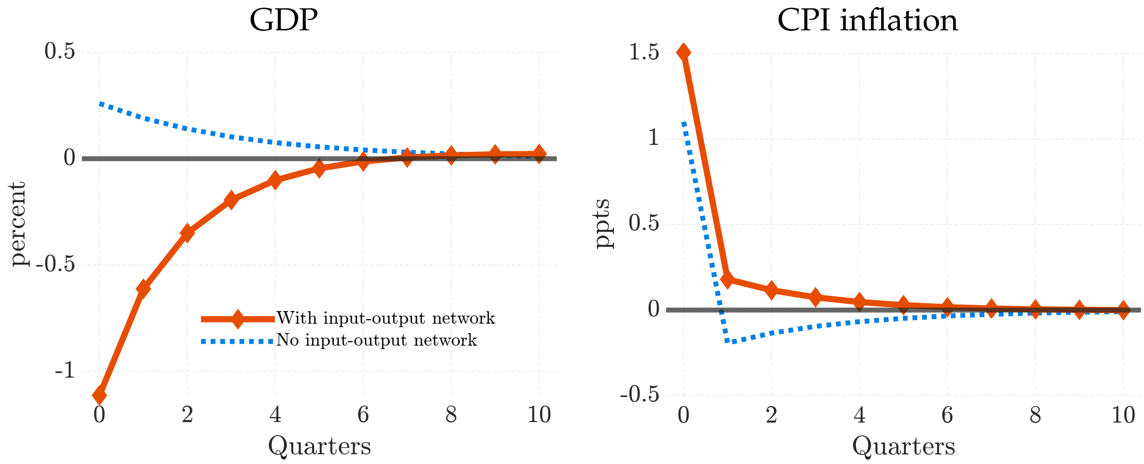
network, the economy effectively becomes a multi-sector horizontal system in which domestic production costs are not directly affected by tariffs. As a result, the tariff stimulates domestic production by shielding the domestic economy from foreign competition. Note also that in the presence of a production network, the inflation response to the tariff shock becomes more pronounced and persistent.[4]

Figure 6 illustrates the sectoral heterogeneity in responses to a tariff shock. In line with the theory, value added (left panel) increases in some sectors, in which the upstream propagation effect from higher demand for domestic varieties outweighs the downstream propagation effect of rising input costs. In most sectors, however, the downstream propagation dominates, resulting in negative sectoral responses and ultimately driving the aggregate recession shown in Figure 5. Sectoral domestic prices (right panel), on the other hand, increase across all sectors.

In addition to the uniform tariff, we also construct the model response to the ”Liberation Day” tariff scenario. Unlike the uniform tariff, the “Liberation Day” policy implies a non-uniform distribution of effective tariffs across sectos (see Table 2). As shown in Figure 7, the “Liberation Day” tariff shock leads to a decline in domestic output and a rise in inflation. Similar to the uniform tariff, the recessionary impact on output is primarily driven by the downstream

[4]This is consistent with the notion that production networks in sticky-price economies amplify the persistence of inflation response to shocks, see Afrouzi and Bhattarai (2023).

Figure 7: Aggregate effects of "Liberation Day" tariffs



Notes: This figure shows the aggregate impulse responses to the imposition of "Liberation Day" tariff policy, as detailed in Table 2 in the quantitative model. Red solid lines with markers denote responses under the full production network; blue dashed lines are responses when no intermediate inputs are used in production. Responses are in percent/ppts relative to steady state.

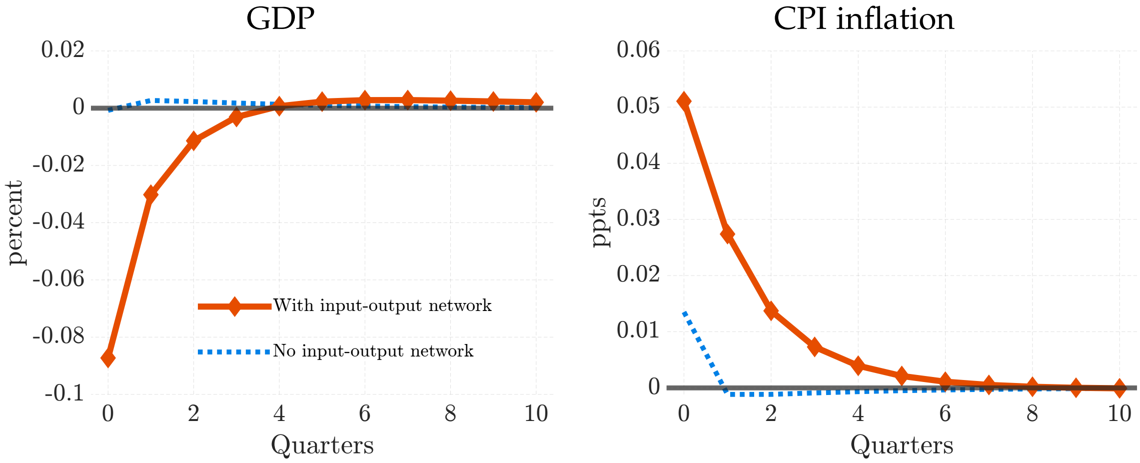
transmission of tariffs through the production network, as confirmed by the counterfactual without production linkages.

While the qualitative effects of the uniform and "Liberation Day" tariff scenarios are broadly similar, there is a notable quantitative difference. The "Liberation Day" tariffs are approximately 50% more inflationary than the uniform tariffs for the same reduction in domestic output. This suggests that the "Liberation Day" tariffs are more stagflationary – an outcome driven by their non-uniform application across sectors, which amplifies relative price distortions.

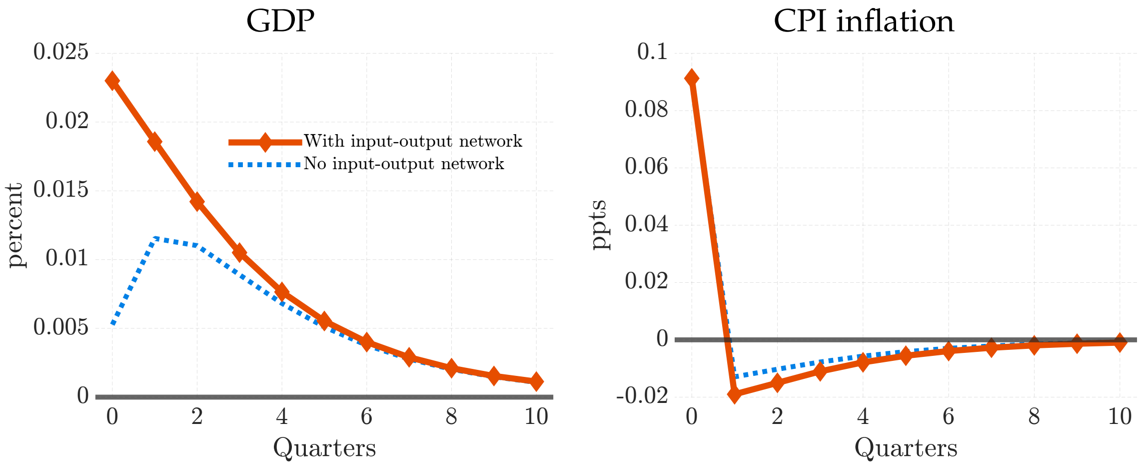
Having shown that tariffs can increase output in individual sectors, we now ask whether sector-specific tariffs can cause an aggregate expansion, despite the presence of the production network. In our quantitative model, for nearly all sectors with a significant import share, a sector-specific tariff results in an aggregate recession. This implies that almost all tradable sectors play a large enough role as (direct or indirect) suppliers to other sectors in the domestic economy, such that downstream propagation through higher input prices dominates the upstream propagation through higher demand. To illustrate this, the upper panels of Figure 8 show the aggregate effects of a 10% tariff in the "Farms" sector. This tariff is highly recessionary, with the downturn primarily driven by the downstream propagation of the tariff through the domestic supply network. Moreover, the downstream propagation through the network amplifies the price

Figure 8: Aggregate effects of sector-specific tariffs

(a) 10% Tariff in "Farms" sector



(b) 10% Tariff in "Apparel, leather, and allied products" sector

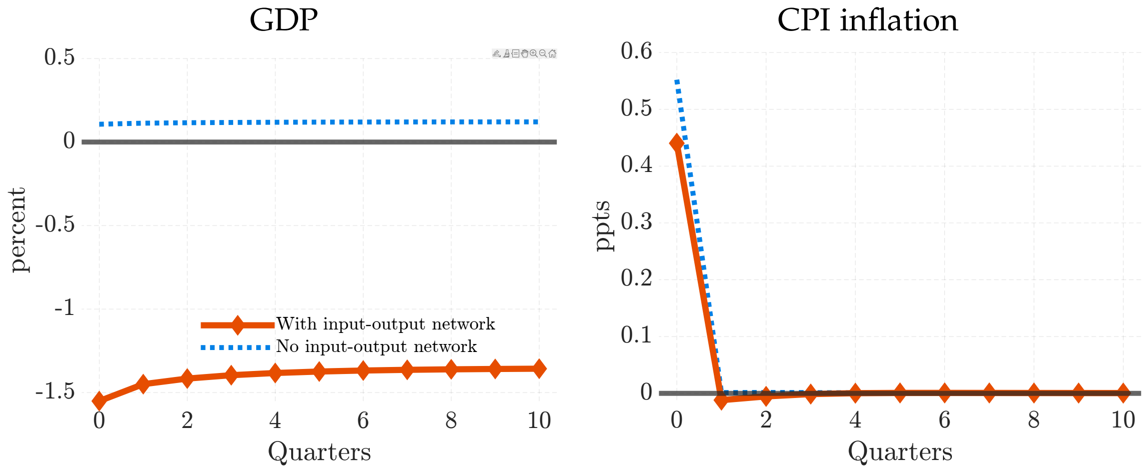


Notes: This figure shows the aggregate impulse responses to the sector-specific import tariff of 10% in the quantitative model. Panel (a) presents the response to a tariff imposed on the Farm sector (BEA2 code 111CA). Panel (b) shows the response to a tariff on the "Apparel and leather and allied products" sector (BEA2 code 315AL). Red solid lines with markers denote responses under the full production network; blue dashed lines are responses when no intermediate inputs are used in production. Responses are in percent/ppts deviations from the steady state.

response.

However, not all sector-specific tariffs lead to an aggregate recession — imposing tariffs on certain sectors can result in aggregate expansion. An illustration of this possibility is the "Apparel and leather and allied products" sector. As shown in the bottom panels of Figure 8 , imposing a tariff on this sector is expansionary, with input-output linkages amplifying the boom. This indicates that although the sector likely transmits shocks in both directions, its

Figure 9: Aggregate effects of permanent uniform 10% tariff



Notes: This figure shows the aggregate impulse responses to the imposition of a permanent 10% import tariff on all sectors in the quantitative model. Red solid lines with markers denote responses under the full production network; blue dashed lines are responses when no intermediate inputs are used in production. Responses are in percent/ppts deviations from the steady state.

role as a demander of inputs contributes more to propagation than its role as a supplier, leading to dominant upstream effects. Note that in this case, the inflation dynamic is only marginally influenced by the presence of a production network, as downstream propagation – which primarily shapes the price response – is particularly weak.

Finally, we examine the effects of a *permanent* 10% uniform tariff. Figure 9 shows the results. Whereas GDP jumps almost immediately to its slightly higher long-run value without a network, it somewhat overshoots its new (lower) long-run value in the first few quarters after the shock when accounting for input-output linkages. Notably, the long-run level of GDP in this case is lower than the short-run impact of a non-permanent shock, since households can not smooth their consumption after a tariff increase in the expectations of higher future consumption.

5 Conclusion

What are the short-run effects of an import tariff shock, notably on output and inflation? We address this question with a focus on the propagation of tariffs through the domestic production network—both analytically and by presenting new evidence. The network is also key to the aggregate effect of the shock: we find that it can even alter the sign of the effect of a tariff on GDP and inflation—even when it is imposed uniformly across all sectors.

Our quantitative results show that the aggregate consequences of tariffs are sensitive to their distribution across sectors and the structure of the production network. As we simulate the "Liberation Day" tariffs, we find output effects that are similar to the uniform tariff but the inflationary effect is stronger still—underscoring the importance of accounting for production linkages in trade policy evaluation.

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Appendix

A Model derivations and proofs

A.1 Steady-state domestic sales shares

Consider the steady state sectoral market clearing condition: $Y_i = C_i^D + \sum_j X_{ji}^D + E_i$. Rewrite it in terms of shares: $\frac{Y_i}{C} = \frac{C_i^D}{C} + \sum_j \frac{X_{ji}^D}{C} + \frac{E_i}{C}$. The corresponding shares are $\frac{C_i^D}{C} = \frac{C_i^D}{C_i} \cdot \frac{C_i}{C} = (1-\gamma_i)\beta$, $\frac{X_{ji}^D}{C} = \frac{X_{ji}^D}{X_{ji}} \cdot \frac{X_{ji}}{Y_j} \cdot \frac{Y_j}{C} = (1-\gamma_i)\cdot(1-\alpha_j)\omega_{ji} \cdot \frac{Y_j}{C}$, $\frac{E_i}{C} = d_i$. Let us denote the domestic sales share $\frac{Y_i}{C} = \xi_i$. Then, we can write $\xi_i = (1-\gamma_i)\beta_i + (1-\gamma_i)\sum_j(1-\alpha_j)\omega_{ji}\xi_j + d_i$, which in matrix form gives $\boldsymbol{\xi} = (I - I_\gamma)\boldsymbol{\beta} + \boldsymbol{d} + (I - I_\gamma)\Omega'\boldsymbol{\xi}$, from where the expression for vector of sales shares follows:

$$\boldsymbol{\xi} = L' \cdot [(I - I_\gamma)\cdot \boldsymbol{\beta} + \boldsymbol{d}] \tag{30}$$

where $L = [I - \Omega(I - I_\gamma)]^{-1}$ is the Leontieff inverse matrix, relevant in this context.

A.2 Proof of Proposition 1

Sectoral market clearing. We log-linearize the sectoral market clearing condition. First, we multiply by sectoral good price: $P_{t,i}Y_{t,i} = P_{t,i}C_i^D + \sum_j P_{t,i}X_{t,ji}^D + P_{t,i}E_{t,i}$. Then we have,

$$\xi_i(p_{t,i}+y_{t,i}) = (1-\gamma_i)\beta_i(p_{t,i}+c_{t,i}^d) + I_d(e_t + d_{t,i}) + (1-\gamma_i)\sum_j(1-\alpha_j)\omega_{ji}\xi_j(p_{t,i}+x_{t,ji}^d)$$

where e_t is exchange rate, $d_{t,i}$ is export demand shock in sector i.

We can express $p_{t,i} + x_{t,ji}^d = x_{t,ji} + \eta(p_{t,i}^x - p_{t,i}) + p_{t,i} = x_{t,ji} + p_{t,i}^x + (\eta - 1)\gamma_i s_{t,i}$, where $s_{t,i} = (e_t + \tau_{t,i} + p_{t,i}^\star) - p_{t,i}$ is terms of trade. And $x_{t,ji} + p_{t,i}^x = y_{t,j} + p_{t,j} - \mu_{t,j}$ follows from intermediate input demand equation, where $\mu_{t,i}$ is sectoral markup.

Then, in matrix form, upon rearranging the terms, we can write

$$\begin{aligned}\boldsymbol{p_t} + \boldsymbol{y_t} - \boldsymbol{\mu_t} = I_\xi^{-1}L'(I-I_\gamma)I_\beta \cdot (\boldsymbol{p_t} + \boldsymbol{c_t^d}) + I_\xi^{-1}L'I_d \cdot (\mathbf{1}e_t + \boldsymbol{d_t}) - I_\xi^{-1}L'I_\xi \cdot \boldsymbol{\mu_t} + \\ + (\eta-1)I_\xi^{-1}L'(I-I_\gamma)\Omega' I_\xi I_\gamma \boldsymbol{s_t}\end{aligned}$$

Similarly, we can express $p_{t,i} + c_{t,i}^d = (\eta-1)\gamma_i s_{t,i} + (p_t^c + c_t) = (\eta-1)\gamma_i s_{t,i} +$

m_t, where $m_t = p_t^c + c_t$ is the money supply, controlling the nominal spending in the economy. Note also, that under this assumption, combined with risk sharing, we have $m_t = e_t$. Then we have

$$\begin{aligned} \boldsymbol{p_t} + \boldsymbol{y_t} - \boldsymbol{\mu_t} = I_\xi^{-1} L'(I - I_\gamma) I_\beta \cdot [(\eta - 1) I_\gamma \boldsymbol{s_t} + \mathbf{1} m_t] + \\ I_\xi^{-1} L' I_d \cdot (\mathbf{1} e_t + \boldsymbol{d_t}) - I_\xi^{-1} L' I_\xi \cdot \boldsymbol{\mu_t} + \\ + (\eta - 1) I_\xi^{-1} L'(I - I_\gamma) \Omega' I_\xi I_\gamma \boldsymbol{s_t} \end{aligned}$$

Rearranging the terms we obtain the expression for sectoral outputs:

$$\boldsymbol{y_t} = -\boldsymbol{p_t} + \mathbf{1} m_t + (I - I_\xi^{-1} L' I_\xi) \cdot \boldsymbol{\mu_t} + I_\xi^{-1} L' I_d \cdot \boldsymbol{d_t} + (\eta - 1) I_\xi^{-1} L'(I - I_\gamma)[I_\beta + \Omega' I_\xi] I_\gamma \cdot \boldsymbol{s_t}$$

Now, from the marginal cost expression we can write:

$$\boldsymbol{p_t} = \boldsymbol{\mu_t} - \boldsymbol{a_t} + \Omega \boldsymbol{p_t^x} + I_\alpha \mathbf{1} m_t$$

Given that $\boldsymbol{p_t^x} = I_\gamma \boldsymbol{s_t} + \boldsymbol{p_t}$, we can rearrange the terms and rewrite:

$$\boldsymbol{p_t} = \hat{L} \boldsymbol{\mu_t} - \hat{L} \boldsymbol{a_t} + \hat{L} \Omega I_\gamma \boldsymbol{s_t} + \mathbf{1} m_t$$

where $\hat{L} = (I - \Omega)^{-1}$ is the Leontieff inverse relevant in this context. Substituting this price expression back into output, we obtain:

$$\begin{aligned} \boldsymbol{y_t} = -(\hat{L} - I + I_\xi^{-1} L' I_\xi) \cdot \boldsymbol{\mu_t} + \hat{L} \boldsymbol{a_t} + I_\xi^{-1} L' I_d \cdot \boldsymbol{d_t} + \\ + (\eta - 1) I_\xi^{-1} L'(I - I_\gamma)[I_\beta + \Omega' I_\xi] I_\gamma \cdot \boldsymbol{s_t} - \hat{L} \Omega I_\gamma \cdot \boldsymbol{s_t} \end{aligned}$$

From this expression, we get the statement in Proposition 1. The statement of Corollary 1 follows from the expression for prices.

Propagation on final output. We compute GDP as value added. Real GDP (in log-deviations) is given by:

$$va_t^R = va_t^N - p_t^{GDP}$$

where v_t^N is nominal GDP and p_t^{GDP} is GDP deflator. Nominal value added (in levels) is: $VA_t = \sum_i VA_{t,i}$. Sectoral value added euqals labor income $VA_{t,i} =$

$W_{t,i}L_{t,i} = \alpha_i P_{t,i} Y_{t,i}$. Then, aggregate nominal value added is:

$$va_t^N = \sum_i \alpha_i \xi_i (p_{t,i} + y_{t,i}) = \mathbf{1'} I_\alpha I_\xi \cdot (\boldsymbol{p_t} + \boldsymbol{y_t})$$

GDP deflator is and index of domestic prices $p_t^{GDP} = \sum_i \tilde{\xi}_i \cdot p_{t,i} = \mathbf{1'} I_{\tilde{\xi}} \cdot \boldsymbol{p_t}$. Then, real value added is:

$$va_t^R = \mathbf{1'} I_\alpha I_\xi \cdot (\boldsymbol{p_t} + \boldsymbol{y_t}) - \mathbf{1'} I_{\tilde{\xi}} \cdot \boldsymbol{p_t}$$

where $\alpha_i \xi_i = \frac{VA_i}{VA} = \frac{\alpha_i \xi_i}{\sum_i \alpha_i \xi_i}$ are value added weights. Here we have used the fact that around steady state with balanced trade we have: $\sum_i \alpha_i \xi_i = 1$. The GDP deflator can be constructed with value added weights, yielding $\tilde{\xi}_i = \alpha_i \xi_i$.

Given the link between $\boldsymbol{s_t}$ and sectoral output and prices, we have the result of Corollary 2.

Propagation of tariffs. Since terms of trade contain both domestic prices and tariffs, the propagation of tariffs in general depends on how prices react. Let $s_{t,i} = \tau_{t,i} - p_{t,i}$. If no production network, domestic prices do not change in response to tariffs, and we have $\boldsymbol{s_t} = \boldsymbol{\tau_t}$. In the presence of a network, the effect of tariffs on prices is $\boldsymbol{p_t} = [I + \hat{L}\Omega I_\gamma]^{-1} \hat{L}\Omega I_\gamma \boldsymbol{\tau_t}$ which is also fully driven by the downstream matrix. Then, ToT themselves $\boldsymbol{s_t} = (I - [I + \hat{L}\Omega I_\gamma]^{-1} \hat{L}\Omega I_\gamma) \cdot \boldsymbol{\tau_t}$. The second term is generally much smaller than the first one, because production networks are sparse. Hence, terms of trade are still closely mapped into tariffs.

B Empirical appendix

B.1 Data description

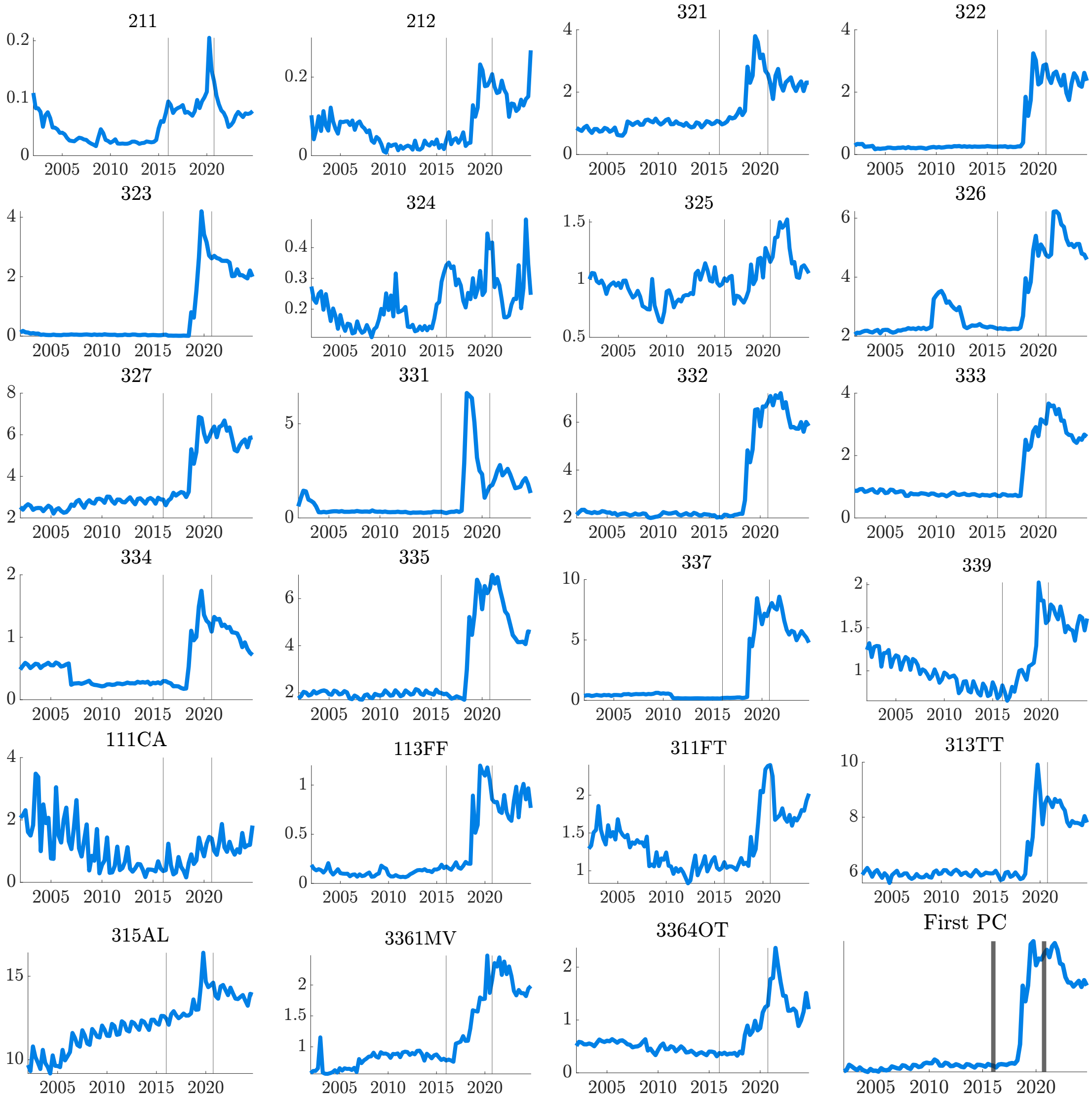
Table B.3: Tariff Sectors

BEA2	sector
111CA	Farms
113FF	Forestry, fishing, and related activities
211	Oil and gas extraction
212	Mining, except oil and gas
311FT	Food and beverage and tobacco products
313TT	Textile mills and textile product mills
315AL	Apparel and leather and allied products
321	Wood products
322	Paper products
323	Printing and related support activities
324	Petroleum and coal products
325	Chemical products
326	Plastics and rubber products
327	Nonmetallic mineral products
331	Primary metals
332	Fabricated metal products
333	Machinery
334	Computer and electronic products
335	Electrical equipment, appliances, and components
3361MV	Motor vehicles, bodies and trailers, and parts
3364OT	Other transportation equipment
337	Furniture and related products
339	Miscellaneous manufacturing

Table B.4: Output and Price Sectors

BEA2	Sector
111CA	Farms
113FF	Forestry, fishing, and related activities
211	Oil and gas extraction
212	Mining, except oil and gas
213	Support activities for mining
22	Utilities
23	Construction
311FT	Food and beverage and tobacco products
313TT	Textile mills and textile product mills
315AL	Apparel and leather and allied products
321	Wood products
322	Paper products
323	Printing and related support activities
324	Petroleum and coal products
325	Chemical products
326	Plastics and rubber products
327	Nonmetallic mineral products
331	Primary metals
332	Fabricated metal products
333	Machinery
334	Computer and electronic products
335	Electrical equipment, appliances, and components
3361MV	Motor vehicles, bodies and trailers, and parts
3364OT	Other transportation equipment
337	Furniture and related products
339	Miscellaneous manufacturing
42	Wholesale trade
441	Motor vehicle and parts dealers
445	Food and beverage stores
452	General merchandise stores
481	Air transportation
482	Rail transportation
483	Water transportation
484	Truck transportation
485	Transit and ground passenger transportation
486	Pipeline transportation
487OS	Other transportation and support activities
493	Warehousing and storage
4A0	Other retail
511	Publishing industries, except internet (includes software)
512	Motion picture and sound recording industries
513	Broadcasting and telecommunications
514	Data processing, internet publishing, and other information services
521CI	Federal Reserve banks, credit intermediation, and related activities
523	Securities, commodity contracts, and investments
524	Insurance carriers and related activities
525	Funds, trusts, and other financial vehicles
532RL	Rental and leasing services and lessors of intangible assets
5411	Legal services
5412OP	Miscellaneous professional, scientific, and technical services
5415	Computer systems design and related services
55	Management of companies and enterprises
561	Administrative and support services
562	Waste management and remediation services
61	Educational services
621	Ambulatory health care services
622	Hospitals
623	Nursing and residential care facilities
624	Social assistance
711AS	Performing arts, spectator sports, museums, and related activities
713	Amusements, gambling, and recreation industries
721	Accommodation
722	Food services and drinking places
81	Other services, except government
HS	Housing
ORE	Other real estate

Figure B.10: Tariff time series



Notes: Time series of tariffs (in levels) for all sectors with nonzero tariffs during the sample. Grey vertical lines indicate the first Trump presidency. The last panel shows the first principal component, which explains 88% of the variation.

C Quantitative appendix

Aggregation of Pasten et al. (2024) price adjustment frequencies.

Since the data provided by Pasten et al. (2024) is mostly on the level of 6-digit BEA code, we aggregate it to two digits using Domar weights. We compute the latter based on the ”Use” table for 402 industries from 2017. To do so, we again exclude the government, scrap, and noncomparable imports sectors and then compute intermediate input shares, final consumption shares and labor shares among the remaining sectors as above. For the matching of 6-digit to 2-digit BEA codes, we make use of the BEA's levels of aggregation: Sector (most aggregated), summary, underlying summary, and detail (least aggregated). There is also a fifth level of further disaggregation, on which some of the Pasten et al. (2024) price adjustment frequencies are reported. We will refer to these levels as first to fifth level, starting with the sector level. We want to aggregate to the second level and preceed as follows:

In general for each industry on the second level, we use the Domar-weighted (normalized so that the weights sum up to one) average of all available Pasten et al. (2024) frequencies at the fourth level. If the frequency is missing for at least one, but not all industries on the fourth level within one industry on the third level, we replace it with the Domar weighted average of the other fourth-level industries in the same third-level industry.[5] In the same fashion, we use Domar-weighted averages to aggregate the industries of the third level within one industry to the second level. If the (average) frequency is missing for at least one, but not all third-level industries, we replace the missing ones with the weighted average of the other industries of the third level within the same second-level industries. This procedure gives us a frequency for most of our 63 second-level industries. For the other ones, we proceed as follows:

- For industries 42, 4A0, HS, ORE, 623, 721, and 713, there is precisely one frequency available that is already reported by Pasten et al. (2024) at either a higher or lower level of aggregation than the fourth, so we use this one.
- For industries 113FF, 315AL, 485, 512, 523, 525, 5415, 55, 61, 624, 711AS, and 722, we use the Domar-weighted average of the other second-level industries within the same first-level sector.

[5]When there is no frequency available at the fourth level (for which we can compute Domar weights, but multiple ones on the fifth level, for which we can not, we treat these frequencies as missing.

- For the remaining industries 23 and 81, we use the domar-weighted average of all other second-level industries.

Table C.5: Country-specific tariff rates

Country	Tariff rate (%)	Country	Tariff rate (%)	Country	Tariff rate (%)
Algeria	30	Malawi	17	Austria (EU)	20
Angola	32	Malaysia	24	Belgium (EU)	20
Bangladesh	37	Mauritius	40	Bulgaria (EU)	20
Bosnia & Herzegovina	35	Moldova	31	Croatia (EU)	20
Botswana	37	Mozambique	16	Cyprus (EU)	20
Brunei	24	Myanmar	44	Czech Rep. (EU)	20
Cambodia	49	Namibia	21	Denmark (EU)	20
Cameroon	11	Nauru	30	Estonia (EU)	20
Chad	13	Nicaragua	18	Finland (EU)	20
China	34	Nigeria	14	France (EU)	20
Côte d'Ivoire	21	Macedonia	33	Germany (EU)	20
Congo (Kinshasa)	11	Norway	15	Greece (EU)	20
Equatorial Guinea	13	Pakistan	29	Hungary (EU)	20
Falkland Islands	41	Philippines	17	Ireland (EU)	20
Fiji	32	Serbia	37	Italy (EU)	20
Guyana	38	South Africa	30	Latvia (EU)	20
India	26	Sri Lanka	44	Lithuania (EU)	20
Indonesia	32	South Korea	25	Luxembourg (EU)	20
Iraq	39	Switzerland	31	Malta (EU)	20
Israel	17	Syria	41	Netherlands (EU)	20
Japan	24	Taiwan	32	Poland (EU)	20
Jordan	20	Thailand	36	Portugal (EU)	20
Kazakhstan	27	Tunisia	28	Romania (EU)	20
Laos	48	Vanuatu	22	Slovakia (EU)	20
Lesotho	50	Venezuela	15	Slovenia (EU)	20
Libya	31	Vietnam	46	Spain (EU)	20
Liechtenstein	37	Zambia	17	Sweden (EU)	20
Madagascar	47	Zimbabwe	18	**All other countries**	**10**