The Contribution of Imports to PCE Inflation*

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May 21, 2025

[PRELIMINARY AND INCOMPLETE - FIRST DRAFT MAY 2025]

Abstract

We develop a new methodology for tracing out how border price increases may pass through into US consumer prices. This methodology builds upon a static open economy model with a network structure, markups, and domestic retailers, from which we carefully map each model object to publicly-available US data, including input-output tables and information on industry and retailer margins. We calculate import price sensitivities by expenditure category, which lends itself to a few applications. First, we build a consumption-weighted import price index that improves consumer prices prediction. Second, we predict the partial-equilibrium effects of various tariff scenarios. An additional 10 percent tariff on the rest of the world would prompt a 0.78 to 1.34 percentage point increase in inflation, with significant heterogeneity by country. Finally, we show full pass-through to consumer prices of the 2018 tariffs.

Keywords: tariffs, inflation, import prices, indirect imports
JEL Codes: F40, E65, E31

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Introduction

How do border price fluctuation impact consumer inflation? In a world of rapidly escalating tariffs and trade wars, such estimates are critical for both policy makers and business leaders. While it is clear that, at least in a partial-equilibrium framework, border price increases will pass through to US consumer prices, there has been less work to date that maps and measures the effects of price changes of imported goods on the retail prices of consumption goods.

Our paper develops a new methodology for tracing out how import border price increases may pass through into US consumer prices. Our methodology brings together two key insights. First, assessing how import prices affect US consumers requires looking beyond direct consumer purchases of imported products; domestically-produced goods also contain imported components. Second, due to often large producer and retail markups, it is of immense consequence to take into account how markups respond to cost changes of imported components.

Our methodology follows from a static open economy model of domestic firms that use intermediate domestic and foreign goods, along with domestic labor, in a network structure. In order for the model, which is similar to that of Baqaee and Rubbo (2023) and Silva (2024), to better map to the data, we explicitly add in markup and retailers. Specifically, we add domestic retailers that bundle domestic final goods, foreign final goods, and domestic labor. We carefully lay out how each model object maps to official, publicly-available US data.

Our methodology allows us to construct import price sensitivity matrices, which map the purchaser price sensitivity of each consumer expenditure category to changes in the foreign price of each underlying commodity. We show that 10 percent of personal consumption expenditure (PCE) was imported in 2023, and we break down this overall share by expenditure category. Using price changes of each expenditure category over time, we calculate the contribution of import price changes to PCE inflation since 2007.

Our calculated import sensitivities, along with category-level price changes, allow us to build a consumption-weighted import price index. We show how this index outperforms the BLS Import Price Index excluding fuel and food in predicting future inflation, especially at shorter-term horizons of one and three months.

As our final application, we use our methodology to understand the pass-through of tariffs on consumer prices, under different markup response assumptions. Using census data, we calculate the share of each commodity that is imported from each country, allowing us to predict the effect, for any given tariff, on each consumer expenditure category. We use this to simulate the partial-equilibrium effect of tariff shocks on consumer prices under a number of different scenarios. We find that when margins remain constant in percentage terms (on top of marginal costs), i.e. under full pass-through, tariffs can have almost double the effect relative to when margins remain constant in dollar terms. This is because the network effects of an upstream tariff propagate downstream, with each producer charging an additional percent markup on top of increased suppliers' costs. As an example, we consider the tariffs imposed by the United States in 2018. We find that they would have increased PCE inflation by 0.08 percentage points under constant-dollar markups and by 0.16 percentage points under constant-percent markups. Additionally, we simulate an additional 10 percent tariff on all countries in the world and also on various countries. We find that the tariff on all countries would prompt a 0.78 to 1.34 percentage point increase in inflation, with significant heterogeneity when we consider different countries.

We then ask the question, how well do our predicted shocks correspond to actual price changes? We answer this question using the 2018 tariffs. The first rounds of tariffs impacted washing machines, aluminum, and steel, while tariffs placed between July and September impacted goods imported from China. It has been particularly hard for the economic literature to estimate the effects of 2018 tariffs on consumer prices. We believe this is because of the missing network mapping between import prices and retail prices under the correct assumption. Under a difference-in-difference framework, in which we compare expenditure categories with various exposures around the China tariffs of 2018, we find full pass-through under our constant markup assumption. When examining the dynamics of the response, we find that prices rose significantly in the second month of tariffs and continued to rise through the beginning of 2019.

Related Literature This study contributes to a few strands of the literature. First, it contributes to and builds upon studies of inflation with production networks (Basu, 1995; Baqaee and Farhi, 2019; La'O and Tahbaz-Salehi, 2022; Rubbo, 2023; Baqaee and Rubbo, 2023; Minton and Wheaton, 2023; di Giovanni et al., 2023; Silva, 2024). These studies emphasize the importance of the interaction between sectoral price and wage rigidities and production networks in understanding inflation. Our paper carefully considers how price shocks are disseminated along supply chain networks, taking into account various markup practices.

Second, this paper contributes to the pass-through literature. There is a large literature on exchange rate pass-through (Feenstra, 1989; Goldberg and Knetter, 1997; Amiti, Itskhoki and Konings, 2014), backed up by a theoretical literature that explains variable markups through real rigidities (Kimball, 1995; Atkeson and Burstein, 2008). We most closely relate to the studies that have examined pass-through in the context of the 2018 US-China trade war. A number of studies have found that the full burden of the 2018 tariffs was paid by US importers. Fajgelbaum et al. (2019), Amiti, Redding and Weinstein (2019), and Cavallo et al. (2021) all show full-pass through at the border using US customs data. It is less clear in the existing literature how these higher border prices impacted US consumer prices. Cavallo et al. (2021) uses microdata from two large household retailers to show that these specific retailers had low pass-through of border prices to consumer prices. However, the literature thus far is unclear how consumer prices elsewhere responded. After carefully constructing exposure measures at the consumer expenditure category level (a procedure we first explained in Barbiero and Stein, 2025), we find full pass-through of tariff exposure to consumer prices.[1]

Finally, our study contributes to the literature on inflation forecasting, as reviewed in Stock and Watson (2009) and Faust and Wright (2013). Specifically, we supplement the prototypical direct forecasting model of inflation by including the BLS Import Price Index excluding fuel and food and our consumption-weighted import price index as additional regressors. We find that including our consumption-weighted import price index can improve upon a model that only uses past inflation and on a model that additionally uses the official import price index.

The paper proceeds as follows. Section 1 presents our partial-equilibrium network model. Section 2 describes the data that we use, all of which is publicly available. Section 3 describes how we map the model to the data, how we construct the import price sensitivity of expenditure categories, and how we construct the consumption-weighted import price index. Section 4 goes through a few applications of our methodology: first, it describes the import share of consumption and breaks this down by category; second, it presents a forecasting exercise in which we forecast inflation with the consumption-weighted import price index; third, it uses our import price sensitivities to simulate tariff shocks and output the partial-equilibrium inflation response to these shocks; fourth, it compares these predicted inflation outcomes to category-level inflation around the 2018 tariffs. Finally, 5 concludes.

[1] Written concurrently with this study, Baslandze et al. (2025) and Minton and Somale (2025) also focus on empirical estimates of tariff pass-through on consumer prices. Baslandze et al. (2025) use micro-level data linking imports to consumer expenditures. They focus on retail categories available in their dataset. We use public data at the industry level to focus on the full effect on the US economy. Moreover, we consider the full network effects of tariffs, not only the effect related to directly affected suppliers. Minton and Somale (2025) focus on the full network effect of tariffs and their pass-through on PCE prices but they do not focus on the importance of markup response assumptions; that is, they only compute the 'constant-dollar' percent markup effect similar to Barbiero and Stein (2025). To the extent of our knowledge, our study is the first to evaluate and test the full network effects on PCE inflation under full pass-through. We also focus on a broader set of consumer expenditure categories, in order to evaluate the full effect on the US economy.

1 Model

To help interpret our methodology and its assumptions we build a static open economy model in partial equilibrium, with two kinds of primary factors: import goods and labor. There are two kinds of producers in the domestic economy: retailers and firms. Firms use intermediate domestic and foreign goods, and labor to produce domestic goods. Retailers bundle domestic final goods and foreign final goods with domestic labor. Households consume composite retail goods. Due to the market structures, both domestic goods producers and retailers incorporate a markup into their price. Without loss of generality, trade is balanced. The model is similar to Baqaee and Rubbo (2023) and Silva (2024), except we explicitly add markup and retailers for better mapping with the data.

Households We assume households have homothetic utility of various consumption goods bundled by retailers and indexed by e. This utility, written as $U = U(C_1, ..., C_e, ..., C_E)$, is subject to the budget constraint:

$$\sum_{e=1}^{E} p_e c_e = wL + \sum_{e=1}^{E} \pi_e + \sum_{i=1}^{N} +\pi_i$$

In other words, households earn wages w for their labor L, and retail and domestic-goods producers profits are rebated to households.

Retailers The producers of C_e are monopolistically competitive retailers that combine domestic final goods indexed by i and foreign final goods indexed by i^* with the following Hicks-neutral constant returns to scale production function:

$$x_e = A_e F^e(L_e, \{x_{ei}\}_{i=1,...,N}, \{x_{ei^*}\}_{i^*=1,...,N^*}),$$

where A_e is productivity, L_e is labor, and x_{ei} and x_{ei^*} represent final good quantities used in production.

The cost minimization problem of retailers is

$$\min_{L_e,\{x_{ef}\}_{f=1,...,N},\{x_{ei^*}\}_{i^*=1,...,N^*}} w_e L_e + \sum_{i=1}^{N} p_i x_{ei} + \sum_{i^*=1}^{N} p_{i^*} x_{ei^*}, \tag{1}$$

such that $x_e \geq \bar{x_e}$. Retailers do not use other retailers' goods to generate their aggregate bundle x_e. This means that there is no network structure to track *within* the retailer market.

Each producer e's optimal price in equilibrium is:

$$p_e = (1+\mu_e)MC_e = (1+\mu_e)\frac{TC_e}{x_e} = \frac{(1+\mu_e)}{A_e}\left[\frac{w_e L_e}{x_e} + \sum_{i=1}^{N}\frac{p_i x_{ei}}{x_e} + \sum_{i^*=1}^{N^*}\frac{p_{i^*}x_{ei^*}}{x_e}\right].$$

where μ_e denotes markup, MC_e denotes marginal cost, TC_e denotes total cost, w_e denotes wages, and p_i and p_{i^*} are the prices of x_{ei} and x_{ei^*}, respectively.

To a first order approximation where $d\log y = \hat{y}$, the above expression simplifies to

$$\hat{p}_e = \hat{\mu}_e - \hat{A}_e + (1+\mu_e)\theta_e^L \hat{w}_e + \sum_i (1+\mu_e)\theta_{ei}\hat{p}_i + \sum_{i^*}(1+\mu_e)\theta_{ei^*}\hat{p}_{i^*},$$

where θ_e^L is the sales-based share of factor L defined as $\theta_e^L = \frac{w_e L_e}{p_e x_e}$, $\theta_{ei} = \frac{p_i x_{ei}}{p_e x_e}$ is the sales-based share of domestically produced final good i sold by retailer e, and $\theta_{ei^*} = \frac{p_{i^*}x_{ei^*}}{p_e x_e}$ is the sales-based share of imported good i^* sold by retailer e. Since the above expression holds for each retailer, we can express it in matrix form for all retailers as

$$\hat{P}^E = \hat{M}^E - \hat{A}^E + M^E\left(\Theta^L \hat{W}^E + \Theta\hat{P} + \Theta^*\hat{P}^*\right), \tag{2}$$

where $\hat{P}^E$ is a $1 \times E$ vector of all retail price changes, $\hat{M}^E$ and $\hat{A}^E$ are shocks to markups and productivity of retailers, and M^E is a $E \times E$ diagonal matrix of retail markups. The Θ matrices are $E \times N$ sales-based factor shares matrices. $\hat{W}^E$, $\hat{P}$, and $\hat{P}^*$ are wage and producer-price changes. Note that capital letters are either vectors or matrices. If we keep constant all exogenous primitive factor prices and productivity except final goods prices, the above expression collapses to:

$$\hat{P}^E = M^E\left(\Theta\hat{P} + \Theta^*\hat{P}^*\right) \tag{3}$$

Domestic Goods The monopolistically competitive producers of the domestic good i's cost minimization function is

$$\min_{L_i,\{x_{ij}\}_{j=1,\ldots,N},\{x_{ij^*}\}_{j^*=1,\ldots,N}} w_i L_i + \sum_{j=1}^{N} p_j x_{ij} + \sum_{j^*=1}^{N^*} p_{j^*}x_{ij^*}, \tag{4}$$

such that $x_i = A_i F^i(L_i, \{x_{ij}\}_{j=1,\ldots,N}, \{x_{ij^*}\}_{j^*=1,\ldots,N}) \geq \bar{x}_i$. Thus, unlike retailers, there is a network structure within domestic good production.

Each producer i optimal price in equilibrium is:

$$p_i = (1+\mu_i)MC_i = (1+\mu_i)\frac{TC_i}{x_i} = \frac{(1+\mu_i)}{A_i}\left[\frac{w_i L_i}{x_i} + \sum_{j=1}^{N}\frac{p_j x_{ij}}{x_i} + \sum_{j^*=1}^{N^*}\frac{p_{j^*} x_{ij^*}}{x_i}\right]$$

As in Baqaee and Rubbo (2023) and Silva (2024), we can show that, to a first order approximation where $d\log y = \hat{y}$ this turns into:

$$\hat{p}_i = \hat{\mu}_i - \hat{A}_i + (1+\mu_i)\frac{w_i L_i}{p_i x_i}\hat{w}_i + \sum_j (1+\mu_i)\frac{p_j x_{ij}}{p_i x_i}\hat{p}_j + \sum_{j^*}(1+\mu_i)\frac{p_{j^*} x_{ij^*}}{p_i x_i}\hat{p}_{j^*}$$

We can express this equation as a function of sales-based factor shares for a factor r, $\Omega^r_{ij} = \frac{p^r_j x^r_{ij}}{p_i x_i}$:[2]

$$\hat{p}_i = \hat{\mu}_i - \hat{A}_i + (1+\mu_i)\Omega^L_i \hat{w}_i + \sum_j (1+\mu_i)\Omega_{ij}\hat{p}_j + \sum_{j^*}(1+\mu_i)\Omega^*_{ij}\hat{p}_{j^*}$$

Since the equation holds for every product i we can express it in matrix form:

$$\hat{P} = \hat{M} - \hat{A} + \Omega^L \hat{W} + M\Omega\hat{P} + M\Omega^*\hat{P}^*,$$

where $\hat{P}$ is the $N \times 1$ vector of domestic price changes, and $\hat{M}$ is the $N \times 1$ vector of markup shocks. Ω^L is the sales-based vector of labor costs, which is a diagonal matrix in this model, though this assumption can be relaxed. Ω is the matrix of intermediate goods cost, while Ω^* is import factor share matrix. M is a diagonal matrix, where each element of the diagonal is the good-specific markup. Inverting the system gives

$$\hat{P} = (\mathbb{I} - M\Omega)^{-1}\left(\hat{M} - \hat{A} + \Omega^L \hat{L} + M\Omega^*\hat{P}^*\right). \tag{5}$$

The above equation represents the general case. If we keep constant shocks to productivity, markups, and wages, this collapses to

$$\hat{P} = (\mathbb{I} - M\Omega)^{-1} M\Omega^*\hat{P}^*. \tag{6}$$

[2]Alternatively, we can express it in terms of cost-based factor shares $\tilde{\Omega}^r_{ij} = (1+\mu_i)\Omega^r_{ij} = \frac{p_i}{MC_i}\frac{p^r_j x^r_{ij}}{p_i x_i} = \frac{p^r_j x^r_{ij}}{TC_i}$:

$$\hat{p}_i = \hat{\mu}_i - \hat{A}_i + \tilde{\Omega}^L_i \hat{w}_i + \sum_j \tilde{\Omega}_{ij}\hat{p}_j + \sum_{j^*}\tilde{\Omega}^*_{ij}\hat{p}_{j^*}$$

Plugging (6) into (3), we obtain

$$\hat{P}^E = M^E(\Theta^* + \Theta(\mathbb{I} - M\Omega)^{-1}M\Omega^*)\hat{P}^*. \tag{7}$$

If we assume that all markups (retailers and producers) are zero then the matrices M^E and M turn into identity matrices. In this case, the model collapses into one where the value-added component present in observed input-output matrices is another factor of production that we keep constant in dollar terms. Later on, we will call this assumption the 'constant-dollar' assumption, as it corresponds to a partial equilibrium scenario where profits remain constant in dollar terms, after a change in foreign prices. We will call the scenario in which markups are constant as in the expression above a 'constant-percent' markup assumption, which corresponds to full-passthrough of marginal costs increases.

2 Data

We use a number of publicly-available tables from the US Bureau of Economic Analysis (BEA) Input-Output Accounts: the Use Tables, the Make Tables, the Import Matrices, and the PCE bridge.[3] In all cases, we use the 'after redifinition' versions of the tables. We define the following matrices corresponding to the data available from the BEA. In doing so, we try to call each matrix with the same nomenclature as BEA (2008) 'Mathematical Derivation of the Domestic Requirements Tables for Input-Output Analysis'

- U: The intermediate portion of the total use table, providing the value of each commodity purchased by each industry, in USD million. This is a commodity-by-industry matrix.

- U^*: the intermediate portion of the import matrix, providing the value of each commodity imported by each industry. This is a commodity-by-industry matrix.

- V: the make matrix, providing the value of each commodity made by each industry. This is an industry-by-commodity matrix.

- g: a column vector in which each entry shows the total amount of each industry's gross output

- q: a column vector in which each entry shows the total amount of each commodity's gross output.

[3] The Input-Output Accounts data can be downloaded at the following link: `https://www.bea.gov/industry/input-output-accounts-data`.

- s: a column vector representing total compensation of employees in each industry.
- C: a column vector containing total final demand for each commodity, in producers' prices. This is available in the final demand portion of use matrices.
- C^*: a column vector containing final demand for imports in each commodity, in producers' prices. This is available in the final demand portion of the import matrices.
- R: The PCE concordance matrix between BEA commodity code and BEA NIPA (national income and product account) line, available from the PCE bridge files, evaluated at producers' prices. This is a commodity by expenditure category matrix.[4]
- C^p: a column vector showing personal consumption expenditure in each NIPA category, at purchasers' prices.

We use a few additional publicly-available datasets. First, we use the US Census Bureau Foreign Trade import data, from which we can calculate the total amount imported into the US of each HTSUSA commodity code from each foreign country in each year.[5] Second, we use the BEA-NAICS concordance table, available in the input–output raw data files from the BEA website. Third, we use the aggregated and disaggregated import price indices published by the US Bureau of Labor Statistics (BLS). Finally, we use the seasonally-adjusted average hourly earnings of all employees series from the BLS' Current Employment Statistics (CES) data.

3 Methodology

3.1 Mapping the Model to the Data

One contribution of this paper in its own right is to carefully map each model object to its empirical dataset. To emphasize that often what is available in practice does not correspond exactly to what is required by theory we use another notation for empirical objects.

To define the empirical objects, we normalize the data matrices in Section 2 as follows:

- $B = (U - U^*)\,\mathrm{diag}^{-1}(g)$: domestic direct requirement matrix, showing the domestic inputs required per unit of gross output. It's a N commodities by I industries matrix.

[4] The PCE Bridge files can be downloaded at the following link: `https://www.bea.gov/industry/industry-underlying-estimates`.

[5] The Census data can be found at the following link: `https://www.census.gov/foreign-trade/data/dataproducts.html`.

- $B^* = U^* \operatorname{diag}^{-1}(g)$: the foreign direct requirement matrix. It's a N commodities by I industries matrix.

- $D = V \operatorname{diag}^{-1}(q)$: market share matrix, showing the proportion of the total output of each commodity produced in each industry. It's an I industries by N commodities matrix.

- $\omega^* = \operatorname{diag}(C^* \oslash C)$: is the share of imported final demand in each commodity, and where $\oslash$ is the Hadamard division operator for element-wise division. It's an N by N matrix.

- $\omega^D = \mathbb{I} - \omega^*$ is the share of domestic goods in final demand. It's an N by N matrix.

- $\tilde{R} = R \operatorname{diag}^{-1}(C^p)$: is the bridge matrix normalized by total personal consumption expenditure, representing the share of each commodity's expenditure value in producer prices over expenditure in the retail category at purchaser value. It's an N commodities by E expenditure categories matrix.

There is a now a direct mapping between the matrices in Equation (7) and official BEA data. First, note that all theoretical matrices follow the general convention in the literature to have outputs in the row and inputs in the columns of the factor share matrix Ω. The BEA instead specifies inputs in the rows and outputs in the columns of the use tables. Moreover, the BEA distinguishes between commodity and industry in their input-output table. To obtain a commodity-by-commodity input output table we therefore take the input coefficient matrices B and B^* and multiply them by the market share matrix D.

$$\begin{aligned} (M\Omega)^\top &= B\tilde{M}D \\ (M\Omega^*)^\top &= B^*\tilde{M}D \\ \text{where} \quad \tilde{M} &= \operatorname{diag}(G \oslash (S + \mathbf{1}^\top U) \end{aligned}$$

$\tilde{M}$ is the industry-specific markup over variable cost of the industry, computed as gross output over salaries and cost of materials. Each diagonal element of $\tilde{M}$ can also be written as 1 plus gross operating surplus and taxes over variable costs. Given that we will use this matrix to represent our full pass-through scenario, the above expression effectively assumes that gross-operating surplus and taxes are expressed as a constant percentage on top of variable costs. This assumption can be relaxed with additional data on gross operating surplus decomposition.

Retailers in the model bundle foreign and domestic goods into different retailer categories at once. In the data, the foreign and domestic good share in and the decomposition between purchaser and producer categories come from different sources (use tables vs. bridge files). Therefore, the matrices Θ and Θ^* can be decomposed into:

$$\begin{aligned} M^E\Theta &= \omega^D\tilde{R}\tilde{M}^E \\ M^E\Theta^* &= \omega^*\tilde{R}\tilde{M}^E \\ \text{where} \quad \tilde{M}^E &= \operatorname{diag}(C^p \oslash (S^E + \mathbf{1}^\top R)) \end{aligned}$$

$\tilde{M}^E$ is the gross markup over variable costs of the retail sector. S^E is a vector of imputed salaries for retail, wholesale and transportation in each expenditure category. It is computed as the share of salaries over cost of materials taken from the use matrix and multiplied by each industry's producer value contribution to personal consumption. Given the above definition the empirical equivalent of equation (7) becomes:

$$(\hat{P}^E)^\top = (\hat{P}^*)^\top(\omega^* + B^*\tilde{M}D(\mathbb{I} - B\tilde{M}D)^{-1}\omega^D)\tilde{R}\tilde{M}^E \tag{8}$$

3.2 Constructing The Import Price Sensitivity of Expenditure Categories

We refer to the following $N \times E$ matrix as the import price sensitivity matrix:

$$\text{PCE Sensitivity:} \quad \Delta = (\omega^* + B^*\tilde{M}D(\mathbb{I} - B\tilde{M}D)^{-1}\omega^D)\tilde{R}\tilde{M}^E \tag{9}$$

This matrix maps the purchaser price sensitivity of each NIPA expenditure category to changes in the foreign price of each BEA commodity.[6] In practice, these sensitivities are year-specific, but we omit the time subscript for simplicity. If we substitute $\tilde{M}$ and $\tilde{M}^E$ to be identity matrices, that is under our constant-dollar assumption, each element of Δ, Δ_{je}, can also be interpreted as the share of foreign commodity j in personal consumption expenditure in category e.

We can also decompose (9) into:

$$\text{Direct Sensitivity:} \quad \Delta^{\text{Direct}} = \omega^*\tilde{R}\tilde{M}^E \tag{10}$$

$$\text{Indirect Sensitivity:} \quad \Delta^{\text{Indirect}} = (B^*\tilde{M}D(\mathbb{I} - B\tilde{M}D)^{-1}\omega^D)\tilde{R}\tilde{M}^E \tag{11}$$

The direct sensitivity is the predicted response to an import price increase of PCE prices due to the share of personal expenditures in foreign final goods. The indirect sensitivity is the

[6] Note how to compute the total sensitivity of each NIPA expenditure category to foreign prices we should use $\mathbf{1}^\top\Delta$.

predicted response of PCE prices due to the share of domestic final goods consumption that use imported intermediate goods in their production process.

Finally we define

$$\text{Total PCE sensitivity:}\, \Delta^{Tot} = \Delta\, w^p, \quad \text{where} \quad w^p = C^p / \mathbf{1}^\top C^p$$

w^p is the importance share of each PCE category in total PCE. Post-multiplying the PCE price sensitivity by the PCE importance share vector provides the sensitivity to each commodity's import of total PCE.

Finally, we build another concordance matrix to test several tariff scenarios. We define F as a matrix containing the share of country-product specific value of import for each BEA comodity. Each row represents a country-10digit HTSUS product code combination, while each row represents one of the 402 BEA commodities. We can then use a country-product specific vector of tariffs τ_t at any given time to predict the tariff effect into each expenditure category as:

$$\hat{P}^E = \tau F \Delta w^p \tag{12}$$

The foreign trade bridge matrix F offers a convenient bridge to simulate the effects of tariffs or border shocks τ starting at the most disaggregated level possible.

3.3 Interpolation of Data from More Detailed Years

BEA input-output tables are published each year. A coarse version of each of the tables is available annually from 1997 to 2023 and includes 71 industry groups and 73 commodity groups. Finer versions with 402 industries and 402 commodities are available in 2007, 2012, and 2017. Similar to the input-output account matrices, the Bridge files also come in two versions: a coarser version with annual updates from 1997 to 2023 using 73 commodity groups and 76 NIPA expenditure groups, and a finer version for 2007, 2012, and 2017 using 402 commodities and 212 NIPA expenditure codes. We use the coarser level of aggregation in the yearly data and multiply the coarse tables by the interpolated cell-blocks share trends from the detailed tables to populate input-output tables at the most disaggregated level for all years between 1997 to 2023.

3.4 Constructing the Consumption-Weighted Import Price Index

As explained, our methodology allows us to compute the import price sensitivity of the NIPA expenditure categories to price changes in BEA commodity categories under two different markup assumptions: constant-percent markup (or full pass-through) and a partial pass-through assumption of constant markups in dollar terms. We can use the BEA-NAICS concordance to group various BEA codes into a single NAICS code. We use NAICS codes that correspond to the most disaggregated NAICS level of the BLS import price series.[7] If a BEA commodity does not map to a BLS series, we drop that commodity from this analysis, which translates to an assumption of zero import price growth. Because our shares are additive, the rows of the sensitivity matrix Δ that belong to a single NAICS code can simply be added together. The results yields a $P \times E$ matrix, where P refers to the number of these NAICS codes. This matrix $\tilde{\Delta}^{P\times E}$ is akin to the import price sensitivity matrix Δ, except it gives the import price sensitivity of each NIPA category to a change in the price of each NAICS category code. In order to get a $P \times 1$ vector that gives the price sensitivity of core PCE to a change in the price of each NAICS category code, we can do the following operation: $\tilde{\Delta}_{P\times E} J_{E\times 1}$, where J represents a matrix of ones.

In order to turn this sensitivity vector into an index, we reinterpret these sensitivities as shares, and simply rescale these shares so that they sum to one within a date across NAICS codes. We then multiply monthly price changes from the BLS import price series by the shares calculated for that year.

4 Results

4.1 Import Shares

Our import sensitivities under our partial pass-through assumption of constant dollar markup can be reinterpreted as the share of US PCE that is imported. Under this assumption, markup is a domestic factor of production that is exogenous to import price changes. In this case, the sensitivity of consumer prices to import price changes is equivalent to the share of consumer expenditure that is imported.

Summing across all PCE categories, we find that 6 percent of core PCE was directly imported in 2023, and 4 percent was indirectly imported. In total, spending on direct and indirect imports accounted for 10 percent of total core PCE.[8] This percentage includes US components of foreign goods that are then imported into the US.

These shares have been consistent over the past two decades.[9] Our methodological framework enables us to break down these shares into underlying input commodities or

[7]For example, the BEA code 1111A0 includes NAICS codes 11111 and 11112, so we map this BEA code to the NAICS code 1111. However, the BLS does not include an import series for NAICS 1111, only 111. Thus, BEA code 1111A0 corresponds to BLS code 111.

[8]Our calculation of the import contribution to PCE is similar but not equivalent to that of Hale, Hobijn and Fernanda Nechio (2019), who estimate that 11 percent of headline PCE can be traced to imported goods.

[9]See Appendix Figure A.1.

expenditure categories. Figure 1 shows the contribution of both direct and indirect imports to PCE, broken down by NIPA expenditure category. For example, *direct* imports of pharmaceutical and other medical products account for 0.65 percent of PCE. Spending on *indirect* imports used in the domestic production of pharmaceutical and other medical products comprises 0.16 percent of PCE. Total imports—the sum of the direct and indirect components—in the pharmaceutical and other medical products sector account for 0.81 percent of PCE. The chart also highlights that some expenditure categories, such as hospital and nursing home services, may use a lot of indirect imports, though those services tend to be domestically produced.

4.2 Forecasting Inflation with the Consumption-Weighted Import Price Index

Figure 2 shows the contribution of import prices to core PCE inflation under the full pass-through assumption from 2007 through 2024. This contribution is broken down into the direct and indirect import channels in red and blue bars, respectively. For reference, core PCE inflation is shown in the black line.

We next turn to assessing the forecasting ability of our consumption-weighted import price index. Specifically, we compare its forecasting ability to the BLS Import Price Index excluding fuel and food. Unlike our index, where weights are based on the import price sensitivity of consumption, the BLS import price indicies weight goods with trade dollar value shares. Additionally, our index takes food and energy into account in predicting core PCE as indirect imports. In other words, food and energy price changes may impact our overall index through the supply chain. The "core" BLS import price does not include any impact of food or energy.

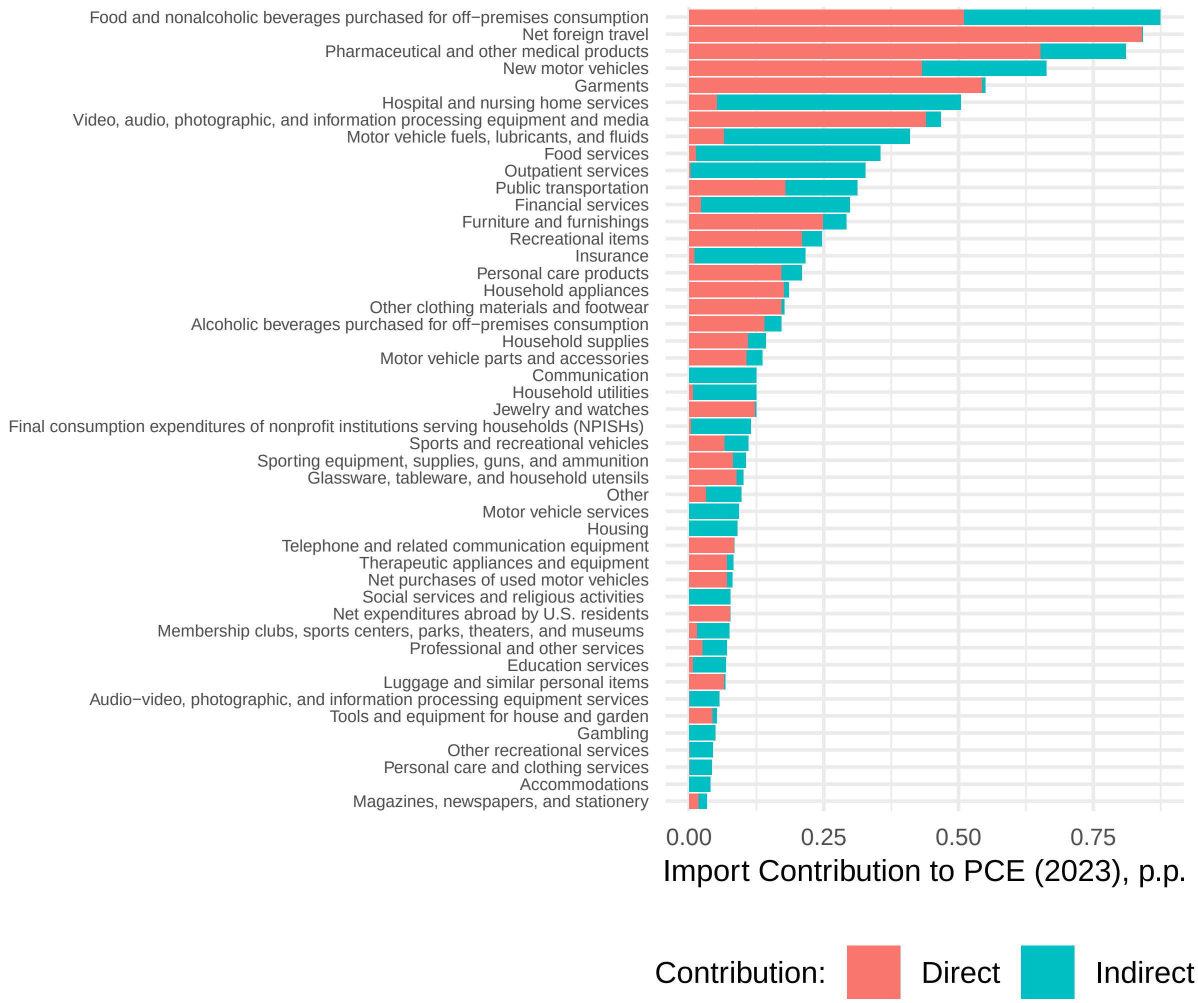
We implement h-month-ahead forecasts of core PCE with both our index and the "core" BLS import price index, re-estimating the model every month from 2012m1 until today.

$$p_{t+h} - p_{t+h-1} = \alpha + \beta(z_t - z_{t-1}) + \sum_{j=0}^{11} \alpha_j (p_{t-j} - p_{t-j-1}) + \varepsilon_{t+h}, \tag{13}$$

where p denotes the core PCE price index in a given month and z denotes the relevant index. For various horizons of $h = 1, 3, 6, 12$ months we then report the additional R^2 that our model delivers via an alternative model:

$$p_{t+h} - p_{t+h-1} = \alpha + \sum_{j=0}^{11} \alpha_j (p_{t-j} - p_{t-j-1}) + \varepsilon_{t+h}. \tag{14}$$

Figure 1: PCE Shares of Imports, by Expenditure Category

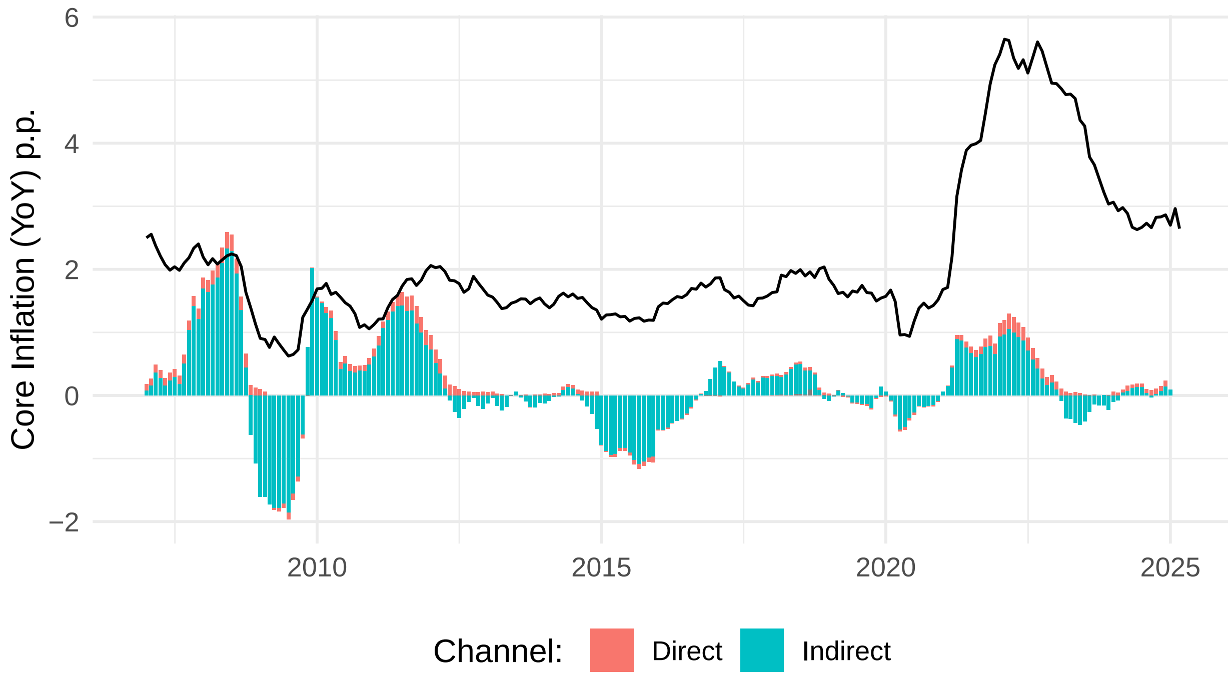


Notes: The red bars show the share of PCE corresponding to imported goods that are directly consumed by US households. The blue bars show the share of PCE corresponding to imports that are used as inputs in domestic production. We use the national income and product accounts (NIPA) categories of goods and services. *Sources*: US Bureau of Economic Analysis and authors' calculations.

We also report the RMSE ratio between our baseline model, Equation 13 where z denotes our consumption-weighted import price index, and the competing model, Equation 13 where z denotes the "core" BLS import price index. We also run a Diebold-Mariano test between these two competing models and report the test statistic and p-value.

Results are reported in Table 1. We can see that at all four horizons, our baseline model outperforms the competing model where our consumption-weighted import price index is replaced with the core BLS import price index. For horizons of 1 and 3 months this outperformance is statistically significant.

Figure 2: The Contribution of Import Price Changes to Core PCE Inflation



Notes: The import price contribution is computed from disaggregated import prices weighted according to our import sensitivities. The red bars show price increases due to direct imports, and the blue bars show those due to indirect imports. The black line shows core PCE inflation. *Sources*: BEA, BLS, authors' calculations.

Table 1: The Predictive Power of Import Prices on Core PCE Inflation

			Diebold-Mariano Test	
Horizon	Additional R2	RMSE Ratio	Statistic	p-value
1	0.0191	0.964	-2.173	0.0298
3	0.0121	0.978	-4.153	0.0000
6	0.0010	0.979	-0.627	0.5309
12	0.0007	0.974	-1.612	0.1069

Notes: Additional R2 is the difference between the R2 of the model using our index and the R2 of the model without an additional predictor z. RMSE is the square root of the average prediction error; the RMSE ratio is the ratio of the RMSE of the model with our index versus the RMSE of the model with the "Core" BLS import price index. The null hypothesis of the the Diebold-Mariano test is that a variable has the same forecast accuracy of the "Core" BLS import price index. A negative statistic indicates that the model with our index is our better predictor. *Sources*: BEA, BLS.

4.3 Simulation of Tariff Shocks

Beside offering a one-to-one mapping between imports and personal consumption expenditure, our methodology offers a straightforward tool to study the inflationary effect of specific tariff episodes. In this section, we outline the importance of the markup assumption response in determining the total impact on PCE inflation. Second, we show how our methodology is a useful tool to intuitively assess the impact of tariff exemptions, a feature of most tariff reforms.

We show the effect of different tariff scenarios under our two main markup response assumptions introduced in Section 1. The first assumption is called 'constant-dollar' markup assumption, or partial pass-through. Under this assumption profits remain constant in dollar terms after a tariff increase. Given that we also assume that wages remain constant, this assumption entails that tariffs have an effect only in the foreign share of value added that is taxed. It corresponds to assuming the markup matrices M^E and M in Equation 7 to be identity matrices. The second assumption is called 'constant-percent' markup assumption, or full pass-through. This assumption is more common in standard macro and trade models, where domestic producer charge a constant markup (in percentage terms) on top of marginal costs.

Our estimates assume that the full burden of the tariffs is paid by US importers, consistent with what was observed with the tariff increases that were imposed in 2018 (Fajgelbaum et al., 2019; Amiti, Redding and Weinstein, 2019; Cavallo et al., 2021). Figure 3 shows the PCE inflation effect under three different tariff scenarios. First, we use the cumulated effect of all tariffs introduced on US imports in 2018.[10] The second scenario is an hypothetical uniform 10% tariff applied to all imports. The third scenario is a uniform 10% tariff on all imports but with a US content exemption, that is, the tariff is not applied on the percentage of value added originated in the US.[11]

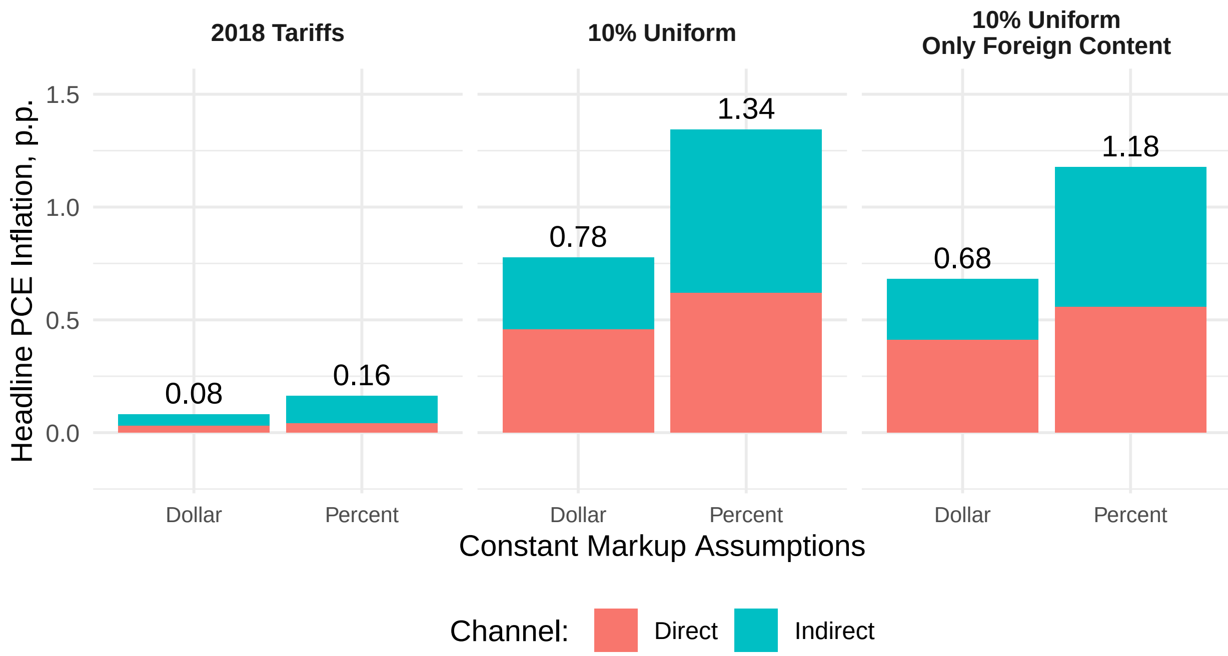
Figure 3 shows that the predicted partial-equilibrium effect of 2018 tariffs on PCE inflation varied from 0.08 p.p. to 0.16 p.p. Most of the effect is indirect, that is coming from higher costs of US domestic producers. We believe that this is why previous literature struggled to find a pass-through of these tariffs into consumer prices (Cavallo et al., 2021). In the next section, we show how these estimates find empirical confirmation in cross-sectional PCE response. The effect is predicted to be more than 10 times larger if instead a 10 percent uniform tax was introduced on all US goods. Exempting US content of US imports makes only a marginal difference of 0.1 to 0.2 percentage points.

There are two notable results from Figure 3. First, given the importance of markups in the

[10]These tariffs, and related exemptions, were provided by Fajgelbaum et al. (2019) at the country-product level.

[11]This is a typical exemption included in most executive orders introduced by the Trump administration in 2025. Our methodology can easily account for such exemption using the OECD input-output tables. In particular we discount for the US-content in each country's export to the US. These shares can vary widely for each country-product combination. For the case of Canada and Mexico we use the share of USMCA-compliant goods instead.

Figure 3: Headline PCE Impact under different Tariff Scenarios



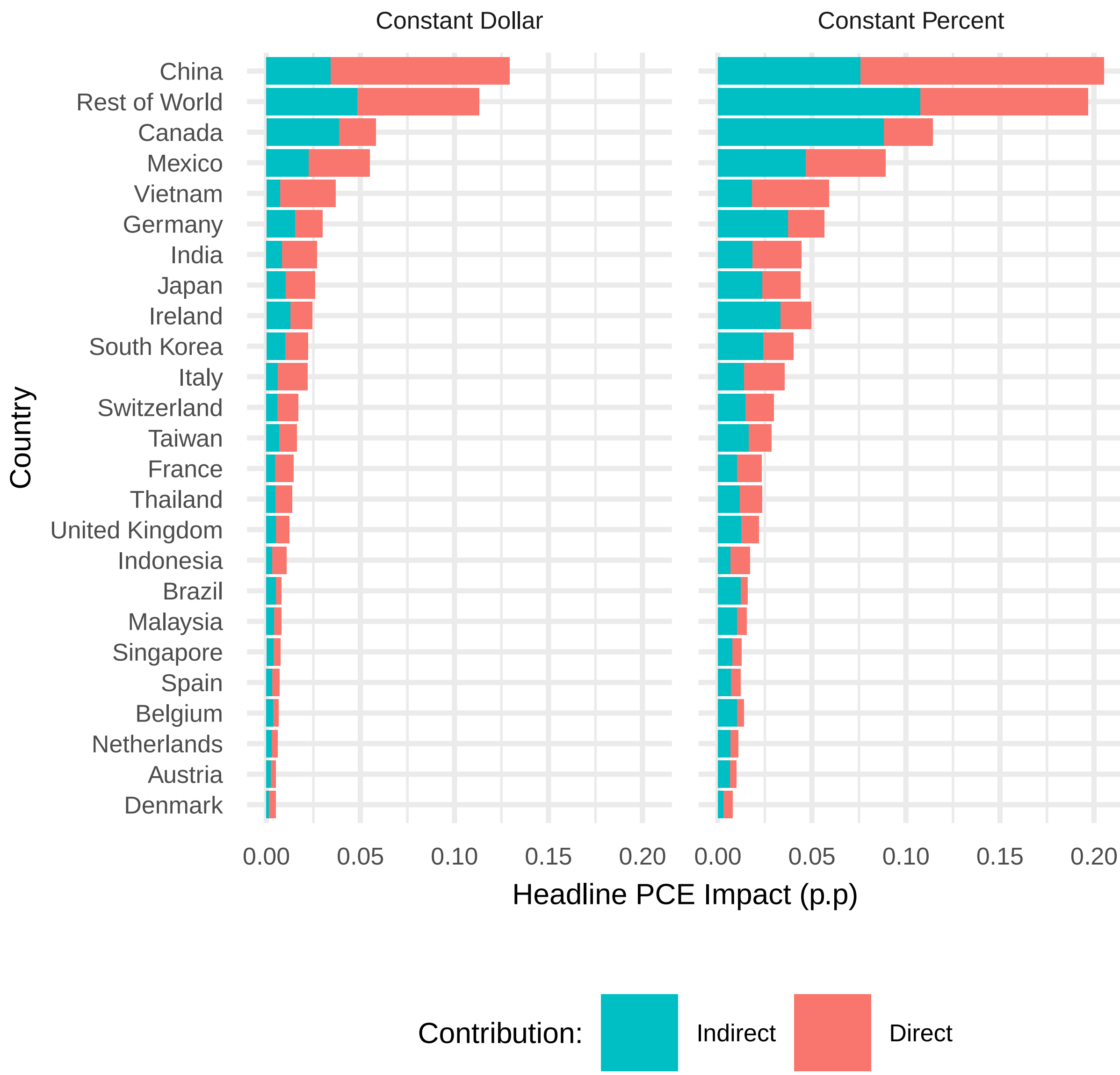
Notes: The three tariff scenario are computed from equation (12). In the first scenario we use as τ_1 the cumulated tariffs introduced by the Trump administration in 2018 and gathered at the country-HTSUS level by Fajgelbaum et al. (2019). In the second scenario we use $\tau_2 = 10\%$. In the third scenario we use $\tau_3 = (\mathbf{1} - s^{\mathrm{US}}) \oslash 10\%$, where s^{US} is the US content in US imports computed for each country-ISIC product combination from the OECD 2020 TiVA database. We use the share of USMCA imports to discount the tariff effects for Canada and Mexico instead.
Sources: US Bureau of Economic Analysis, US Census Bureau, Fajgelbaum et al. (2019), OECD TiVA, and authors' calculations.

data, assuming constant-dollar or constant-percent markup can almost double the predicted effect. Second, note how the increased effect under constant percent markup is mostly passing through indirect effects. What is the intuition behind this result? An upstream marginal cost due to a tariff can have an outsized effect due to the fact that each producer along the supply chain charges a constant markup on top each other input purchases.

Figure 4 shows the decomposition of a 10 percent uniform tariff with US-content exemption decomposed by goods' origin country. China is the top source of inflationary effect, mostly due to direct purchases form consumer. However, note how the indirect effect becomes more important under the constant-percent markup assumption. Canada and Mexico are also important inflationary sources under a 10 percent tariff, and this is despite the tariff discount on USMCA-compliant goods.

Note that our methodology implies that the effect grows linearly to the simulated tariff vector (conditional on the markup assumption). For instance, since Figure 4 implies that a

Figure 4: Source country Decomposition of a 10% Uniform Tariff with US-content exemption



Notes: Each line represents the country-specific contribution to the total PCE tariff effect computed as in equation (12) where $\tau = (\mathbf{1} - s^{\mathrm{US}}) \oslash 10\%$. s^{US} is the US content in US imports computed for each country-ISIC product combination from the OECD 2020 TiVA database. We use the share of USMCA imports to discount the tariff effects for Canada and Mexico instead.
Sources: US Bureau of Economic Analysis, US Census Bureau, and authors' calculations.

10% tariff with US-discounted content on Chinese goods has a 0.12 to 0.21 p.p. effect on PCE inflation, a similar 20% tariff will have an effect between 0.24 to 0.42 p.p.

4.4 Past Tariff Shocks Pass-through into Consumer Prices

As discussed in the previous section, our methodology allows us to predict the effect of tariff shocks on PCE inflation in a partial-equilibrium framework. It is natural to then ask, how have our predicted shocks, based on calculated import price sensitivities, actually passed through to PCE in past episodes? The answer may provide validating evidence for our markup assumption.

We use a few different methodologies to answer this question. In all cases, we zoom in on the 2018 tariffs and focus on NIPA expenditure groups individually.[12] To start, we focus on the China tariffs enacted between July and September 2018. We collapse the different waves of tariffs into one tariff shock, and we run a difference-in-difference specification in which we compare year-over-year price changes of expenditure categories with various predicted tariff effects. Formally, we run the following regression model:

$$\pi_{i,t} = \alpha_i + \delta_t + \beta \text{Post-Period}_t \times s_i + \gamma \hat{w}_{i,t-1} + \varepsilon_{i,t}, \tag{15}$$

where π denotes the year-over-year price change,[13] s denotes the predicted shock, and $\hat{w}$ denotes the year-over-year wage change and is included as a control variable.[14] Predicted shocks are calculated using the tariff data in Fajgelbaum et al. (2019). i refers to the NIPA expenditure category and t refers to the monthly date. The post-period begins in July 2018, and our sample runs from July 2017 through April 2019. We choose this end date so as not to contaminate with the tariffs put on China starting in May of 2019. Our regression also includes NIPA and time fixed effects. The key parameter of interest is β, which approximates pass-through. A coefficient of one would indicate full-pass through.

Results are shown in Table 2. We can see that for goods, there seems to have been full pass-through using the constant-percent markup assumption, shown by the significant coefficient of one. If we use the constant-dollar assumption, pass-through would seem higher than one. This is evidence in favor of our constant-percent markup assumption. When we turn to services, we see weaker results, with positive but insignificant coefficients.

We next estimate effects each month during the sample period in order to better understand the dynamics of the response. Specifically, we run the following regression:

$$\pi_{i,t} = \alpha_i + \delta_t + \beta_t s_i + \gamma \hat{w}_{i,t-1} + \varepsilon_{i,t}, \tag{16}$$

[12] The analyses in this section use NIPA expenditure groups at the level shown in Figure 1.

[13] We take year-over-year price changes to control for seasonality.

[14] The wage control come from the CES seasonally-adjusted average hourly earnings data. The data is at the NAICS level, so in order to get it to the NIPA-level, we follow a similar procedure to the one outlined in subsection 3.4.

Table 2: Pass-through Depending on Markup Assumption

	Goods		Services	
	(1)	(2)	(3)	(4)
Post-period × Predicted Effect	1.000**		0.845	
Assumption: Constant-Percent	(0.453)		(1.267)	
Post-period × Predicted Effect		1.275**		1.678
Assumption: Constant-Dollar		(0.620)		(1.607)
Wage change	-0.002	-0.003	0.004	0.005
	(0.029)	(0.030)	(0.036)	(0.037)
NIPA FE	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes
R^2	0.644	0.643	0.691	0.691
R^2 within	0.024	0.022	0.008	0.009
N	594	594	506	506

Notes: This table examines pass-through from the China tariffs enacted between July and September 2018. The post-period begins in July 2018, and our sample runs from July 2017 through April 2019. Standard errors are clustered at the NIPA expenditure category level. *Sources*: BEA, BLS, Fajgelbaum et al. (2019), authors' calculations.

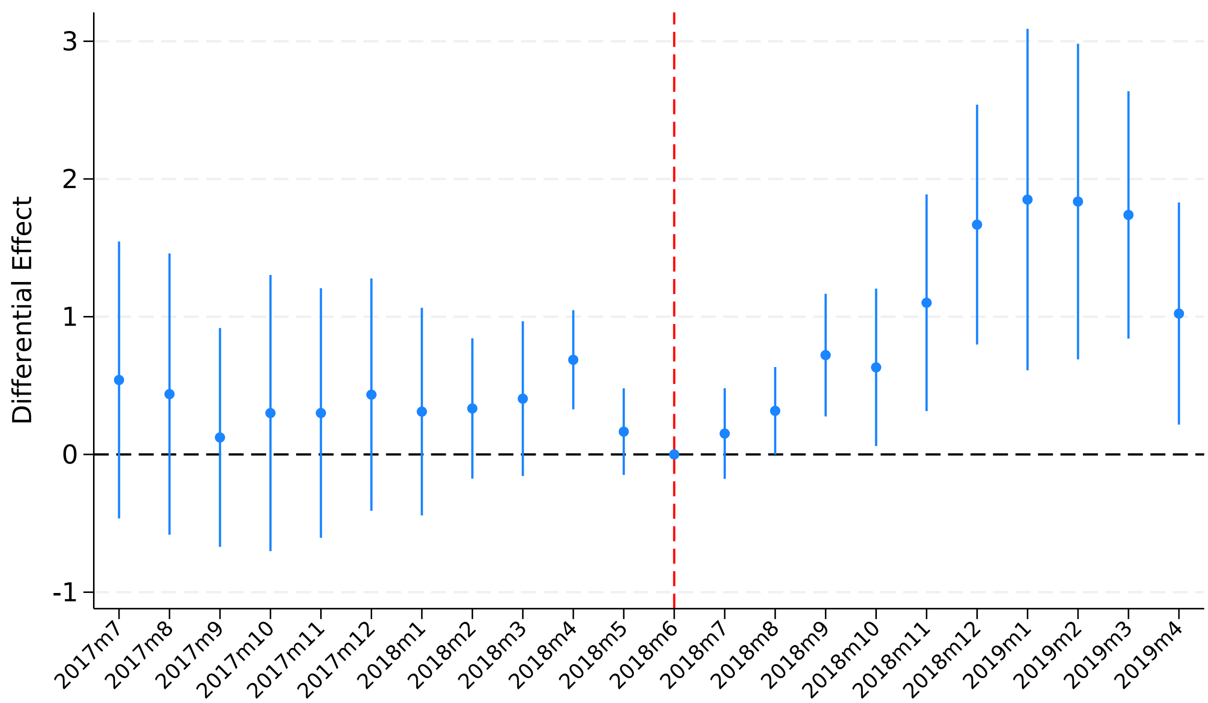
where predicted shocks are now only calculated using the constant-percent markup assumption and where we include expenditure categories for both goods and services. Results are shown in Figure 5. We can see significant results starting in August 2018, with prices continuing to rise for affected expenditure categories through the beginning of 2019.[15] We can also see that, for the most part, the parallel trends assumption seems to hold, though there may have been anticipation effects in April 2018. The uptick in 2018 may also have been caused by contamination by earlier tariffs. We thus turn to a method that can better account for the multiple tariff shocks throughout the year.

In our final analysis in this section, we run local projections (Jordà, 2005) in which we consider the impact of a continuous shock variable. More formally, we use the following regression specification for $h \in [-6, 6]$:

$$\pi_{i,t+h} - \hat{p}_{i,t-1} = \alpha_i + \delta_t + \beta_h s_{i,t} + \gamma_h \hat{w}_{i,t-1} + \sum_{j=1}^{12} \lambda_{h,j} s_{i,t-j} + \varepsilon_{i,t}. \tag{17}$$

[15] In comparing this figure to Table 2, it is worth keeping in mind that the table gave the average results in the pre- and post-periods. We would expect that in some months, prices rise more and, in some months, prices rise less, as different products and producers may update prices with a different frequency. We would also expect inflation to return to baseline eventually; however, we end our sample in April 2019 due to the additional tariffs starting in May 2019.

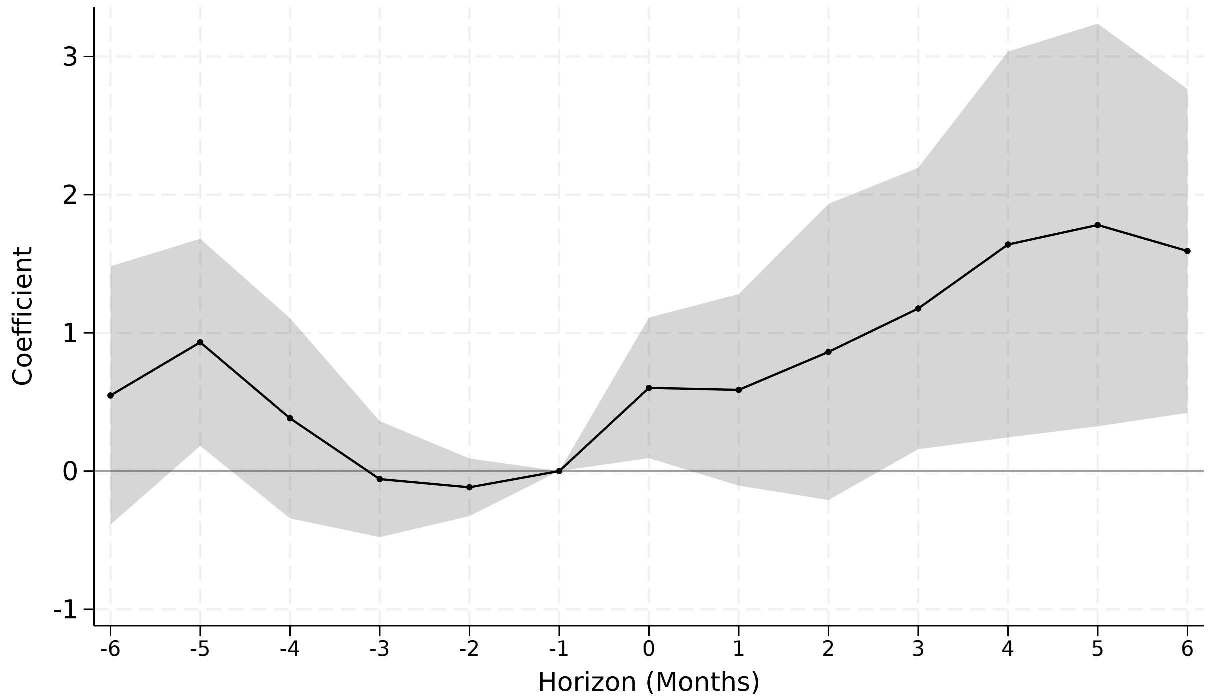
Figure 5: Estimated Pass-through of 2018 China Tariffs



Notes: This figure examines pass-through from the China tariffs enacted between July and September 2018. Standard errors are clustered at the NIPA expenditure category level. The dotted red line shows the last month before the post-period. The blue bars give 90% confidence intervals. *Sources*: BEA, BLS, Fajgelbaum et al. (2019), authors' calculations.

As before, our sample runs from July 2017 through April 2019. However, now our dynamic shock variable covers the washing machine tariffs enacted in February 2018, the steel and aluminum tariffs enacted between March and June 2018, and China tariffs enacted between July and September 2018. Results are shown in Figure 6 and give a similar picture to the study of the July to September tariffs on China. Prices rose on impact and continued to rise for a few months before levelling off. Note how the coefficients have much wider confidence intervals toward the end of the sample, with three months having estimates around 1.7. While we cannot reject the hypothesis of 100% pass-through, another reason why estimates may be larger than one for some months is a protectionist effect on domestic producers in the industries affected by tariffs.

Figure 6: Estimated Tariff Pass-through on PCE Categories



Notes: This table examines pass-through from all tariffs enacted in 2018. Standard errors are clustered at the NIPA expenditure category level. *Sources*: BEA, BLS, Fajgelbaum et al. (2019), authors' calculations.

5 Conclusion

In this paper, we study the effects of import prices at the border on US consumer prices. We do so by developing a new methodology, which builds off a static open economy model of firms that use domestic and foreign goods in a network structure, to which we add markups and retailers. We carefully map each model object to official, publicly-available US data, thus building matrices that show the sensitivity of each consumer expenditure category to import price changes in underlying commodities.

We show how these matrices allow us, as well as future researchers, to do a number of things. First, we can use them to understand the percent of PCE that is imported, and we can break this down into expenditure category and into direct and indirect imports. Second, we can calculate a consumption-weighted import price index, which we show outperforms the BLS "core" import price index in inflation forecasting. Third, we can assess the partial-equilibrium effect of various tariff scenarios, a crucial tool for policymakers and business leaders as tariff schedules are updated. Finally, we show that when we use our network mapping between import prices and retail prices, we find full pass-through from the 2018 tariffs to consumer prices.

References

Amiti, Mary, Oleg Itskhoki, and Jozef Konings. 2014. "Importers, Exporters, and Exchange Rate Disconnect." *American Economic Review*, 104(7): 1942–1978.

Amiti, Mary, Stephen J. Redding, and David E. Weinstein. 2019. "The Impact of the 2018 Tariffs on Prices and Welfare." *Journal of Economic Perspectives*, 33(4): 187–210.

Atkeson, Andrew, and Ariel Burstein. 2008. "Pricing-to-Market, Trade Costs, and International Relative Prices." *American Economic Review*, 98(5): 1998–2031.

Baqaee, David, and Elisa Rubbo. 2023. "Micro Propagation and Macro Aggregation." *Annual Review of Economics*, 15:91-123.

Baqaee, David Rezza, and Emmanuel Farhi. 2019. "The Macroeconomic Impact of Microeconomic Shocks: Beyond Hulten's Theorem." *Econometrica*, 87(4): 1155–1203.

Barbiero, Omar, and Hillary Stein. 2025. "The Impact of Tariffs on Inflation." *Federal Reserve Bank of Boston Current Policy Perspectives*, 25(2).

Baslandze, Salome, Simon Fuchs, KC Pringle, and Michael Dwight Sparks. 2025. "Tariffs and Consumer Prices." *Federal Reserve Bank of Atlanta - Policy Hub.*

Basu, Susanto. 1995. "Intermediate Goods and Business Cycles: Implications for Productivity and Welfare." *The American Economic Review*, 85(3): 512–531.

Cavallo, Alberto, Gita Gopinath, Brent Neiman, and Jenny Tang. 2021. "Tariff Pass-Through at the Border and at the Store: Evidence from US Trade Policy." *American Economic Review: Insights*, 3(1): 19–34.

di Giovanni, Julian, Şebnem Kalemli-Özcan, Alvaro Silva, and Muhammed A. Yıldırım. 2023. "Pandemic-Era Inflation Drivers and Global Spillovers." *Federal Reserve Bank of New York Staff Reports.*

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal. 2019. "The Return to Protectionism." *The Quarterly Journal of Economics*, 135(1): 1–55.

Faust, Jon, and Jonathan H. Wright. 2013. “Chapter 1 - Forecasting Inflation.” In *Handbook of Economic Forecasting*. Vol. 2, , ed. Graham Elliott and Allan Timmermann, 2–56.

Feenstra, Robert C. 1989. “Symmetric pass-through of tariffs and exchange rates under imperfect competition: An empirical test.” *Journal of International Economics*, 27(1): 25–45.

Goldberg, Pinelopi Koujianou, and Michael M. Knetter. 1997. “Goods Prices and Exchange Rates: What Have We Learned?” *Journal of Economic Literature*, 35(3): 1243–1272.

Hale, Galina, Bart Hobijn, and Doris Wilson Fernanda Nechio. 2019. “How Much Do We Spend on Imports?” *FRBSF Economic Letter*, 2019-10.

Jordà, Òscar. 2005. “Estimation and inference of impulse responses by local projections.” *American Economic Review*, 95(1): 161–182.

Kimball, Miles S. 1995. “The Quantitative Analytics of the Basic Neomonetarist Model.” *Journal of Money, Credit and Banking*, 27(4): 1241–1277.

La’O, Jennifer, and Alireza Tahbaz-Salehi. 2022. “Optimal Monetary Policy in Production Networks.” *Econometrica*, 90(3): 1295–1336.

Minton, Robbie, and Mariano Somale. 2025. “Detecting Tariff Effects on Consumer Prices in Real Time.” *FEDS Notes*.

Minton, Robert, and Brian Wheaton. 2023. “Delayed Inflation in Supply Chains: Theory and Evidence.”

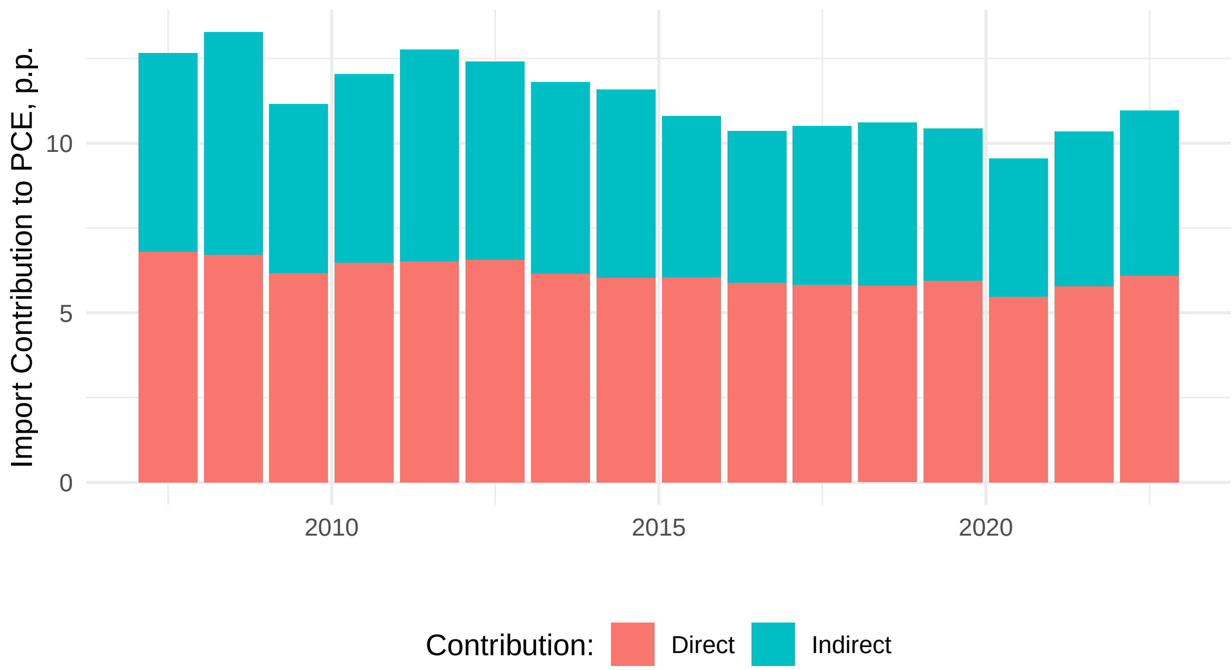
Rubbo, Elisa. 2023. “Networks, Phillips Curves, and Monetary Policy.” *Econometrica*, 91(4): 1417–1455.

Silva, Alvaro. 2024. “Inflation in Disaggregated Small Open Economies.”

Stock, James H., and Mark W. Watson. 2009. “Phillips Curve Inflation Forecasts.” In *Understanding Inflation and the Implications for Monetary Policy: A Phillips Curve Retrospective*. , ed. Jeff Fuhrer, Yolanda K. Kodrzycki, Jane Sneddon Little and Giovanni P. Olivei, 99–202. Cambridge: MIT Press.

A Additional Figures

Figure A.1: PCE Shares of Imports over Time



Notes: The red bars show the share of PCE corresponding to imported goods that are directly consumed by US households. The blue bars show the share of PCE corresponding to imports that are used as inputs in domestic production. *Sources*: US Bureau of Economic Analysis and authors' calculations.