# Import Buyer Price Rigidities and the Transmission of Tariff/Exchange Rate Shocks

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**Abstract**

A standard practice is to employ the trade elasticity – the elasticity of trade flows to a given trade cost shock – to identify the effects of tariffs and exchange rates. In this paper, I show that trade elasticities, even if shock-specific, are not sufficient statistics for the aggregate import response to tariff and exchange rate variation. As I show, import buyer rigidities, i.e. the price stickiness of importing firms, shape firms' import response differently depending on the composition of the shock. That these nominal rigidities are heterogeneous and shocks are not fully persistent implies a nonlinearity in the import response. This paper first presents a series of stylized facts regarding the distinct effect of import buyer rigidities on different shocks, and that identified variation of both tariff and exchange rate shocks are not fully persistent. It then develops a small open economy New Keynesian model in which I illustrate how the heterogeneous import buyer rigidities can create a wedge in the aggregate import responses to tariff or tariff-exchange rate shocks relative to the case without heterogeneity. I characterize and quantify these wedges, which allows me to account for the role of heterogeneity in measuring the welfare losses from tariff and tariff-exchange rate movements. Accounting for heterogeneity and transience changes the implied GDP loss calculated by Fajgelbaum et al. (2019) from 0.04% to 0.075% and also dampens the exchange rate channel of tariffs.
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# 1 Introduction

The trade elasticity is typically used as a sufficient statistic to determine how trade flows respond to a trade shock such as tariffs or exchange rates (or both, as tariff shocks are often accompanied by an exchange rate fluctuation). It has traditionally been useful because it governs how much trade quantities respond to a given trade cost shock, which can then be used to identify the overall response of the trade balance. In this paper, I demonstrate that the trade elasticity fails as a sufficient statistic for interpreting tariff or exchange rate shocks, and provide a way to correct this problem. Correcting it nearly doubles the measured GDP loss from the 2018–19 trade war (from 0.04% to 0.075%) and dampens the US exchange rate channel.

I show that this failure arises due to the presence of firms that intermediate trade between foreign and domestic entities ("import buyers"). In particular, these firms are heterogeneous with respect to their nominal pricing rigidities when they sell domestically. These "import buyer rigidities" change import demand adjustment. As firms vary with regard to this rigidity, there are heterogeneous import demand responses to shocks such as tariffs or exchange rates. Along the firm distribution of price stickiness, the slope of these differences across firms is nonlinear due to the interaction with transitory shock variation. As a result, via Jensen's inequality, trade elasticities are not sufficient statistics for the aggregate import response to tariff or exchange rate shocks. Through the framework I develop, I characterize and quantify for a range of shocks the wedge in the aggregate import response that heterogeneity introduces relative to the homogeneous benchmark.

The paper first presents a series of facts which illustrate that import buyer rigidities change quantity responses to shocks, and that identifying shock variation is transitory (persistence less than unity). As I will show, this generates heterogeneous import demand responses to trade shocks which are nonlinear along the distribution of import buyer rigidities, compromising aggregation from trade elasticities. I proceed to develop a framework to explore these concepts and then quantify the consequences for aggregation.

In the model framework, I add a layer of intermediary firms, import buyers, to a small open economy New Keynesian model and allow for heterogeneous price stickiness across these firms. Given shock persistence less than unity or incomplete pass-through (or both), the model generates the insight that a tariff or exchange rate shock introduces a nonlinearity in the distribution of firm-level import demand responses to the shock(s). This nonlinearity undoes the sufficient-statistic role of the trade elasticity and instead requires a correction. The model lends itself to characterizing the curvature: I provide results for tariffs alone and for each type of currency choice (local currency pricing (LCP), producer currency pricing

(PCP), and dominant currency pricing (DCP)). Via Jensen's inequality, the sign of the shocks and curvature then directly speak to whether aggregation from the trade elasticity is stronger or weaker than the actual overall trade response.

To generate the correction term for the aggregate import response accounting for heterogeneity, I leverage the model to identify the total effect of heterogeneous import buyer rigidities on the aggregate import response. In particular, I define the Heterogeneity Import Gap (HIG) which is the percentage difference in import response across heterogeneous and homogeneous import buyer rigidity cases. Note that comparing these cases effectively captures how the import buyer rigidity itself changes aggregation. Measured trade elasticities are observed for trade flows subject to import buyer rigidities and are identified on average, i.e. therefore are measured for an average import buyer rigidity. Comparing the heterogeneous-rigidity (data-consistent) case to the homogeneous-rigidity benchmark thus captures the full role of import buyer rigidities in shaping aggregate import responses relative to the value identified using measured elasticities. Quantifying this HIG then enables me to determine the necessary correction factor.

Quantification of the HIG shows that accounting for heterogeneity amplifies the contraction from tariffs meaningfully: nearly double the calculated contraction from Fajgelbaum et al. (2019) (from an equivalent of 0.04% of GDP to 0.075% of GDP). Accounting for heterogeneity also changes the role of the exchange rate. It weakens the exchange rate channel of tariffs under LCP but strengthens it under PCP. Under tariff escalation with a dollar appreciation, this has the effect of lowering the mitigative power of the exchange rate in US imports (which are LCP) while strengthening the exchange rate amplification in US exports (which are PCP). For the US, this effect can actually dampen the exchange rate channel of tariffs. I provide additional results for DCP.

The next section discusses related literature, and the following Section 3 discusses the data used and empirical design. Section 4 presents the three empirical facts used to guide the theoretical analysis in Section 5. Section 6 contains quantitative simulations of the model, Section 7 applies the model analysis to the 2018-19 US tariff escalation, and I conclude in Section 8.

# 2 Literature Review

This paper first contributes to work regarding the International Elasticity Puzzle by providing a rationalization for the puzzle and demonstrating an additional facet: even shock-specific trade elasticities are not sufficient statistics for the import response to tariff or joint tariff-exchange rate shocks. Originally stated by Ruhl (2008), international trade and

open-economy macro models require different trade elasticities to match empirical moments. Empirical research since has demonstrated both time-varying (i.e. Boehm et al. (2023)) and also shock-varying trade elasticities (i.e. Fontagné et al. (2018) and Fitzgerald and Haller (2018)). There have been recent individual efforts to estimate these trade elasticities (Boehm et al. (2023) or Fajgelbaum et al. (2019); exchange rate elasticities from Amiti et al. (2022), De Gregorio et al. (2024), or Gertler (2026), which also yield different values over time and also by shock. This paper demonstrates that accounting for firm intermediation of trade first rationalizes the puzzle with a microfoundation for shock-specific trade elasticities and then also generates broader implications for the aggregation of joint shocks.

This paper also builds on the literature regarding the influence of exchange rates and tariffs on trade flows. In US data, values of pass-through for both shocks have been well established. Previous work on the 2018 US tariff escalation documented complete pass-through in both US exports and imports (Fajgelbaum et al. (2019), Amiti et al. (2019), Cavallo et al. (2021)). I build on work documenting currency choice patterns in US exports and imports from work such as Gopinath and Rigobon (2008), Gopinath and Itskhoki (2010), and Gopinath et al. (2010). Relative to this analysis, I focus on the quantity demand side, but I implicitly rely on these existing pass-through estimates.

On the quantity demand side, there is relatively less evidence, particularly with US data. Work on tariff-based trade elasticities such as Boehm et al. (2023) and exchange rate-based such as Amiti et al. (2022) demonstrate the presence of frictions attenuating demand effects of these shocks, at least in the short-run. Work such as Burstein et al. (2003), Corsetti and Dedola (2005), Auclert et al. (2024), and Fitzgerald et al. (2023) has emphasized a range of demand-or-supply-side frictions which could generate such effects. The first two papers highlight the role of distributional costs, the third develops a model of sluggish households, and the fourth explores the role of investment in customer base. The importance of these frictions has been well-established to be crucial in changing how international cost shocks like exchange rates and tariffs influence trade flows.

Building on that earlier literature, recent work by Gertler (2026) focuses on import buyer rigidities, the price stickiness of the importing firm. Import buyer rigidities attenuate import demand elasticities but cause them to be increasing in the persistence of pass-through. In this paper, I focus on how heterogeneous import buyer rigidities, that importing firms have varying stickiness, shape the distributional and aggregate effects of a joint tariff-exchange rate shock.

The distinction between Gertler (2026) and this paper is as follows. Gertler (2026) establishes the level effect: import buyer rigidities attenuate import demand elasticities, with the attenuation increasing in the persistence of pass-through. This paper takes that

mechanism as an input and establishes three distinct results: that import buyer rigidities are heterogeneous across firms and affect tariff and exchange rate shocks asymmetrically, that identified shock variation is not fully persistent, and that the interaction of these two facts breaks the aggregation from measured trade elasticities to aggregate import responses. The characterization of the resulting nonlinearity, the Heterogeneity Import Gap, and the welfare corrections are new to this paper. I make note where empirical inputs are drawn from Gertler (2026); the core analysis is new to this paper.

# 3 Data and Empirical Design

## 3.1 Data

I employ data from the Longitudinal Firm Trade Transactions Database (LFTTD), linking it to tariff data[1] and exchange rate data.[2] As in Gertler (2026), I merge on specification controls including PPI and GDP, originating from the International Monetary Fund International Financial Statistics data (IMF IFS). To construct the import buyer rigidity, I aggregate industry-level stickiness information from Nakamura and Steinsson (2008) to the firm level using linkage information and employment weights from the Longitudinal Business Database and Economic Census data. The sample used in this paper covers the monthly period from January 2013 through April 2019.

Following Gertler (2026) I also convert the firm-level import buyer rigidity to the traded-product level, again using employment weights. This conversion allows me to compare imports to exports (the latter lacking importing firm information). However, it also has the benefit of increasing power for exchange rate-based analysis, which has a relatively weaker first-stage in US imports due to low pass-through and a strong US firm factor component in exchange rate variation. On the other hand, the product-level measure for tariffs – which are imposed on far fewer products than exchange rates influence – generates noise. Accordingly, for US imports I will report analysis using both firm-level and product-level import buyer rigidity measures, and demonstrate consistency across both. Moreover, the two measures serve as joint robustness.

Throughout, the import buyer rigidity should be interpreted as measured effective price stickiness rather than a claim about its structural source. Firms may adjust prices infrequently because of menu costs, contracting frictions, inventory management, or customer-base considerations; the empirical analysis does not require distinguishing among these.

[1] From Fajgelbaum et al. (2019), originally from the U.S. Census.
[2] From Bloomberg.

What the aggregation results in Section 5 require is only that import demand responses differ systematically with measured stickiness and that this stickiness is heterogeneous across importing firms – both of which I document directly. The model formalizes this stickiness with Calvo pricing, which maps measured adjustment frequency into a Calvo parameter parsimoniously.[3]

### 3.2 Empirical Method

I employ a panel-data local projections approach following Boehm et al. (2023) and Gertler (2026). I leverage a contemporaneous shock local projection as an instrument for a longer-run shock change. This strategy both provides a clear interpretation of the identified elasticities – as originating from a single exchange rate shock – while also improving robustness to endogeneity concerns regarding estimating quantity effects of exchange rates. The estimating equations take the form of:

$$\Delta q_{nt}^{m} = \gamma \Delta_0 s_{nt} + \beta_q X_{nt} + \xi_{nt} + \varepsilon_t^q, \tag{1}$$

with the first stage

$$\Delta s_{nt} = \rho \Delta_0 s_{nt} + \beta_s X_{nt} + \xi_{nt} + \varepsilon_t^s, \tag{2}$$

Here, $t$ refers to month, $n$ is the unit of observation, and $j$ is partner country. $\Delta$ refers to a 10-month projection, i.e. $\Delta s_{nt} = s_{nt+10} - s_{nt-1}$. In this setting $n = \{f, h, j\}$ where $f$ refers to (US) firm, $h$ is HS-10 product, and $j$ is again partner country. $X_{nt}$ and $\xi_{nt}$ are the full sets of controls and fixed effects respectively. In all analysis, the outcome is projected on the shock, i.e. a local projection regression is estimated.

## 4 Stylized Facts

In this section I present three stylized facts. First, the import buyer rigidity substantially attenuates trade quantity responses to tariffs. Second, from Gertler (2026) the import buyer rigidity has little effect on import processes subject to LCP, but a large effect on processes

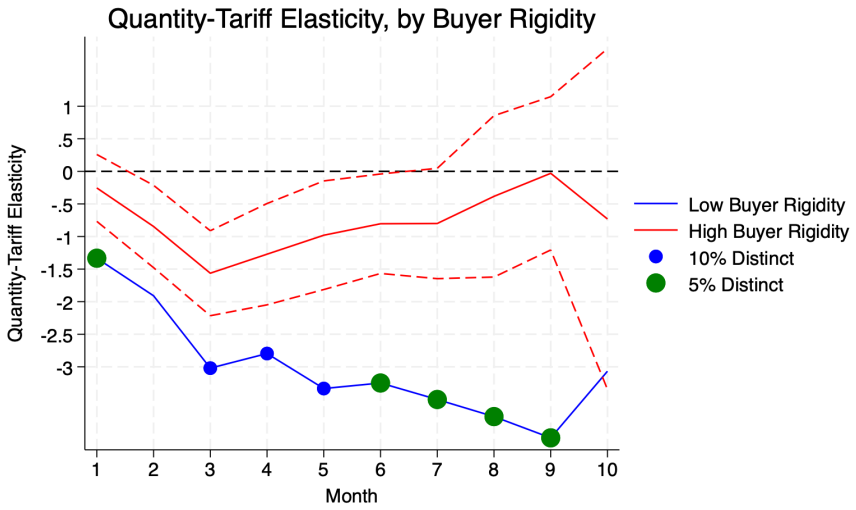
[3]The nonlinearity in Section 5 (Propositions 1 and 2) does not depend on the Calvo assumption per se: under any time-dependent pricing scheme, a firm that adjusts less frequently responds to a transitory shock averaged over a longer interval, and because the shock decays geometrically this generates curvature in responses across adjustment frequencies. Calvo pricing determines the specific functional form and hence the quantitative magnitude of the HIG. Under state-dependent pricing, sufficiently large shocks induce adjustment even at firms with high measured rigidity, compressing the heterogeneity; the persistence of the measured attenuation among sticky import buyers through the 2018–19 escalation suggests such selection is limited in this setting.

subject to PCP. Relatedly, exchange rates can offset tariffs for sticky importers but far less so for flexible importers. Finally, I show that identifying shock variation is substantially less persistent than unity (and substantially less persistent than raw variation would suggest).

## 4.1 Facts 1 and 2: Import Buyer Rigidities, Tariffs, and Exchange Rates

Figure 1 (originally from Gertler (2026)) demonstrates that firms with relatively sticky prices (high import buyer rigidities) have dampened tariff-based trade elasticities as compared to firms with relatively flexible prices (low import buyer rigidities). Appendix Table 6 reports the point estimates at the 6- and 10-month horizons.

Figure 1: Fact 1: Tariffs and the Import Buyer Rigidity




**Note**: Equation 1 estimated using Equation 2 as the first stage, in US imports for tariffs, over horizons $k = 1, ..., 10$. The red line represents the quantity-tariff elasticity for the sample of import buyers with average Calvo rigidity of 0.95, and the blue line the quantity-tariff elasticity for the counterpart group with a Calvo rigidity of 0.8. Dashed lines represent 95% confidence intervals, and blue and green dots on the blue line represent horizons in which the flexible import buyers' tariff elasticity is respectively 10% or 5% distinct from that of the sticky buyers. Originally from Gertler (2026).

Next, Table 1 (originally Gertler (2026)) contains the estimates of how the import buyer rigidity affects quantity-exchange rate elasticities for PCP versus LCP. Note that under PCP, the buyer rigidity substantially attenuates the quantity response to exchange rates; under LCP there is little attenuation.

Comparing the two tables, the averages for high- and low-buyer-rigidity firms for exchange rate effects are similar to the high-buyer-rigidity elasticity for tariffs. One takeaway is thus that amongst sticky importers, quantity effects of tariffs and exchange rates are reasonably

Table 1: Fact 2: LCP and PCP ER and the Import Buyer Rigidity

| | (1) US Exports "PCP" | (2) US Imports "LCP" |
|---|---|---|
| Low Buyer Rigidity | -0.6241*** | -0.6197** |
| | (0.2016) | (0.2758) |
| High Buyer Rigidity | -0.2092 | -0.5793*** |
| | (0.2282) | (0.1795) |
| Difference | 0.415* | 0.04047 |
| | (0.231) | (0.2138) |
| Firm-product-time | Y | Y |
| Firm-partner-sector | Y | Y |
| PPI, GDP, Tariff | Y | Y |
| Lag Controls (11) | Y | Y |
| N | 505000 | 1957000 |

**Note**: Quantity-exchange rate elasticities $\frac{\gamma}{\rho}$; 10 month exchange rate projection instrumented with the contemporaneous exchange rate shock. Equation 1 is the reduced form and Equation 2 is the first stage, with the exchange rate as the shock. The exchange rate is interacted with indicators for below- and above-median import buyer rigidity faced on average by each traded product. The table reports the quantity-exchange rate elasticities for the two bins as well as the statistical difference between the two. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and imports. All first-stage F-statistics reflect a strong first stage. Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY24-P2874-R11645). This is a part of clearance request #11645. Originally from Gertler (2026). $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

offsetting. However, for flexible importers, there is a large disparity. Accordingly, there is a meaningful asymmetry in both the influence of tariffs and exchange rates and also their effect on the distribution of firms.

## 4.2 Tariff vs. ER in US Imports

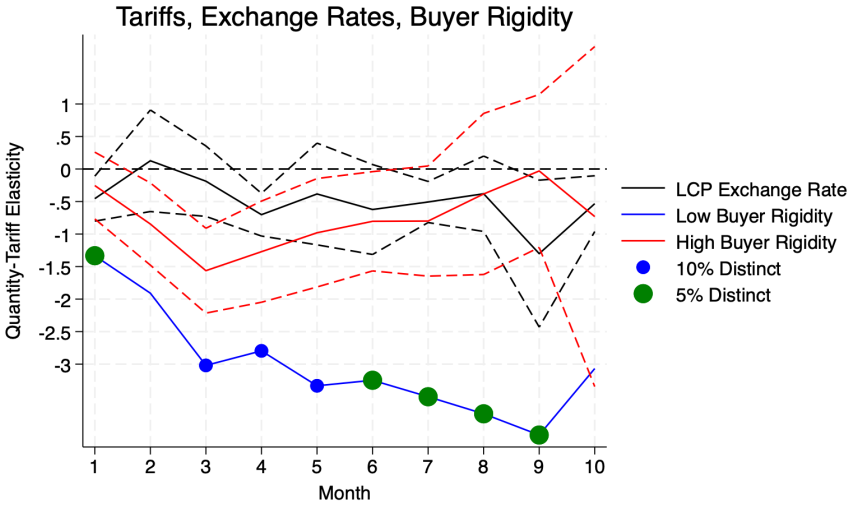
From Figure 1 and Table 1 it is apparent that in US imports, import buyer rigidities substantially dampen trade quantity responses to tariff shocks, whereas they have small effects on quantity responses to exchange rate shocks. Therefore, as an exercise I compare the average quantity response to exchange rates relative to the distribution of tariff responses. The objective of this exercise is to discern where along the distribution of firms' import buyer rigidities the tariff and exchange rate shocks are approximately equal.

Figure 2 demonstrates the comparison between exchange rate effects and tariff effects.

Again, I plot the average exchange rate effect as it is relatively homogeneous empirically. The figure illustrates the fact that the import response to exchange rates is similar to the sticky import buyers' response to tariffs. However, it is far more muted in comparison to flexible import buyers' response to tariffs.

In essence, for the above-median subsample of firms with an average price rigidity of 20 months (Calvo rigidity of 0.95), quantity responses to tariffs are equal to quantity responses to exchange rates. This sample of firms makes up about 2/3 of US imports. For the rest of firms (with an average rigidity of 5 months, i.e. Calvo rigidity of 0.8), there is a large disparity in the firms' relative responses to tariffs relative to exchange rates. For these firms, quantities move substantially more in response to tariffs than they do to exchange rates.

Figure 2: Buyer Rigidity Heterogeneity: Tariff versus Exchange Rate Response, US Imports




**Note**: Equation 1 estimated using Equation 2 as the first stage, in US imports for exchange rates (black) and tariffs (red and blue), over horizons $k = 1, ..., 10$. The red line represents the quantity-tariff elasticity for the sample of import buyers with average Calvo rigidity of 0.95, and the blue line the quantity-tariff elasticity for the counterpart group with a Calvo rigidity of 0.8. Dashed lines represent 95% confidence intervals, and blue and green dots on the blue line represent horizons in which the flexible import buyers' tariff elasticity is respectively 10% or 5% distinct from that of the sticky buyers. Point estimates originally from Gertler (2026).

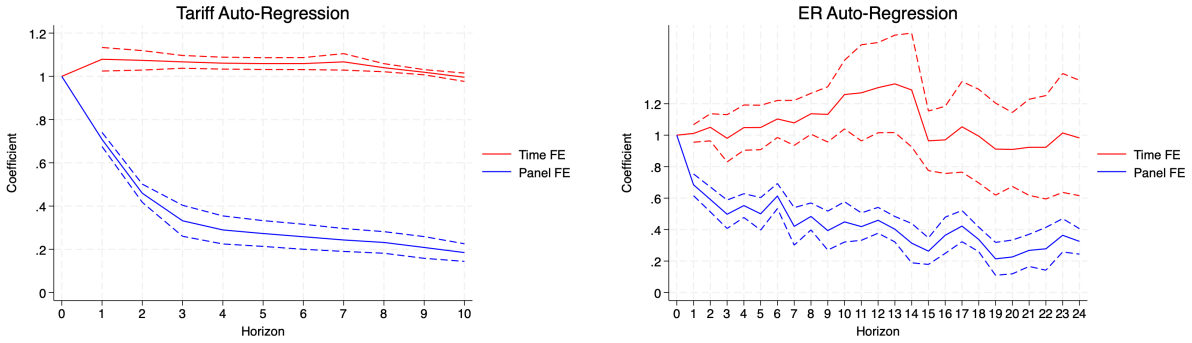
Note that results from Fajgelbaum et al. (2019) and Gertler (2026) imply that there is full pass-through of tariffs into US import prices whereas there is only partial pass-through of the exchange rate. The import buyer rigidity therefore additionally colors this asymmetry.

## 4.3 Fact 3: Tariff and Exchange Rate Persistence

The final stylized fact I present is that the identifying variations of tariffs and exchange rates are not fully persistent. In particular, these shocks' variations utilized in data are substantially less persistent than unity. When a trade elasticity is measured using fixed effects, the researcher is extracting shock variation dependent on those fixed effects. When a shock's persistence is lower with these fixed effects, the trade elasticity is identified with a shock of lower persistence.

As I will show, persistence less than unity generates shock variation that interacts with import buyer rigidities nonlinearly. Import buyer rigidities have a greater dampening effect when shocks are less persistent. This does not scale linearly with the rigidities when shock persistence is less than unity. I will show in Section 5 this ultimately contributes to the insufficiency of the trade elasticity as a sufficient statistic.

Figure 3: Fact 3: Shock Persistence




**Note**: The left figure contains tariff autoregressive local projection coefficients $\rho_k^\tau$ estimated for $k = 1, ..., 10$ horizon changes. The right figure contains exchange rate autoregressive local projection coefficients $\rho_k^\tau$ estimated for $k = 1, ..., 24$ horizon changes. The blue lines reflect the full specification with controls from Equation 2, and the red lines reflect a sparse specification in raw data (i.e. not restricted to control availability) with only a time fixed effect and 11 lag shock controls (corresponding to a year of changes). 95% confidence intervals reported. All standard errors clustered by HS product and partner country. Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY26-P2874-13160). This is a part of clearance request #11894.

## 4.4 Robustness

An obvious concern with this analysis is that the import buyer rigidity is constructed differently for the exchange rate versus tariff analysis. The firm-level measure is more precise and increases power when product coverage is narrow (ie as for tariffs), whereas the product-

level measure is noisier but increases power when product coverage is wide (ie for exchange rates). I report this counterpart for tariffs in the Appendix, demonstrating that although the coefficients are noisier they are consistent.

In particular, I show that the result is consistent for tariffs with the product-level measure, but both groups attenuated relative to the firm-level measure (and noisier). It is clear that the qualitative results from Fact 1 and Fact 2 are robust, but it remains to be seen whether comparing the point estimates from Table 1 across exchange rates and tariffs is meaningful. An additional note of robustness is then that through the above logic, in Table 1 the estimates for tariffs would be accurate and the estimates for exchange rates would be under-powered and attenuated. However, these estimates for exchange rates are if anything larger than the estimates from Gertler (2026) of quantity-exchange rate elasticities in US imports using the full sample. It is accordingly reasonable that the point estimates of exchange rates in Table 1 are informative of the true values, and meaningful to interpret.

Finally, I report additional robustness regarding the import buyer rigidity results in Appendix A; this analysis is drawn from Gertler (2026).

## 4.5 Discussion

The results in this section are suggestive that in US imports the aggregate response to a joint shock such as a tariff-exchange rate shock cannot be inferred from sample average elasticities. US importers demonstrate underlying heterogeneity which influences different shocks differently, implying the true aggregate demand effect in the US could differ from what can be typically measured. I will show that due to the empirical facts from this section, that heterogeneous import buyer rigidities change the response to trade shocks and identified shocks are not persistent, there is a nonlinearity in the distribution of firm responses to trade shocks. This ultimately compromises aggregation from trade elasticities.

In the next Section 5 I develop a framework to determine how the underlying heterogeneity changes the aggregate import response to joint shocks. The analysis applies to joint tariff-exchange rate shocks as estimated in this section. I will consider separately the cases of LCP, PCP, and DCP and characterize the wedges in each case. Then, armed with the empirical results and theoretical model in Section 6 I will quantify the wedges and then apply how this changes the aggregate response of the US economy to the 2018-19 trade war.

# 5 Model

## 5.1 Description

I develop a small open economy New Keynesian model a la Galí and Monacelli (2005). There are three key deviations in this framework. First, trade is in intermediate goods (either intermediate inputs, or final goods to be resold domestically). Second, a layer of importing firms – termed "import buyers" – intermediate the trade process, i.e. purchase goods from foreign exporters and then repackage to sell to domestic households. Third, there are two types of import buyer: one with relatively sticky prices, and one with relatively flexible prices. The building blocks of the model draw from Gertler (2026) but depart by allowing for heterogeneous firms.

Households consume a domestic composite $C$ that is a CES aggregate of a domestic-good composite and a foreign-good composite. Domestic manufacturers produce the domestic-good composite $C^h$ using only labor. The foreign-good composite $C^r$ is a CES aggregate between goods produced by the sticky import buyers ($C^{rH}$) and goods produced by the flexible import buyers ($C^{rL}$). Import buyers produce their goods using a linear technology and a foreign-manufactured input. Foreign manufacturers are subject to tariff and exchange rate shocks entering marginal costs, and price subject to a shock-specific (tariff, PCP exchange rate, LCP exchange rate) nominal rigidities. I will later provide a quantitative extension of the model to account for DCP.

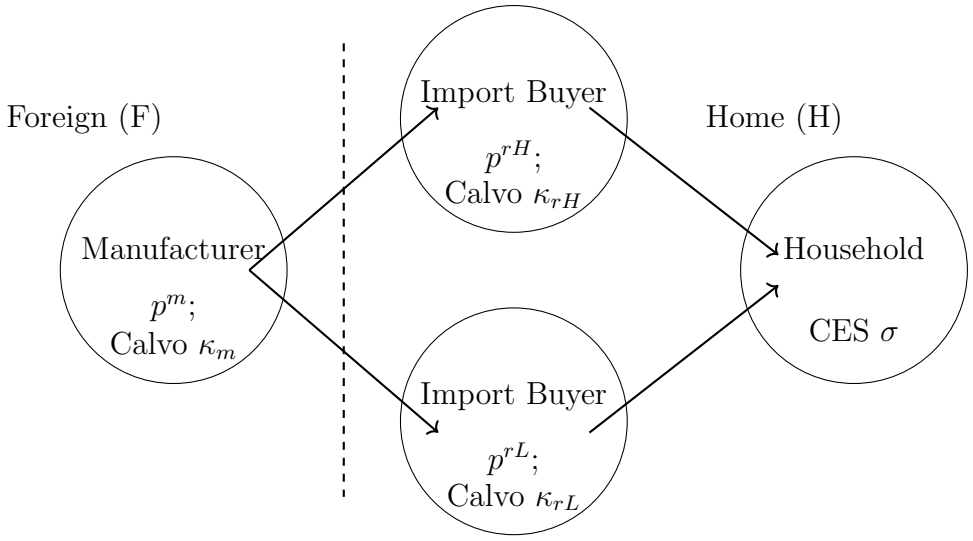
All firms are monopolistic competitors and price subject to Calvo rigidity $\kappa$ which is allowed to vary by firm and shock type. In each period, a firm adjusts its price with i.i.d. probability $1-\kappa$, where $\kappa$ measures the degree of price rigidity. I allow $\kappa$ to vary depending on firm and shock type.

I assume complete domestic markets, but incomplete international financial markets. Monetary policy adjusts the domestic interest rate using a Taylor rule. To generate joint tariff-exchange rate shocks I assume that changing the value of the tariff generates an exchange rate fluctuation. I introduce this mechanism into the model by including a tariff wedge into the uncovered interest rate parity (UIP) equation determining the exchange rate response to economic activity.

Figure 4 contains the general setup of the model. It reflects that two types of import buying firms intermediate the trade process. As a result, as in Gertler (2026) the import demand elasticity depends on the import buyers' price and thus how much that price adjusts to shock pass-through. In this paper, due to the firm heterogeneity the framework will generate an import demand elasticity that is both shock-specific and buyer-rigidity-specific. Crucially, the import buyer rigidity will change the import demand elasticity differently for different

shock types. As I will show, this implies that joint tariff-exchange rate shocks generate a nonlinear import quantity response relative to the firm distribution. I use the structure of the model to determine the curvature of the nonlinearity which enables me to characterize the percent gap between the aggregate response under heterogeneity as compared to a counterfactual homogeneous-import-buyer benchmark, the "Heterogeneity Import Gap." Finally, I provide characterization of the sign of the HIG for tariff-exchange rate shocks where the latter is priced a la PCP, LCP, or DCP, and quantify the magnitudes in Section 6.

Figure 4: Overview of Import Process




## 5.2 Environment

**Households**.

Domestic consumption $C_t$ is a CES aggregate of domestic and foreign manufactured composites, $C_t^h$ and $C_t^r$, with elasticity of substitution $\sigma$ and domestic good share $h$:

$$C_t = \left( h\big(C_t^h\big)^{\frac{\sigma-1}{\sigma}} + (1-h)\big(C_t^r\big)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{3}$$

The aggregate price index $P_t$ is given by

$$P_t = \left( h\big(P_t^h\big)^{1-\sigma} + (1-h)\big(P_t^r\big)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{4}$$

The parameter $\sigma$ is the frictionless CES elasticity. In the model, I will show how this elasticity is distorted, and accordingly influenced by pass-through, in the import process.

The household's per-period utility function is a function of consumption $C_t$, labor used to produce domestic goods $N_t^h$, and labor used to produce goods to export abroad $N_t^{m*}$. It is given by

$$U(C_t, N_t^h, N_t^{m*}) = \frac{(C_t)^{1-\omega}}{1-\omega} - \left( \frac{(N_t^h)^{1+\phi} + (N_t^{m*})^{1+\phi}}{1+\phi} \right), \tag{5}$$

with $\omega$ as household relative risk aversion and $\phi$ is the inverse Frisch labor supply elasticity.

As in Gopinath et al. (2020), international financial markets are incomplete but there is full domestic risk-sharing. Households have access to domestic state-contingent bonds $B_t(s')$ and a foreign nominal bond $B_t^*$. Each state-contingent bond has price $Q_t(s')$ that pays one unit of domestic currency in period $t+1$ and state $s' \in S$. The foreign nominal bond has price of unity in foreign currency at time $t$ and pays the gross nominal interest rate $1+i_t^*$ in period $t+1$. Define $\varepsilon_t$ as units of domestic currency per one unit of foreign currency. Denote the wage in the domestic sector as $W_t^h$ and the wage in the export sector $W_t^{m*}$. Also let $\Pi_t$ denote per-period profits of all domestic firms. Then the per-period budget constraint is given by

$$P_t C_t + \varepsilon_t B_{t+1}^* + \sum_{s' \in S} Q_t(s') B_{t+1}(s') \leq W_t^h N_t^h + W_t^{m*} N_t^{m*} + \Pi_t + \varepsilon_t \Psi_t^u (1+i_t^*) B_t^* + \sum_{s' \in S} B_t(s'). \tag{6}$$

I allow for frictions in international borrowing. $\Psi_t^u$ denotes an i.i.d. shock to the cost of foreign borrowing.[4]

**Import Buyers.**

The foreign-good composite $C_t^r$ is a CES aggregate of two composites: $Q_t^{rH}$ and $Q_t^{rL}$, which are the composites produced by the sticky-priced and flexible-priced import buyers respectively, where individual import buyers are indexed by $i$. Given the substitution elasticities $\sigma_{rH}$ and $\sigma^{rL}$, and the share of the sticky composite $h^H$, we have:

$$C_t^r = \left( h^H \left(C_t^{rH}\right)^{\frac{\sigma_r - 1}{\sigma_r}} + (1-h^H)\left(C_t^{rL}\right)^{\frac{\sigma_r - 1}{\sigma_r}} \right)^{\frac{\sigma_r}{\sigma_r - 1}}, \tag{7}$$

where

$$Q_t^{rH} = \left( \sum_i \left(Q_{it}^{rH}\right)^{\frac{\sigma_{rH}-1}{\sigma_{rH}}} \right)^{\frac{\sigma_{rH}}{\sigma_{rH}-1}} \tag{8}$$

and

[4]See Itskhoki and Mukhin (2021) for the microfoundation of the UIP deviation. That analysis is beyond the scope of this paper.

$$Q_t^{rL} = \left( \sum_i \left( Q_{it}^{rL} \right)^{\frac{\sigma_{rL}-1}{\sigma_{rL}}} \right)^{\frac{\sigma_{rL}}{\sigma_{rL}-1}}. \tag{9}$$

As I describe shortly, $P_t^r$ is determined by price-setting by individual import buyers that take into account the current and expected path of import prices.

Domestic import buyer $i$ in group $H$ or $L$ produces goods $Q_{it}^{rH}$ or $Q_{it}^{rL}$ (respectively) using an imported intermediate composite $Q_t^m$ according to the following linear technology:

$$Q_{it}^r = A^r Q_t^{mi}, \tag{10}$$

where $Q_t^{mi}$ is the amount of the imported composite used by firm $i$.[5] $A^r$ is a common productivity factor. $Q_t^m$ is a composite of imported foreign intermediates produced by monopolistically competitive foreign exporters subject to substitution elasticity $\sigma_m$. Let $Q_{jt}^m$ be the intermediate good sold by foreign exporter $j$. Then

$$Q_t^m = \left( \sum_j \left( Q_{jt}^m \right)^{\frac{\sigma_m-1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_{m-1}}}. \tag{11}$$

Let $P_{it}^r$ be the price of the domestic import buyer $i$'s output and $P_t^m$ the price of the intermediate input composite. Total period profits by a domestic import buyer $\Pi_{it}^r$ are given by

$$\Pi_{it}^r = P_{it}^r Q_{it}^r - P_t^m Q_t^{mi}. \tag{12}$$

As noted earlier, import buyer prices are sticky as in Calvo. Each period, a fraction of firms $1 - \kappa_{ri}$ adjust price while fraction $\kappa_{ri}$ holds price fixed and just produce to meet demand.

**Manufacturing Firms**.

There are two types of monopolistically competitive manufacturing firms: manufacturers which sell domestically and exporters. Both types of firms choose inputs to minimize costs. The domestic-good composite $C_t^h$ is a CES aggregate of differentiated products $Q_{it}^h$ produced by domestic manufacturers indexed by $i$, subject to substitution elasticity $\sigma_h$.

$$C_t^h = \left( \sum_i \left( Q_{it}^h \right)^{\frac{\sigma_h-1}{\sigma_h}} \right)^{\frac{\sigma_h}{\sigma_h-1}}. \tag{13}$$

[5]Having import buyers use the composite export good as opposed to an individual good simplifies the aggregation. The reason is that the price of the composite is the same for all import buyers.

Domestic manufacturers $i$ produce with the following linear technology using labor:

$$Q_{it}^h = A^h L_{it}^h. \tag{14}$$

Foreign exporters produce with a similar linear technology:

$$Q_{jt}^m = A^m L_{jt}^m. \tag{15}$$

Domestic manufacturers' profits are given as a function of their output price $P_{it}^h$ and their sector wage $W_t^h$.

$$\Pi_{it}^h = P_{it}^h Q_{it}^h - W_t^h L_{it}^h. \tag{16}$$

Foreign exporters' profits are given as a function of their output price $P_{jt}^m$ and their foreign sector wage $W_t^m$.

$$\Pi_{jt}^m = \frac{P_{jt}^m}{\varepsilon_t} Q_{jt}^m - W_t^m L_{jt}^m. \tag{17}$$

The identities are symmetric, and denoted with a $*$, for firms which sell to foreign. Finally, as noted earlier manufacturers have sticky prices as in Calvo. Importantly, import demand will depend not only on the stickiness of exporters' prices but also on the stickiness of import buyers', as I describe below.

**Pricing Conditions.**

Note that in equilibrium, quantities produced are equal to the supply of consumption goods, i.e. for firm type $g = \{r, h, r*, h*\}$, $Q_t^g = C_t^g$. Recall $Q^m$ (and implicitly $Q^{m*}$) is defined by Equation 11. Henceforth define firm type $g = \{r, h, m, r*, h*, m*\}$. From the cost minimization problems of households and import buyers, we obtain the following demand functions for each firm $l \in \{i, j\}$ (domestic or foreign) within group $g$.

$$Q_{lt}^g = \left(\frac{P_{lt}^g}{P_t^g}\right)^{-\sigma_g} Q_t^g. \tag{18}$$

All firms within each group $g$ are identical, so reset prices $\bar{P}_t^g$ for firm $l \in \{i, j\}$ producing goods of type $g$ satisfy

$$max_{\bar{P}_t^g} \sum_{s=t}^{\infty} \beta^{s-t} \Theta_{t,s} \kappa_g^{s-t} \left( \bar{P}_t^g Q_{lt+s}^g - MC_{t+s}^g \right), \tag{19}$$

subject to Equation 18. $\Theta_{t,s} = \beta^{s-t} \frac{C_s^{-\omega}}{C_t^{-\omega}} \frac{P_t}{P_s}$ is the stochastic discount factor between periods $t$ and $s$ given the structure of preferences. $MC_t^g$ represents the marginal cost firm $g$.

By the law of large numbers, the price indices of firm type $g$, $P_t^g$, are given by

$$P_t^g = \left((1-\kappa_g)\left(\bar{P}_t^g\right)^{1-\sigma_g} + \kappa_g\left(P_{t-1}^g\right)^{1-\sigma_g}\right)^{\frac{1}{1-\sigma_g}}. \tag{20}$$

They depend on the reset price in each sector along with the lag price index, as well as the relative rigidity.

**Closing the Model.**

Real net exports in domestic currency are given by the domestic currency value of exports abroad minus the domestic currency value of imports, normalized by the domestic price index.

$$NX_t = \frac{1}{P_t}\left(\varepsilon_t P_t^{m*} Q_t^{m*} - P_t^m Q_t^m\right), \tag{21}$$

where $Q_t^{m*}$ and $Q_t^m$ are aggregate exports and imports respectively. Real gross domestic product is given by

$$GDP_t = C_t + NX_t. \tag{22}$$

I assume the supply of the state-contingent domestic bonds is zero in equilibrium:

$$B_t(s') = 0, \forall s' \in S. \tag{23}$$

I assume that the foreign interest rate responds to the tariff, i.e. Home imposing a tariff generates a foreign depreciation. To ensure that the behavior of net foreign assets is stationary, following Schmitt-Grohe and Uribe (2003) I assume the foreign interest rate depends on $\frac{B_t^*}{P_t}$. Thus we have:

$$i_t^* = \delta + \psi(exp(-\frac{B_t^*}{P_t}) - 1) - \tau, \tag{24}$$

where $\delta = \frac{1}{\beta} - 1$ is the steady state foreign interest rate.

Finally, the nominal interest rate $i_t$ is set according to the following standard Taylor rule that relates it to the behavior of inflation $\pi_t$, the steady state interest rate $\delta$, and also allows for interest rate smoothing governed by the parameter $\xi$. $\Psi_t^i$ is an i.i.d. shock.

$$i_t - \delta = (1-\xi)(i_{t-1} - \delta) + \xi(\phi\pi_t) + \Psi_t^i. \tag{25}$$

I assume first-order autoregressive processes for the two exogenous shocks $\Psi_t^i$ and $\Psi_t^u$.

**Assumptions about the Foreign Economy**.

The framework assumes foreign consumption $C_t^*$, foreign manufacturers' labor and wage $N_t^{h*}$ and $W_t^{h*}$, and foreign exporters' labor $N_t^m$ and wage $W_t^m$ are taken as given. The framework also allows for other unspecified types of firms in the foreign country so that the foreign price level is not necessarily the foreign import buyer price index. Accordingly, I hold the foreign aggregate price level $P_t^*$ fixed.

## 5.3 Decentralized Equilibrium

In a decentralized equilibrium, households maximize the expected path of utility subject to the budget constraint from Equation 6. Firms maximize expected profits described in Equations 12, 16, and 17. Domestic goods and labor markets clear.

**Euler Conditions.**

Intertemporal optimization implies Euler conditions for domestic and foreign bonds. The Euler condition for domestic bonds is[6]

$$C_t^{-\omega} = \beta E_t \left[ C_{t+1}^{-\omega} (1 + i_t) \frac{P_t}{P_{t+1}} \right]. \tag{26}$$

The Euler conditions imply an uncovered interest parity (UIP) condition that relates the change in the exchange rate to the interest rate differential. Here, the tariff shock enters the UIP wedge due to its influence on the foreign interest rate.

$$E_t \left[ C_{t+1}^{-\omega} (1 + i_t) \frac{P_t}{P_{t+1}} \right] = E_t \left[ C_{t+1}^{-\omega} (1 + i_t^*) \frac{P_t}{P_{t+1}} \frac{\varepsilon_{t+1}}{\varepsilon_t} \Psi_t^u \right], \tag{27}$$

where $(1+i_t) = (\sum_{s' \in S} Q_t(s'))^{-1}$ is the inverse price of the domestic bond delivering one unit of domestic currency in period $t+1$. Recall $\varepsilon_t$ is units of domestic currency per one unit of foreign, so $\frac{\varepsilon_{t+1}}{\varepsilon_t}$ denotes the expected exchange rate shock in units of domestic currency per one unit of foreign. A decrease in the domestic interest rate causes a domestic exchange rate depreciation. Note the shock $\Psi_t^u$ serves as an exogenous disturbance to the UIP condition.

By the above UIP condition, the exchange rate fluctuates due to an interest rate shock ($\Psi_t^i$) or a UIP shock ($\Psi_t^u$). The subsequent propagation to trade prices and quantities is subject to the following demand and pricing conditions.

[6]The condition for foreign bonds is given by

$$C_t^{-\omega} = \beta E_t \left[ C_{t+1}^{-\omega} (1 + i_t^*) \frac{P_t}{P_{t+1}} \frac{\varepsilon_{t+1}}{\varepsilon_t} \Psi_t^u \right].$$

**Labor Supply.**

Labor supply for domestic manufacturers satisfies

$$\frac{W_t^h}{P_t} = (C_t)^{\omega}(N_t^h)^{\phi}. \tag{28}$$

Labor supply for domestic exporters satisfies

$$\frac{W_t^{m*}}{P_t} = (C_t)^{\omega}(N_t^{m*})^{\phi}. \tag{29}$$

**Household Demand.**

Household demand for the consumption aggregate $C_t$ is given by the Euler conditions and the path of real interest rates and exchange rates. Household demand for the components of the aggregate $C_t^h$ and $C_t^r$ are given by

$$C_t^h = h\left(\frac{P_t^h}{P_t}\right)^{-\sigma} C_t, \tag{30}$$

and

$$C_t^r = (1-h)\left(\frac{P_t^r}{P_t}\right)^{-\sigma} C_t. \tag{31}$$

Note that expenditure-switching depends partly on the substitution between the domestic and foreign composites: the relationship between Equations 30 and 31. The remaining component depends on the export response, $Q_t^{m*}$.

**Marginal Costs.**

As shown earlier, pricing and pass-through depends on marginal cost, given by the following equations for each sector. First, the nominal marginal cost of the import buyers is given by

$$MC_t^r = \frac{P_t^m}{A^r}. \tag{32}$$

The nominal marginal cost of domestic manufacturers is given by

$$MC_t^h = \frac{W_t^h}{A^h}. \tag{33}$$

The nominal marginal cost of domestic exporters is given by

$$MC_t^{m*} = \frac{W_t^{m*}}{\varepsilon_t A^{m*}}. \tag{34}$$

Finally, the nominal marginal cost of foreign exporters is given by

$$MC_t^m = \frac{\varepsilon_t W_t^m}{A^m}. \tag{35}$$

Note that in foreign, $MC_t^{r*}$ and $MC_t^{h*}$ are symmetric.

**Pricing Optimality.**

The first-order condition for the optimal reset price again for group $g = \{rH, rL, m, h, r*, m*, h*\}$ is given by

$$E_t \sum_{s=t}^{\infty} \Theta_{t,s}(\kappa_g)^{s-t} Q_{s|t}^g (\sigma_g - 1)\left(\bar{P}_t^g - \frac{\sigma_g}{\sigma_g - 1} MC_s^g\right) = 0. \tag{36}$$

Now, henceforth lowercases represent logs. Log linearizing, we have

$$\bar{p}_t^g = (1 - \beta\kappa_g) E_t\{\sum_{k=0}^{\infty} (\beta\kappa_g)^k (mc_{t+k}^g + \mu^g)\}, \tag{37}$$

where $\mu^g = \ln\left(\frac{\sigma_g}{\sigma_g - 1}\right)$ and is constant over time and sector. The price index is in turn given by

$$p_t^g = (1 - \kappa_g)\bar{p}_t^g + \kappa_g p_{t-1}^g. \tag{38}$$

Define the decentralized equilibrium as an allocation of prices such that Equations 3 - 38 hold.

## 5.4 Model Solution

Finally, define $e$ as the log exchange rate and shock $s$ as any general log shock which shifts the demand curve for foreign goods.

In this section, I define the aggregate import response and the individual trade elasticities with respect to exchange rates and tariffs.

**Definition 1**: The aggregate import response to a joint tariff-exchange rate shock $\vec{s}$ is given (in logs) by

$$\frac{dq^{ri}}{d\vec{s}} = \frac{\partial q^{ri}}{\partial \tau} + \frac{\partial q^{ri}}{\partial e}\frac{\partial e}{\partial \tau}. \tag{39}$$

**Lemma 1**: For shock $s$ of an exchange rate subject to local currency pricing ($\kappa_m \in (0, 1)$) or subject to producer currency pricing ($\kappa_m = 0$), or a tariff ($\kappa_m = 0$)

$$\frac{dq^{ri}}{ds} = -\sigma(1 - \kappa_{ri})\left((\frac{1 - \beta\kappa_{ri}}{(1 - \beta\kappa_{ri}\rho)(1 - \beta\kappa_{ri}\kappa_m)})(1 - \kappa_m)\frac{1 - \beta\kappa_m}{1 - \beta\kappa_m\rho}\right). \tag{40}$$

*Proof.* From solving the Calvo system of Equations 37 and 38 for the import buyers' and intermediate input producers' prices. Solution from Gertler (2026).

The following Proposition 1 characterizes the linearity of the distribution of the import demand responses with respect to the import buyer rigidity for the case in which $\frac{de}{d\tau} = 0$, i.e. without an exchange rate shock.

**Proposition 1**: The following characterizes the curvature of the import response curve with respect to heterogeneous import buyer rigidities to a tariff shock $s = \tau$ in which tariff persistence $\rho < 1$. Consider the curve containing three points: the values of the import quantity response for $\kappa_{ri} \in \{\kappa_L, \bar{\kappa}_{ri}, \kappa_H\}$, where $\bar{\kappa}_{ri}$ is the sample average $\kappa_{ri}$.

1. **Tariff Increase**: A tariff increase generates a concave distribution.

2. **Tariff Decrease**: A tariff decrease generates a convex distribution.

*Proof.* From differentiating Equation 40 in Lemma 1, see Appendix B.

Then, Proposition 2 provides the same characterization for the case adding the exchange rate shock assuming $\rho = 1$ for tariffs. Note this $\rho = 1$ assumption for tariffs generates a linear distribution of the import buyer responses to the tariff shock along the distribution of rigidities, i.e. $\frac{dq^{ri}}{ds} = \sigma(1 - \kappa_{ri})$for $s = \tau$. This clarifies the analysis when incorporating the exchange rate.

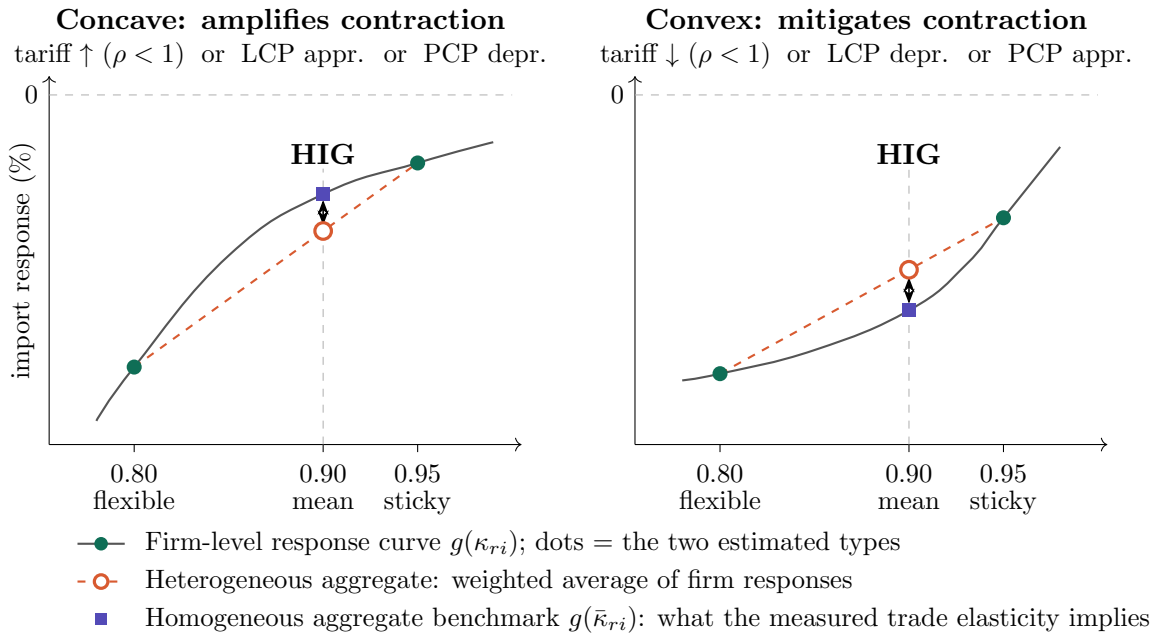
**Proposition 2**: The following characterizes the curvature of the import response curve with respect to heterogeneous import buyer rigidities, to a joint shock involving the exchange rate, assuming $\rho = 1$ for $s = \tau$. Consider the curve containing three points: the values of the import quantity response for $\kappa_{ri} \in \{\kappa_L, \bar{\kappa}_{ri}, \kappa_H\}$, where $\bar{\kappa}_{ri}$ is the sample average $\kappa_{ri}$.

1. **LCP**: For local currency pricing ($\kappa_m \in (0, 1)$) in response to a tariff, the distribution of quantity responses is locally concave below a cutoff $\kappa_{ri}$ in response to an appreciation and locally convex below a cutoff $\kappa_{ri}$ in response to a depreciation.

2. **PCP**: Under producer currency pricing ($\kappa_m = 0$), in response to a tariff, an exchange rate appreciation generates a convex distribution, and an exchange rate depreciation generates a concave distribution.

3. **DCP**: Under dominant currency pricing (a system of two shocks, one with $\kappa_{mD} \in (0, 1)$ and the other with $\kappa_{Dm} = 0$). The curvature of an exchange rate appreciation or depreciation is ambiguous.

Figure 5: Propositions 1 and 2




*Proof.* From differentiating Equation 40 in Lemma 1, see Appendix B.

Note that in the above Proposition 2, LCP, PCP, and DCP each have different distributional curvature in response to a tariff. That is because in the case of $\kappa_m = 0$ (PCP) the gap between sticky and flexible buyers' responses to exchange rates is larger than it is for their responses to tariffs. However, under LCP, the relationship flips: sticky and flexible buyers have more similar responses for exchange rates than they do for tariffs. As a result, in the case of a joint tariff-exchange rate shock the curvature the exchange rate introduces under PCP is the opposite from under LCP. Under DCP, the curvature depends on the value of $\kappa_{Dm}$ and is ultimately an empirical question. This is because DCP layers both LCP and PCP, which have opposite distributional curvature in response to a tariff shock.

Figure 5 illustrates the logic of Propositions 1 and 2. The intuition of Propositions 1 and 2 is as follows. In general, the import buyer rigidity slows adjustment to cost shocks, because firms only adjust when they reset prices. Moreover, a tariff with persistence $\rho < 1$ is a temporary cost shock, so import buyers differ in how much of it they respond to and whether they respond at all depending on their respective rigidities. A flexible importer observes the transitory tariff on her short pricing cycle and adjusts her prices accordingly, generating a large quantity contraction to tariffs on average. By contrast, a sticky importer does not always observe the transitory tariff on its pricing cycle and so may simply look through the shock. This dampening effect falls disproportionately as the buyer rigidity falls because import buyers both begin adjusting *at all* to the shock as well as more quickly

than before. This generates curvature in the distribution of firm responses to the shock. For the exchange rate, the effect is similar with high pass-through. As pass-through falls the persistence of the trade price adjustment increases, increasing the likelihood the import buyer does "observe" the shock and adjust, which shifts the curvature relative to the high pass-through shocks.

This then compromises aggregation from trade elasticities because a trade elasticity is estimated at the average of the distribution. However, the average is not reflective of the aggregate: for example, for a tariff, for low levels of $\kappa_{ri}$ quantity adjustment becomes larger and larger rapidly, whereas as $\kappa_{ri} \to 0$ quantity adjustment clusters close to zero. As a result, a trade elasticity estimated at the mean is not reflective of the distribution. To capture this, I next introduce the concept of the Heterogeneity Import Gap.

**Definition 2**: The Heterogeneity Import Gap in response to joint shock $\vec{s}$ is given by the percent difference in the total import response with heterogeneous import buyer rigidities ($\kappa_{ri} \in \{\kappa_{rH}, \kappa_{rL}\}$) relative to the response with the equivalent average homogeneous rigidity ($\kappa_{ri} = \bar{\kappa}_{ri}$).

$$HIG = \frac{\Delta q^{m,heterog} - \Delta q^{m,homog}}{|\Delta q^{m,homog}|}. \tag{41}$$

The Heterogeneity Import Gap is the amount of correction to be applied to measures of the aggregate import response to a joint shock which use sample-average elasticities. In essence, it captures how much heterogeneity changes the import response. The next Proposition 3 characterizes the directions in which the effects of import responses to tariff are changed by heterogeneous import buyer rigidities.

**Proposition 3**: In partial equilibrium for US imports (LCP), in response to a tariff shock the HIG **amplifies contraction** if the exchange rate either does not move, appreciates under LCP, or depreciates under PCP, and HIG **mitigates contraction** if the exchange rate depreciates under LCP or appreciates under PCP.

*Proof*: Jensen's inequality & linearity results from Propositions 1 and 2.

Proposition 3 characterizes how the aggregate import response to a tariff or joint shock differs due to heterogeneous import buyer rigidities. Due to the interaction of heterogeneous buyer rigidities with transitory (i.e. not persistent) shock variation, the aggregate response to a tariff is larger than what a trade elasticity conveys. Proposition 3 also demonstrates that the exchange rate channel of a tariff weakens mitigative power of an appreciation under LCP and amplifies the contraction under a PCP depreciation, which I will later show has notable implications for US policy.

Finally, note that under specific assumptions the HIG actually represents the correction term in the gains-from-trade calculation from Arkolakis et al. (2012). To see this, note that in Arkolakis et al. (2012) gains from trade are a function of the domestic expenditure share. The HIG represents the percent deviation of the aggregate import response under heterogeneity relative to the homogeneous benchmark. As under certain assumptions changes in the import response map directly to the domestic expenditure share, I can show that the HIG actually represents the amount that heterogeneous import buyer rigidities change the gains from trade. An exploration of this analysis can be found in the Appendix.

# 6 Quantification

## 6.1 Calibration

In the quantitative analysis I focus on the comparison between the above and below median values of the import buyer rigidity in the data. In the data, the above-average import buyers have a rigidity of $\kappa_{ri} = 0.95$. The below-average import buyers have a rigidity of $\kappa_{ri} = 0.8$. The average import buyer rigidity across the sample of US importing firms is $\kappa_r = 0.9$. Accordingly, the following simulations consider two types of import buyers, comparing $\kappa_{ri} = 0.95$ to $\kappa_{ri} = 0.8$, and weighting to reflect the distribution in the LFTTD sample. I run simulations comparing this heterogeneous two-type case to the case of a single import buyer rigidity, $\kappa_r = 0.9$.

I will first consider the scenario in which a tariff is not fully persistent (monthly $\rho^\tau = 0.91$) and the exchange rate does not fluctuate. Then, I will consider the scenario in which the tariff is fully persistent but induces an exchange rate fluctuation, in order to isolate the exchange rate channel.

For each scenario, I simulate the aggregate import response under heterogeneous rigidities and under a homogeneous rigidity. I construct and plot the Heterogeneity Import Gap as in Definition 2: the percent difference in import response with heterogeneous rigidities relative to the homogeneous benchmark.

## 6.2 Simulation: Tariff-Exchange Rate Shocks

### 6.2.1 Tariff Shocks Only

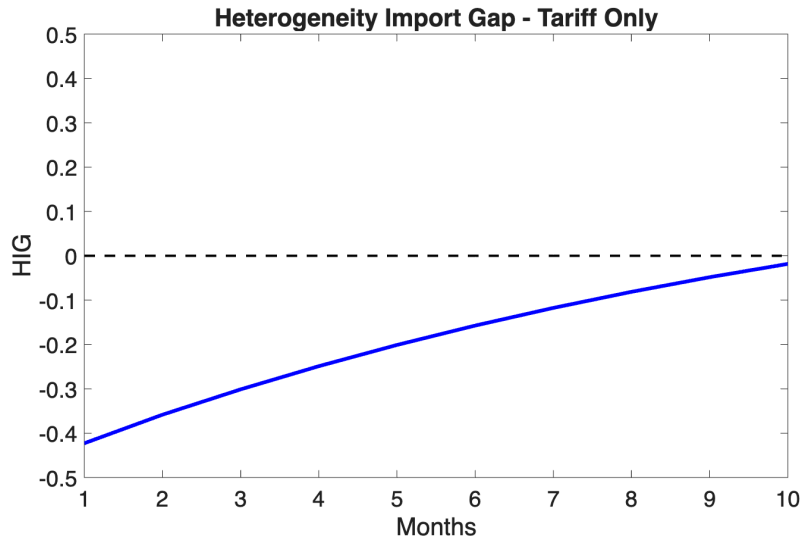
I begin with a simulation of a tariff increase without a companion exchange rate fluctuation. Proposition 3 predicts that with heterogeneous import buyer rigidities a tariff increase is more contractionary than would be predicted from a homogeneous-rigidity benchmark.

Table 2: Calibration

| Parameter | Monthly Value | Source |
|---|---|---|
| $\kappa_m$ (PCP) | 0 | Gopinath and Rigobon (2008) |
| $\kappa_m$ (LCP) | 0.9 | Gopinath and Rigobon (2008) |
| DCP | 0.5 PCP, 0.5 LCP | Assumption |
| $\kappa_{m*}$ | 0 | Gopinath and Rigobon (2008) |
| $\kappa_r$ (Homogeneous) | 0.9 | Estimated (LFTTD) |
| $\kappa_{rh}$ (Sticky) | 0.95 | Estimated (LFTTD) |
| $\kappa_{rl}$ (Flex) | 0.8 | Estimated (LFTTD) |
| $\kappa_{r*}$ | 0.9 | Estimated (LFTTD) |
| $\kappa_h$ | 0.9 | Estimated (LFTTD) |
| $\omega$ | 1 | Log Utility |
| $\beta$ | 0.99 | Standard |
| $\sigma$ | 5 | Anderson and van Wincoop (2004) |
| $\phi$ | 1 | Labor Supply Assumption |
| $\rho^\tau$ (Raw Data) | 1 | Monthly, Estimated |
| $\rho^\tau$ (FGKK, FE) | 0.91 | Monthly, Estimated |
| $\rho^\tau$ (LFTTD, FE) | 0.69 | Monthly, Estimated |
| $\rho^e$ (Bloomberg) | 0.986 | Monthly, Estimated |
| $\rho^e$ (LFTTD, FE) | 0.79 | Monthly, Estimated |
| $A$ | 1 | Normalization |
| $h$ | 2/3 | World Bank (2023) |
| $\psi$ | 0.001 | Assumption |
| ER Response | {0.3,1} | Jeanne and Son (2024), Assumption |

Indeed, the simulation in Figure 6 is consistent with the model's prediction.

Figure 6: Heterogeneity Import Gap: Tariff Shock Only




**Note**: Figure 6 plots the Heterogeneity Import Gap as defined in Definition 2, for the case in which a tariff is imposed on imports and the exchange rate does not fluctuate. The HIG is defined as the difference between the import response under heterogeneous import buyer rigidities and that of the homogeneous benchmark, divided by the absolute value of the latter.

### 6.2.2 Joint Tariff-Exchange Rate Shocks

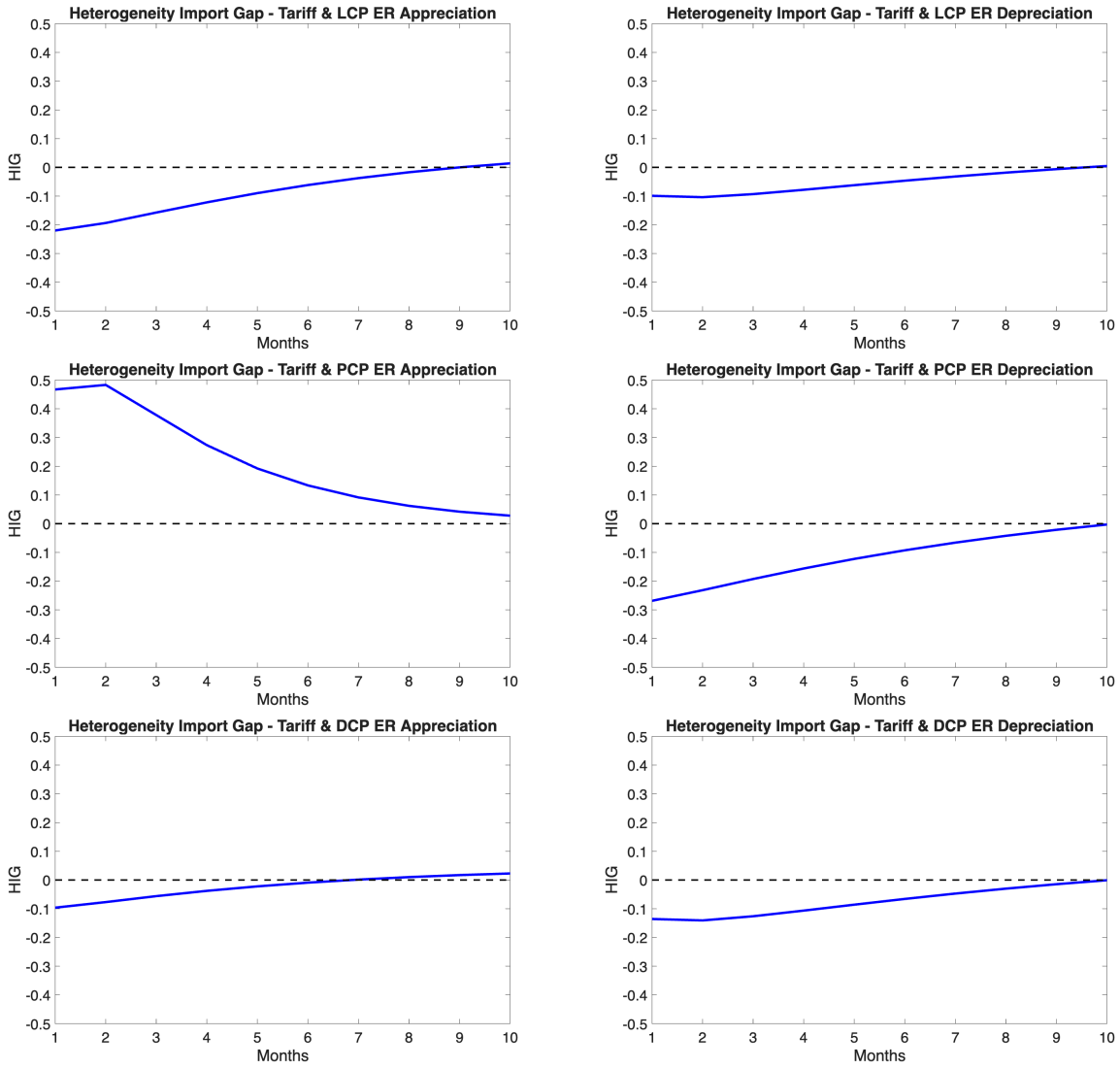
Next, I consider a scenario in which a fully persistent tariff is imposed on imports, and it induces an exchange rate fluctuation. In this scenario, I model the US for which imports are LCP, and also plot PCP and DCP cases. I consider both an appreciation and a depreciation. Figure 7 plots the HIG for these cases.

The above figure confirms the analysis in Proposition 2. That is, under LCP heterogeneous import buyer rigidities enhance the import contraction from tariffs when the exchange rate appreciates (top left figure). That is to say, due to heterogeneous import buyer rigidities an appreciation has less mitigative power on a tariff than is typically measured. Under PCP (middle left) there is also a large HIG, but in the opposite direction. This is consistent with the model prediction.

A depreciation is more difficult to simulate because it increases inflation in the direction that the tariff does, so the endogenous monetary policy contraction pushes the HIG to be more negative. However, the right panel does indicate that consistent with the model, under PCP a depreciation has a more negative HIG than under LCP.

As DCP is essentially a weighted average of PCP and LCP pass-through, the HIG in this

Figure 7: Heterogeneity Import Gap: Tariff-Exchange Rate Shock




**Note**: Figure 7 plots the Heterogeneity Import Gap as defined in Definition 2, for the case in which a tariff is imposed on imports and the exchange rate appreciates one-for-one with the tariff (left panel) or the exchange rate depreciates one-for-one with the tariff (right panel). The top panel plots for LCP ($\kappa_m = 0.9$), the middle panel plots for PCP ($\kappa_m = 0$), and the bottom panel plots for DCP (equally split weight on PCP and LCP exchange rate). The HIG is defined as the difference between the import response under heterogeneous import buyer rigidities and that of the homogeneous benchmark, divided by the absolute value of the latter.

case is a weighted average between the PCP and LCP cases. As PCP and LCP HIG move in the opposite direction for tariffs, the HIG is muted under DCP.

In essence, this analysis illustrates that the exchange rate response to a tariff under LCP is a weaker companion tool than aggregate elasticities would suggest. However, under PCP, the exchange rate channel is relatively stronger than elasticities would suggest. Note that the magnitudes are also meaningful but sensitive to calibration; the exchange rate shocks

are calibrated to match the tariff shocks in magnitudes. Further analysis could focus on identifying the exact magnitudes of the HIG.

## 6.3 Computing the HIG

The model and quantitative exercises have illustrated that the HIG draws from the nonlinearity of the combination of heterogeneous import buyer rigidities with transitory shock variation and variable pass-through. The HIG is defined as the percent difference between the aggregate import response under heterogeneity relative to homogeneity. I can use the model structure to compute this correction term.

Note that the HIG as defined is isomorphic to the difference in mean values across the heterogeneous and homogeneous cases. Then, note that the aggregate import response is given by the integral of the individual import responses to the joint shock over the distribution of import buyer rigidities. A Taylor expansion of the responses (denote as $g_{\vec{s}}(\kappa_{ri}) = \frac{dq}{d\tau}(\kappa_{ri}) + \frac{dq}{de}(\kappa_{ri})$) is given by

$$E[g_{\vec{s}}(\kappa_{ri})] = E[g_{\vec{s}}(\bar{\kappa}_{ri})] + \frac{1}{2} g''_{\vec{s}}(\bar{\kappa}_{ri}) Var(\kappa_{ri}). \tag{42}$$

Then, note that $g(\bar{\kappa}_{ri})$ is equal to the average response under the homogeneous benchmark. Accordingly, the HIG is equivalent to

$$HIG^{Taylor} = \frac{\frac{1}{2} g''_{\vec{s}}(\bar{\kappa}_{ri}) Var(\kappa_{ri})}{|g(\bar{\kappa}_{ri})|}. \tag{43}$$

For consistency with the model I report a two-type model-based implementation detailed in Appendix D. I also report the general continuous measure approximated with data in Appendix D. Note the two-type measure reported in the main text understates the correction.

I calibrate the rest of the formula using the base calibration from this paper. In all cases I find meaningful values for the HIG, but note that accounting for the full time path of shock adjustment would be necessary to identify full effects.

Table 3 illustrates the correction for a tariff or exchange rate (LCP or PCP) shock. Details can be found in Appendix Section D. In the top panel I consider the HIG for various values of $\rho^{\tau}$: unity (raw data), estimated in the product-country level data from Fajgelbaum et al. (2019), and estimated in LFTTD corresponding to Figure 3.

In the top two panels, I find a substantial HIG for a tariff shock and for a PCP exchange rate shock. The LCP exchange rate shock is more linear (consistent with the results in Table 1), but when combined with a tariff shock there is a substantial HIG. Notably, in all tariff scenarios the sign of the HIG implies that the contraction from a tariff or joint tariff-exchange

Table 3: Heterogeneity Import Gap

| | FGKK | | LFTTD | |
|---|---|---|---|---|
| | Taylor | Exact | Taylor | Exact |
| **Tariff HIG** | -11.3% | -10.1% | -30.1% | -28.0% |
| | LCP | | PCP | |
| | Taylor | Exact | Taylor | Exact |
| **ER HIG** | 3.2% | 3.5% | -23.7% | -21.6% |
| **Joint HIG** | | | | |
| Appreciation | -11.9% | -10.6% | -8.4% | -7.3% |
| Depreciation | -10.8% | -9.6% | -13.3% | -11.9% |

**Note**: Heterogeneity Import Gap correction computed for tariffs (top panel), exchange rates (middle panel), and joint tariff-exchange rate shocks (bottom panel). In the top panel, the HIG is computed for tariffs using $\rho^{\tau} = 0.91$ (FGKK data) and $\rho^{\tau} = .69$ (LFTTD data). In the middle and bottom panels the HIG is computed for LCP and PCP separately, and in the bottom panel I calibrate $\rho^{\tau} = 0.91$. Other calibration as in Table 2. Values are used from Gertler (2026) for quantity-exchange rate elasticities for LCP and PCP. The bottom panel assumes the exchange rate-tariff elasticity is 0.3 following Jeanne and Son (2024). All panels report both the HIG calculated using a two-type Taylor expansion as well as an exact two-type calculations, and the Appendix contains further details.

rate shock is meaningfully larger than a standard trade elasticity would imply.

Relative to the homogeneous benchmark, heterogeneity mitigates the exchange rate channel under LCP and amplifies the exchange rate channel under PCP. A positive HIG under LCP-tariff shock implies that when the exchange rate depreciates the contraction is relatively smaller than the benchmark, and that when the exchange rate appreciates the contraction is relatively larger than the benchmark. A negative HIG under the PCP-exchange rate shock implies the opposite.

# 7 Aggregate Effects of 2018-19 Trade War

This section shows how much standard tariff-welfare calculations move once the aggregation correction from the HIG is applied relative to a benchmark trade elasticity calculation. I apply the previous analysis regarding the HIG to the case of the 2018-19 US tariff escalation. I will show that accounting for heterogeneity actually amplifies the contraction from tariffs and also dampens the exchange rate channel.

## 7.1 Applying HIG Calculation to Fajgelbaum et al. (2019)

Based on their pass-through and trade elasticity estimates, Fajgelbaum et al. (2019) calculate the aggregate import and export response to the 2018-19 US tariff escalation. Fajgelbaum et al. (2019) compute the equivalent of

$$EV = \underbrace{-Q^{m\prime}\Delta p^{Q^m}}_{EV^M} + \underbrace{-Q^{x\prime}\Delta p^{Q^x}}_{EV^X},$$

calculating $EV^M = -51$ billion given $\Delta p^{Q^m} = 0.58$ with an import demand elasticity of $-2.53$. For exports, the authors calculate $EV^X = 9.4$ billion. After accounting for tariff revenue = 34.3 billion, the authors find an overall 7.2 billion lost which accounts for 0.04% of US GDP (in 2017, which was 18.9 trillion).

A note on the choice of horizon. The HIG computed in Table 3 is computed from the Lemma 1 response functions evaluated at the 10 month horizon, consistent with the horizon at which the elasticities in Section 4 are estimated. The Fajgelbaum et al. (2019) elasticity of 2.53 is identified from monthly variation during the 2018–19 escalation and their welfare calculation reflects quantity responses within roughly a year of the tariff changes, so the two are evaluated at comparable horizons. Because the HIG enters as a proportional correction to the quantity response, the level of the response is pinned by the Fajgelbaum et al. (2019) estimates themselves. Figure 6 shows the HIG is larger at shorter horizons, so to the extent the welfare-relevant responses occurred within the first months of each tariff wave, the correction applied here is conservative.

In Table 4 I apply the Taylor expansion HIG numbers calculated in Table 3. Appendix E.1 contains the version calculated using the exact two-type calculation and the version calculated using the continuous data-benchmark version. Note that the main-text analysis understates the HIG and welfare correction relative to the robustness. Accounting for the computed tariff-only HIG (from the Fajgelbaum et al. (2019) data) directly modifies the quantity responses in the above calculation. Applied to US imports, this raises the $EV^M$ to $-56.8$ billion, and (computing 11.9% HIG for exports using the estimated export tariff elasticity) lowers $EV^X$ to 8.3 billion. The total welfare loss becomes 0.075% of GDP ($-14.1$ billion), nearly twice as large of a contraction as the 0.04% value found by Fajgelbaum et al. (2019).

This calculation focuses on the response to tariffs only, excluding the role of the exchange rate. Thus, Table 4 next incorporates into calculations the response of the exchange rate, leveraging the implied exchange rate response from Jeanne and Son (2024). In particular, I assume a dollar-tariff elasticity of $-0.3$. I compare the homogeneous benchmark to the

Table 4: Aggregate Effects of the 2018–19 Tariff Escalation: Taylor Two-Type HIG

| | $EV^M$ | $EV^X$ | Net | % of GDP |
|---|---|---|---|---|
| **Tariff only** | | | | |
| FGKK baseline | −51.0 | 9.4 | −7.2 | 0.04 |
| Heterogeneous | −56.8 | 8.3 | −14.1 | 0.075 |
| **Dollar appreciation** | | | | |
| Homogeneous | −46.3 | 5.6 | −6.4 | 0.034 |
| Heterogeneous | −51.8 | 4.9 | −12.6 | 0.067 |
| **Dollar depreciation** | | | | |
| Homogeneous | −55.7 | 13.2 | −8.2 | 0.043 |
| Heterogeneous | −61.7 | 12.1 | −15.3 | 0.081 |

**Note**: Welfare calculation from Fajgelbaum et al. (2019) modified to account for heterogeneity. The top panel considers the tariff-only case, the middle panel considers the case of a joint tariff with a dollar appreciation, and the bottom panel considers the case of a joint tariff with a dollar depreciation. Exchange rate depreciation computed symmetrically to exchange rate appreciation. Taylor expansion HIG applied from Table 3.

heterogeneous case.

Accounting for the exchange rate fluctuation calibrating values from Gertler (2026), we have $EV^M = -46.3$ billion (dollar appreciation offset some import losses from tariffs) and $EV^X = 5.6$ billion (dollar appreciation contracted exports). As a result, naively incorporating the exchange rate into aggregate effects would result in a recalculated aggregate effect of the trade war to be 0.034% of GDP.

Accounting for heterogeneity using the values from Table 3 yields a modified $EV^M = -51.8$ billion and a modified $EV^X = 4.9$ billion. Incorporating tariff revenue effects yields an overall GDP effect of −0.067% (12.6 billion), a proportionately smaller dampening effect of the exchange rate.

When the dollar appreciates in response to a tariff, conventional wisdom is that this at least partially offsets the import price increase from tariffs. However, US imports are LCP and the HIG under LCP functions to dampen the exchange rate channel and also amplify the contraction from tariffs. Moreover, US exports are PCP, and as the foreign exchange rate depreciates in this case heterogeneity amplifies the export contraction. Proposition 2 speaks to exactly the case of the dollar fluctuation during the US trade war: that the US has LCP imports and PCP exports means that heterogeneity dampens the traditionally mitigative exchange rate channel via the HIG.

Hypothetically, consider the case in which the dollar depreciated in 2018-19 as it did in 2025. In this case, a naive incorporation of the exchange rate would suggest a greater

GDP contraction of 0.043% of GDP (relative to the original 0.04% from Fajgelbaum et al. (2019)). Accounting for heterogeneous import buyer rigidities brings the total GDP contraction to 0.081% of GDP (relative to the 0.075% loss in the heterogeneous tariff-only case), a relatively smaller amplification than the homogeneous benchmark. The reason is symmetric to the above logic, drawing from Proposition 2: when the dollar depreciates in response to US tariff, due to dollar rigidity in the US (translating to LCP imports and PCP exports) heterogeneity weakens the exchange rate amplification.

In sum, the analysis in this section has shown that accounting for heterogeneous importers meaningfully changes the calculated GDP loss from the 2018-19 US tariff escalation. With tariffs only, the number jumps from a 0.04% GDP loss to a 0.075% GDP loss (and up to 0.108% in the continuous data-consistent benchmark reported in Appendix E.1), nearly double the original number. Thus, the analysis has first shown that accounting for heterogeneity can dramatically change the calculated economic impact of a tariff shock. Next, in this section I showed that heterogeneity changes the nature of the exchange rate channel for the US. Though conventional wisdom would say an appreciation can mitigate the loss from tariffs in the US, I show that pass-through patterns can dampen the exchange rate channel. Therefore, the actual trade response to a tariff or exchange rate shock can be quite different than what aggregation based on a standard trade elasticity would suggest.

## 7.2 Welfare over the Transition Path

The calculation above applies the HIG as a proportional correction to quantity responses evaluated at a fixed horizon. Because the HIG is horizon-specific – Figure 6 shows it is largest on impact and shrinks as import buyers reset prices – a natural concern is that a fixed-horizon correction misstates the correction to welfare, which accumulates over the entire transition. To address this, Appendix E.2 computes a model-consistent welfare object: the discounted sum of per-period deadweight losses, $\sum_t \beta^t \frac{1}{2}\tau_t|\Delta q_t|$, evaluated on the transition paths of the model under heterogeneous and homogeneous import buyer rigidities.

Under the persistence calibration used in the baseline calculation ($\rho^\tau = 0.91$), the path-integrated welfare HIG in the general equilibrium model is $-8.3\%$ over the full transition and $-16.0\%$ over the first twelve months, bracketing the fixed-horizon correction applied above. The welfare numbers in Table 4 are therefore not an artifact of the fixed-horizon construction.

The general equilibrium channels are essential to this result: in the partial-equilibrium version of the calculation the path-integrated correction reverses sign, as the mid-transition horizons at which sticky import buyers are still adjusting dominate the discounted sum.

Appendix E.2 reports the construction, both persistence calibrations, and the partial equilibrium benchmark.

Table 5: Transition-Path Welfare: HIG

| | (1) FGKK | (2) LFTTD |
|---|---|---|
| **Partial Equilibrium** | | |
| Impact HIG (Table 3) | -10.1% | -28.0% |
| Path-integrated welfare HIG | 10.3% | -13.7% |
| First-year welfare HIG | 6.5% | -14.0% |
| **General Equilibrium** | | |
| Impact HIG (Figure 6) | -42.3% | -70.6% |
| Path-integrated welfare HIG | -8.3% | -48.7% |
| First-year welfare HIG | -16% | -49.2% |

**Note**: Welfare calculation as derived in Appendix E.2. Simulation for tariff shocks only. The top panel reports the partial equilibrium welfare calculation and the bottom panel reports the general equilibrium. In each panel, the first row reports the on-impact HIG, the second reports the full-path integrated welfare HIG, and the third reports the welfare HIG for the first 12 months. Column 1 reports the HIG values calibrated with persistence estimated in the data of Fajgelbaum et al. (2019) and Column 2 reports the HIG values calibrated with persistence estimated in LFTTD data.

# 8 Conclusion

To identify effects of tariff or tariff-exchange rate shocks, standard analysis typically begins with trade elasticities based on sample averages. This paper argues that it is important to account for heterogeneity in the degree of nominal stickiness across importing firms that intermediate between foreign and domestic agents.

This paper makes two key contributions to the analysis of tariff shocks. First, it shows that due to heterogeneous importing firms' price stickiness, trade elasticity calculations meaningfully under-state the GDP response to tariff shocks. Second, it shows that these firms also change the nature of the exchange rate channel of tariffs.

I demonstrate in Census data two types of facts: first, import buyer rigidities change the quantity response to tariff and exchange rate shocks differently; second, identified shocks are not fully persistent. I then develop a theoretical framework to identify implications. That import buyer rigidities are heterogeneous by firm combined with the properties of identified shocks (persistence and pass-through) means that quantity responses to shocks are nonlinear along the firm distribution of rigidities. This compromises aggregation from trade elasticities. I provide a correction and quantify the consequences, showing that contraction from tariff or tariff-exchange rate shocks can be much larger than trade elasticity estimates imply.

Ultimately, this paper cautions against using even shock-specific trade elasticities as sufficient statistics for trade shock evaluation. Import buyer rigidities change the aggregate import response relative to standard measured-elasticity calibration. The framework characterizes the difference and offers a solution. Accounting for import buyer rigidities and their heterogeneity is important for models quantifying the effects of open-economy policies.

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# A Import Buyer Rigidity Robustness

### Tariffs Import Buyer Rigidity - Point Estimates

Table 6: Fact 1: Tariffs and the Import Buyer Rigidity

| | (1) Low (0.8) | (2) High (0.95) |
|---|---|---|
| $k = 10$ | -3.068* | -0.7311 |
| | (1.597) | (1.334 ) |
| N | 316000 | 684000 |
| $k = 6$ | -3.248*** | -0.8035** |
| | (0.9861) | (0.3894 ) |
| N | 355000 | 771000 |
| Firm-product-time | Y | Y |
| Firm-partner-sector | Y | Y |
| Partner-Time | Y | Y |
| Lag Controls (11) | Y | Y |

**Note**: Quantity-tariff elasticity estimated for $k = 10$ horizon (top row) and $k = 6$ horizon (bottom row, reported for consistency as longer horizons lose power), instrumented with the contemporaneous tariff shock. Equation 1 is the reduced form and 2 is the first stage, but using tariffs as the shock, and including a country-time fixed effect. The tariff is interacted with indicators for below- and above-median firm-level import buyer rigidity. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) imports for monthly $\kappa^{r,low} = 0.8002$ (left) and monthly $\kappa^{r,high} = 0.9448$ (right). All first-stage F-statistics reflect a strong first stage (reported in paper). Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY24-P2874-R11330 and CBDRB-FY24-P2874-R11645). This is a part of clearance requests #11330 and #11645. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Point estimates originally from Gertler (2026).

**Product-Level Measure for Tariffs.**

Table 7: Tariffs: Product-level Import Buyer Rigidity

| | (1) Low (0.8) | (2) High (0.95) |
|---|---|---|
| Product-specific | -0.8139 | -0.4486 |
| | (0.5867) | (1.748) |
| N | 2600000 | 565000 |
| Firm-product-time | Y | Y |
| Firm-partner-sector | Y | Y |
| Partner-Time | Y | Y |
| Lag Controls (11) | Y | Y |

**Note**: Quantity-tariff elasticity estimated for $k = 10$ horizon, instrumented with the contemporaneous tariff shock. Equation 1 is the reduced form and 2 is the first stage, but using tariffs as the shock and including a country-time fixed effect. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) imports for monthly $\kappa^{r,low} = 0.8002$ (left) and monthly $\kappa^{r,high} = 0.9448$ (right). Import buyer rigidity constructed using product-aggregated bins. All first-stage F-statistics reflect a strong first stage (reported in paper). Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY24-P2874-R11330 and CBDRB-FY24-P2874-R11645). This is a part of clearance requests #11330 and #11645. Originally from Gertler (2026). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Construction**.

Table 8: Import Buyer Rigidity: Robustness on Construction

| | | (1) US Exports "PCP" | (2) US Imports "LCP" |
|---|---|---|---|
| **Panel A:** | **IO Table** | | |
| Low | | -0.4718** | -0.5893** |
| | | (0.2025) | (0.241) |
| High | | -0.203 | -0.5605 |
| | | (0.313) | (0.3755) |
| N | | 432000 | 1350000 |
| **Panel B:** | **Quantity Weights** | | |
| Low | | -0.4887** | -0.5595** |
| | | (0.1867) | (0.2463) |
| High | | -0.1373 | -0.8101*** |
| | | (0.3597) | (0.1817) |
| N | | 505000 | 1957000 |
| **Panel C:** | **Sample Median** | | |
| Low | | -0.5978*** | -0.664** |
| | | (0.1853) | (0.307) |
| High | | -0.3011 | -0.5588*** |
| | | (0.2357) | (0.1849) |
| N | | 505000 | 1957000 |
| **Panel D:** | **Sample Quartile** | | |
| Low | | -0.6223*** | -0.6744** |
| | | (0.1892) | (0.3088) |
| High | | -0.1627 | -0.5809*** |
| | | (0.3139) | (0.1761) |
| N | | 361000 | 1459000 |
| Firm-product-time | | Y | Y |
| Firm-partner-sector | | Y | Y |
| PPI, GDP, Tariff | | Y | Y |
| Lag Controls (11) | | Y | Y |

**Note**: Quantity-exchange rate elasticities $\frac{\gamma_k}{\rho_k}$ estimated for US exports and imports for $k = 10$ month horizon change; $k = 10$ month exchange rate changes instrumented with the contemporaneous exchange rate shock. Equation 40 is the reduced form and Equation 2 is the first stage. The exchange rate is interacted with indicators for below- and above-median import buyer rigidity. Panel A uses an input-output table construction. Panel B uses the construction as in the text but weights with quantities rather than employment. Panel C splits by the sample median. Panel D reports the difference between the top quartile and below-median groups. All standard errors clustered by HS product and partner country. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and imports. All first-stage F-statistics reflect a strong first stage. Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY24-P2874-R11645). This is a part of clearance request #11645. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Originally from Gertler (2026).

**Continuous**.

Table 9: Import Demand Elasticity: Continuous Import Buyer Rigidity

| | US Exports "PCP" |
|---|---|
| 0% Rigidity | -2.922* |
| | (1.601) |
| 100% - 0% | 2.759 |
| | (1.824) |
| Firm-product-time FE | Y |
| Firm-partner-sector FE | Y |
| PPI, GDP, Tariff | Y |
| Lag Controls (11) | Y |
| N | 505000 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

**Note**: Quantity-price elasticities estimated for US exports and imports for $k = 10$ month horizon change; $k = 10$ month price change instrumented with the contemporaneous exchange rate shock. Equation 40 is the reduced form with the 10-month trade price projection as the independent variable and the exchange rate local projection as the instrument. The price is interacted with the continuous import buyer rigidity measure. The table reports both the uninteracted and the interaction terms. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports. All first-stage F-statistics reflect a strong first stage. Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 2874. (CBDRB-FY24-P2874-R11645). This is a part of clearance request #11645. Originally from Gertler (2026).

# B Proofs of Propositions 1 and 2

Throughout, write $\kappa \equiv \kappa_{ri}$ for the import buyer rigidity and define $r \equiv \beta\rho$ and $m \equiv \beta\kappa_m$, so that $0 \le r, m < \beta < 1$. From Lemma 1 (Equation 40), the firm-level import response to a unit shock is

$$g(\kappa) \;=\; -\sigma\, C\, \frac{(1-\kappa)(1-\beta\kappa)}{(1-r\kappa)(1-m\kappa)}, \qquad C \equiv \frac{(1-\kappa_m)(1-\beta\kappa_m)}{1-\beta\kappa_m\rho} > 0, \tag{44}$$

where $C$ does not depend on $\kappa$. The curvature of the distribution of firm responses is governed by $\operatorname{sign} g''(\kappa)$ on $\kappa \in [0,1)$.

## B.1 Tariff and PCP shocks ($\kappa_m = 0$)

With $\kappa_m = 0$ we have $m = 0$ and $C = 1$, so $g(\kappa) = -\sigma\,(1-\kappa)(1-\beta\kappa)/(1-r\kappa)$.

**Lemma B.1.** *For $\kappa_m = 0$,*

$$g''(\kappa) \;=\; -\frac{2\sigma\beta\,(1-\rho)(1-\beta\rho)}{(1-\beta\rho\kappa)^3}. \tag{45}$$

*Proof.* Decompose the ratio as $(1-\kappa)(1-\beta\kappa)/(1-r\kappa) = \alpha\kappa+\gamma+E/(1-r\kappa)$ with $\alpha = -\beta/r$, $\gamma = (r+\beta r-\beta)/r^2$, and

$$E \;=\; 1-\gamma \;=\; \frac{(1-r)(\beta-r)}{r^2}.$$

Only the pole term survives two differentiations: $g''(\kappa) = -\sigma \cdot 2Er^2/(1-r\kappa)^3$. Substituting $E$ and $r = \beta\rho$ gives $2Er^2 = 2(1-\beta\rho)\beta(1-\rho)$, which is Equation (45). □

*Proof of Proposition 1.* By Lemma B.1, $g''(\kappa) < 0$ for all $\kappa \in [0,1)$ whenever $\rho < 1$, and $g'' \equiv 0$ when $\rho = 1$. Hence for a tariff increase (a positive cost shock) the distribution of firm responses is globally strictly concave in $\kappa$; a tariff decrease reverses the sign of the shock and hence of the curvature, yielding a convex distribution. The case $\rho = 1$ delivers the exact linearity $g(\kappa) = -\sigma(1-\kappa)$ invoked before Proposition 2. □

The PCP exchange rate case of Proposition 2 is Lemma B.1 with $\rho = \rho^e$: the response distribution to a positive (cost-increasing) exchange rate movement is globally concave, so a depreciation generates a concave distribution and an appreciation a convex one, as stated in Proposition 2(2).

## B.2 LCP shocks ($\kappa_m \in (0,1)$)

Assume $m \neq r$ (the knife-edge $\kappa_m = \rho$ is degenerate and handled by continuity; it has measure zero and lies outside the calibrated region). Partial fractions give

$$\frac{(1-\kappa)(1-\beta\kappa)}{(1-r\kappa)(1-m\kappa)} = c_0 + \frac{A}{1-r\kappa} + \frac{B}{1-m\kappa}, \tag{46}$$

with

$$A = \frac{(r-1)(r-\beta)}{r\,(r-m)}, \qquad B = \frac{(m-1)(m-\beta)}{m\,(m-r)}. \tag{47}$$

Hence

$$g''(\kappa) \;=\; -\sigma C\left[\frac{2Ar^2}{(1-r\kappa)^3} + \frac{2Bm^2}{(1-m\kappa)^3}\right]. \tag{48}$$

**Lemma B.2.** *Suppose $\kappa_m > \rho$ (so $m > r$), the empirically relevant case for LCP under partial pass-through. Then $A < 0 < B$, and there is at most one $\kappa^* \in (0,1)$ at which $g''$ changes sign. For a positive (cost-increasing) shock, $g''(\kappa) > 0$ for $\kappa < \kappa^*$ and $g''(\kappa) < 0$ for $\kappa > \kappa^*$. The cutoff solves*

$$\frac{1-r\kappa^*}{1-m\kappa^*} \;=\; T, \qquad T^3 \;=\; \frac{\varphi(r)}{\varphi(m)}, \qquad \varphi(x) \equiv x(1-x)(\beta-x), \tag{49}$$

*so that in closed form*

$$\kappa^* \;=\; \frac{T-1}{Tm-r}, \tag{50}$$

*and $\kappa^*$ is interior to $(0,1)$ if and only if $1 < T < (1-r)/(1-m)$. If instead $\kappa_m < \rho$, the signs of $A$ and $B$ in (47) reverse and the regions of convexity and concavity flip.*

*Proof.* Signs: with $r < \beta < 1$ and $m < \beta < 1$, both $(r-1)(r-\beta)$ and $(m-1)(m-\beta)$ are positive; the denominators in (47) carry the sign of $(r-m)$ and $(m-r)$ respectively, so $m > r$ implies $A < 0 < B$. From (48), $g''(\kappa) < 0$ if and only if

$$\frac{Bm^2}{(1-m\kappa)^3} > \frac{(-A)\,r^2}{(1-r\kappa)^3} \quad\Longleftrightarrow\quad \left(\frac{1-r\kappa}{1-m\kappa}\right)^3 > \frac{(-A)r^2}{Bm^2}.$$

The left side is strictly increasing in $\kappa$ when $m > r$, since $\frac{d}{d\kappa}\frac{1-r\kappa}{1-m\kappa} = \frac{m-r}{(1-m\kappa)^2} > 0$; it rises from 1 at $\kappa = 0$ toward $(1-r)/(1-m)$ at $\kappa = 1$. Hence the inequality holds on at most one upper interval, which establishes uniqueness of the sign change and the stated sign pattern. Substituting (47),

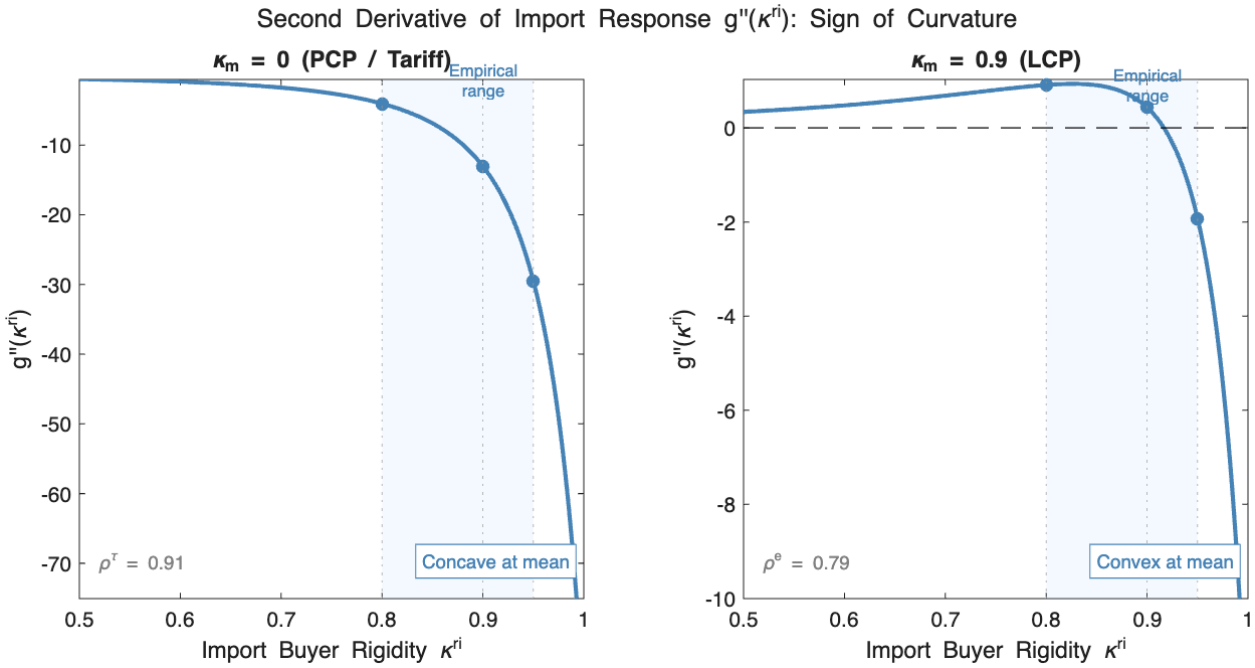
$$\frac{(-A)\,r^2}{Bm^2} = \frac{r(1-r)(\beta-r)}{m(1-m)(\beta-m)} = \frac{\varphi(r)}{\varphi(m)} \equiv T^3,$$

and solving $(1 - r\kappa)/(1 - m\kappa) = T$ for $\kappa$ gives (50). Interiority requires the threshold $T$ to lie strictly between the range endpoints of the left side, i.e. $1 < T < (1 - r)/(1 - m)$. □

*Proof of Proposition 2.* Part (1) (LCP): by Lemma B.2, for a positive shock the response distribution is convex below $\kappa^*$ and concave above it. For imports, an appreciation is a cost-decreasing shock, which reverses the curvature: the distribution is locally concave below the cutoff, and a depreciation locally convex below the cutoff, as stated. Part (2) (PCP): Lemma B.1 with $\rho = \rho^e$, with the sign mapping to appreciation and depreciation as noted above. Part (3) (DCP): the DCP response is a weighted average of the PCP and LCP responses, so $g''_{DCP} = w\, g''_{PCP} + (1 - w)\, g''_{LCP}$. Since the PCP term is signed by Lemma B.1 and the LCP term changes sign at $\kappa^*$ by Lemma B.2, the two components take opposite signs over part of the support and the net curvature depends on $w$ and $\kappa_m^D$; the sign is therefore ambiguous and is an empirical question, resolved by the calibration in Section 6. □

**Calibrated magnitudes.** Evaluating the closed forms at the baseline calibration reproduces Figure 8 exactly. For the tariff case ($\rho^\tau = 0.91$), Equation (45) gives $g''(0.9) = -13.0$. For LCP ($\kappa_m = 0.9$, $\rho^e = 0.79$), Equation (50) gives $\kappa^* = 0.917$, so the empirical rigidity range spans the sign change: $g''(0.9) = 0.43 > 0$ and $g''(0.95) = -1.92 < 0$. Figure 8 plots Equations (45) and (48) over the empirical range and serves as an illustration of these results.

Figure 8: Illustration of Proofs of Propositions 1 and 2




**Note**: Illustration of proofs of Propositions 1 and 2. Second derivative computed of Equation 40. Above zero denotes a positive second derivative (i.e. convexity) and below zero denotes a negative second derivative (i.e. concavity). Simulation considered for a positive shock, i.e. a tariff escalation or exchange rate depreciation. A negative second derivative for a tariff indicates a concave distribution for a tariff escalation and a convex distribution for a tariff deescalation. A negative second derivative for an exchange rate indicates a concave distribution for a depreciation and a convex distribution for an appreciation; a positive second derivative for an exchange rate indicates a convex distribution for a depreciation and a concave distribution for an appreciation.

# C Mapping of HIG to Gains from Trade

From Arkolakis et al. (2012), the gains from trade are given by $\frac{1}{\epsilon}\Delta \log \lambda$ where $\epsilon$ is the trade elasticity and $\lambda$ is the domestic expenditure share. By Definition 2, the HIG is given by the percent

$$HIG = \frac{\Delta q^{m,heterog} - \Delta q^{m,homog}}{|\Delta q^{m,homog}|}.$$

Note that $\Delta \log \lambda = -\frac{1-h}{h}\Delta q^m$ where $1-h$ is the import buyer's share of output. Then, note that the percent difference in the gains from trade calculation is given by

$$\left(\Delta \log \lambda^{heterog} \Big/ \Delta \log \lambda^{homog}\right) - 1 = \left(\left(-\frac{1-h}{h}\Delta q^{m,heterog}\right) \Big/ \left(-\frac{1-h}{h}\Delta q^{m,homog}\right)\right) - 1 =$$
$$\left(\left(HIG|\Delta q^{m,homog}| + \Delta q^{m,homog}\right)/\Delta q^{m,homog}\right) - 1 = \pm HIG. \quad (51)$$

Thus, under the assumptions of Arkolakis et al. (2012) the HIG is equivalent to the change in the gains from trade when accounting for heterogeneity.

# D Computation of the Heterogeneity Import Gap

## D.1 Computation

This appendix describes the two computations of the HIG reported in Table 3: the second-order (Taylor) approximation and the exact two-type computation. Both evaluate the firm-level response function $g_{\vec{s}}(\kappa_{ri})$ from Lemma 1 (Equation 40) under the baseline calibration in Table 2. For joint tariff–exchange rate shocks, the response function is $g_{\vec{s}}(\kappa) = g_\tau(\kappa) + \lambda_{e\tau}\, g_e(\kappa)$, where $g_\tau$ is evaluated with $\kappa^m = 0$ and tariff persistence $\rho^\tau$, $g_e$ is evaluated with $\kappa^m = 0.9$ (LCP) or $\kappa^m = 0$ (PCP) and persistence $\rho^e = 0.79$, and $\lambda_{e\tau} = 0.3$ is the dollar–tariff elasticity from Jeanne and Son (2024). The exchange rate term enters positively when the exchange rate movement offsets the tariff (an appreciation, for imports) and negatively when it reinforces it (a depreciation).

**Two-type distribution.** Both computations refer to the same underlying rigidity distribution. Import buyers take rigidity $\kappa^{rL} = 0.8$ with weight $w^L$ and $\kappa^{rH} = 0.95$ with weight $w^H = 1 - w^L$, the two group-level estimates from the LFTTD. Weights are pinned by requiring the two-type mean to equal the homogeneous benchmark rigidity,

$$w^L \kappa^{rL} + w^H \kappa^{rH} = \bar{\kappa}^{ri} = 0.9,$$

which yields $w^L = 1/3$ and $w^H = 2/3$, consistent with the sticky group's share of US imports (Section 4). This mean-matching convention ensures the HIG isolates the curvature effect of heterogeneity: any weighting in which the weighted mean of the types differs from $\bar{\kappa}^{ri}$ would conflate the HIG with a level shift in the average rigidity. The implied cross-firm variance of this distribution is

$$\mathrm{Var}(\kappa_{ri}) = w^L(\kappa^{rL} - \bar{\kappa}^{ri})^2 + w^H(\kappa^{rH} - \bar{\kappa}^{ri})^2 = 0.005.$$

**Taylor approximation.** The Taylor computation follows Equation 43,

$$\mathrm{HIG}^{Taylor} = \frac{\frac{1}{2}\, g''_{\vec{s}}(\bar{\kappa}^{ri})\, \mathrm{Var}(\kappa_{ri})}{|g_{\vec{s}}(\bar{\kappa}^{ri})|},$$

evaluated at the two-type variance $\mathrm{Var}(\kappa_{ri}) = 0.005$ derived above, so that the approximation and the exact computation described below refer to the same distribution. The second derivative $g''_{\vec{s}}(\bar{\kappa}^{ri})$ is computed by central finite difference with step size $h = 10^{-5}$. The Taylor form requires only the first two moments of the rigidity distribution and is therefore

computable from measured moments without committing to a full distributional form. Its accuracy depends on the size of higher-order terms of $g_{\bar{s}}(\cdot)$ over the support of the distribution, which the exact computation below assesses directly.

**Exact two-type computation.** The exact computation evaluates Definition 2 directly, with no approximation. The heterogeneous aggregate response is the weighted average of the two types' responses, the homogeneous benchmark is the response at the mean rigidity, and the HIG is the percent difference:

$$\text{HIG}^{exact} = \frac{w^L g_{\bar{s}}(\kappa^{rL}) + w^H g_{\bar{s}}(\kappa^{rH}) - g_{\bar{s}}(\bar{\kappa}^{ri})}{|g_{\bar{s}}(\bar{\kappa}^{ri})|}.$$

Because the response function and both points are known, this computation is free of approximation error; Table 3 reports it alongside the Taylor approximation to assess the accuracy of the second-order form.

## D.2 Continuous Distribution

In this section I implement a continuous data-based measure of the HIG for robustness. $g(\bar{\kappa}_{ri})$ is observable with data, as it is the benchmark (i.e. the values $g(\bar{\kappa}_{ri})^{LCP} = 0.5321$ and $g(\bar{\kappa}_{ri})^{PCP} = 0.3936$, from Gertler (2026), and measure $g(\bar{\kappa_{ri}})^{\tau,m} = -1.39$ and $g(\bar{\kappa_{ri}})^{\tau,x} = -0.88$). I then can use the forms from Definitions 1 and 2 and the baseline calibration to determine the magnitude of the correction for tariff and exchange rate shocks. To do so, I compute from Lemma 1 $\frac{d^2}{d^2\kappa_{ri}}\left(\frac{dq}{d\tau}\right)$ and $\frac{d^2}{d^2\kappa_{ri}}\left(\frac{dq}{de}\right)$. I compute this derivative numerically and consider the cases of $\kappa_m = 0.9$ (LCP) and $\kappa_m = 0$ (PCP). The variance of $\kappa_{ri}$ is also observable in data; I measure it to be 0.046 in the Nakamura and Steinsson (2008) data. Table 10 contains the results.

Table 10: Heterogeneity Import Gap - Continuous, Data Input

| | (1) FGKK | (2) LFTTD |
|---|---|---|
| **Tariff HIG** | -21.6% | -28.2% |
| | **LCP** | **PCP** |
| **ER HIG** | 2% | -100% |
| **Joint HIG** | | |
| Appreciation | -24.6% | -14.1% |
| Depreciation | -19.2% | -27.9% |

**Note**: Heterogeneity Import Gap correction computed for tariffs (top panel), exchange rates (middle panel), and joint tariff-exchange rate shocks (bottom panel). Second derivative of response function calculated numerically and variance calibrated as 0.046 from the Nakamura and Steinsson (2008) data. In the top panel, the HIG is computed for tariffs using $\rho^{\tau} = 0.91$ (FGKK data) and $\rho^{\tau} = .69$ (LFTTD data). In the middle and bottom panels the HIG is computed for LCP and PCP separately, and in the bottom panel I calibrate $\rho^{\tau} = 0.91$. Other calibration as in Table 2. Values are used from Gertler (2026) for quantity-exchange rate elasticities for LCP and PCP. The bottom panel assumes the exchange rate-tariff elasticity is 0.3 following Jeanne and Son (2024). Note that for US exports calibrating $\rho^{\tau} = 0.91$ the HIG is $-33.9\%$ for tariffs, $-23.4\%$ for a joint tariff-(PCP) exchange rate appreciation and $-41.9\%$ for a tariff-(PCP) exchange rate depreciation. Note the -100% for PCP reflects a doubling of the trade elasticity, reflective of the magnitude of the estimated elasticity rather than a rule regarding proportion. This version uses the continuous measure and implements the data-consistent trade elasticity, as described in Section 6.

# E Trade War Welfare

## E.1 Additional Calculations With Fajgelbaum et al. (2019)

Table 11: Aggregate Effects of the 2018–19 Tariff Escalation: Exact Two-Type HIG

| | $EV^M$ | $EV^X$ | Net | % of GDP |
|---|---|---|---|---|
| **Tariff only** | | | | |
| FGKK baseline | −51.0 | 9.4 | −7.2 | 0.04 |
| Heterogeneous | −56.1 | 8.5 | −13.4 | 0.071 |
| **Dollar appreciation** | | | | |
| Homogeneous | −46.3 | 5.6 | −6.4 | 0.034 |
| Heterogeneous | −51.2 | 4.9 | −12.0 | 0.063 |
| **Dollar depreciation** | | | | |
| Homogeneous | −55.7 | 13.2 | −8.2 | 0.043 |
| Heterogeneous | −61.0 | 12.2 | −14.5 | 0.077 |

**Note**: Welfare calculation from Fajgelbaum et al. (2019) modified to account for heterogeneity. The top panel considers the tariff-only case, the middle panel considers the case of a joint tariff with a dollar appreciation, and the bottom panel considers the case of a joint tariff with a dollar depreciation. Exchange rate depreciation computed symmetrically to exchange rate appreciation. Exact two-type HIG applied from Table 3.

Table 12: Aggregate Effects of the 2018–19 Tariff Escalation: Continuous Data-Benchmark HIG

| | $EV^M$ | $EV^X$ | Net | % of GDP |
|---|---|---|---|---|
| **Tariff only** | | | | |
| FGKK baseline | −51.0 | 9.4 | −7.2 | 0.04 |
| Heterogeneous | −62.0 | 7.4 | −20.3 | 0.108 |
| **Dollar appreciation** | | | | |
| Homogeneous | −46.3 | 5.6 | −6.4 | 0.034 |
| Heterogeneous | −57.7 | 4.0 | −19.4 | 0.102 |
| **Dollar depreciation** | | | | |
| Homogeneous | −55.7 | 13.2 | −8.2 | 0.043 |
| Heterogeneous | −66.4 | 11.3 | −20.8 | 0.110 |

**Note**: Welfare calculation from Fajgelbaum et al. (2019) modified to account for heterogeneity. The top panel considers the tariff-only case, the middle panel considers the case of a joint tariff with a dollar appreciation, and the bottom panel considers the case of a joint tariff with a dollar depreciation. Exchange rate depreciation computed symmetrically to exchange rate appreciation. Continuous data-benchmark HIG applied from Table 10.

## E.2 Transition-Path Welfare: Construction and Results

**Transition system.** Consider the transition following a unit log tariff shock at $t = 0$ with persistence $\rho^\tau$, so $\tau_t = (\rho^\tau)^t$. Foreign exporters price over the tariff-inclusive marginal cost path subject to rigidity $\kappa^m$; for tariffs, $\kappa^m = 0$ and pass-through into the import price is immediate and complete, consistent with the estimates in Fajgelbaum et al. (2019). Import buyers with rigidity $\kappa_{ri}$ price over the resulting input cost path according to Equations 37 and 38. Under perfect foresight of the shock decay, the buyer's reset price is

$$\bar{p}_t^r \;=\; \frac{1-\beta\kappa_{ri}}{1-\beta\kappa_{ri}\rho^\tau}\, p_t^m,$$

and the price index follows $p_t^r = (1-\kappa_{ri})\bar{p}_t^r + \kappa_{ri} p_{t-1}^r$. The import quantity response is $q_t(\kappa_{ri}) = -\sigma\, p_t^r$. At $t = 0$ this system delivers exactly the response function in Lemma 1 (Equation 40), so the impact-period HIG from this transition reproduces the exact two-type HIG in Table 3 by construction; this serves as the validation of the implementation.

**Welfare object.** The per-period deadweight loss from the tariff wedge is the Harberger triangle, $\frac{1}{2}\,\tau_t\,|\Delta q_t|$, expressed per unit of steady-state import expenditure. This is the net welfare object in the tariff-only case: the consumer price increase net of tariff revenue leaves the triangle, consistent with the treatment of revenue in Section 7. Discounting at $\beta$, welfare

over the transition under rigidity distribution $F$ is

$$W(F) \;=\; \sum_{t=0}^{\infty} \beta^t \, \tfrac{1}{2} \, \tau_t \left| \int q_t(\kappa_{ri}) \, dF(\kappa_{ri}) \right|.$$

The transition-path welfare HIG compares the two-type heterogeneous distribution ($\kappa_{ri} \in \{0.8, 0.95\}$ with mean-matching weights $\{1/3, 2/3\}$ as in Appendix D) to the homogeneous benchmark $\bar{\kappa}^{ri} = 0.9$:

$$\text{HIG}^W \;=\; -\,\frac{W(F^{\text{heterog}}) - W(\bar{\kappa}^{ri})}{|W(\bar{\kappa}^{ri})|},$$

defined such that, consistent with Definition 2, negative values indicate larger discounted losses under heterogeneous import buyer rigidities.

**Results.** Table 5 reports the results. The impact rows confirm the implementations: the partial-equilibrium transition reproduces the exact two-type HIG in Table 3 ($-10.1\%$ and $-28.0\%$), and the general equilibrium impact reproduces the first point of Figure 6. In general equilibrium under $\rho^\tau = 0.91$, the path-integrated welfare HIG is $-8.3\%$ over the full transition and $-16.0\%$ over the first twelve months, bracketing the fixed-horizon correction applied in Section 7.1. The partial-equilibrium benchmark reverses sign at this persistence ($+10.3\%$): absent the endogenous monetary policy and exchange rate responses, the mid-transition horizons at which sticky import buyers are still adjusting prices dominate the discounted sum and mitigate the aggregate loss. The comparison indicates that the general equilibrium channels sustain the amplification over the path, and that the fixed-horizon correction is not an artifact of the horizon at which it is evaluated. Under the lower LFTTD persistence, the partial-equilibrium path-integrated HIG is $-13.7\%$: with a fast-decaying tariff, the impact horizons dominate the discounted sum and the amplification carries through the path.

**Relation to the general equilibrium model.** The transition system above is the partial-equilibrium pricing block of the model in Section 5: it excludes the endogenous monetary policy response, the income effects on demand, and the UIP-wedge exchange rate adjustment. Those channels shape the time path of the HIG in the full model simulation — Figure 6 shows the general equilibrium HIG remains negative over the entire horizon — and therefore bear directly on the sign pattern in the second column of Table 5. The general equilibrium counterpart is computed by evaluating $W(\cdot)$ on the simulated aggregate import paths from the model of Section 6 in place of the partial-equilibrium paths.