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Exchange Rate Pass-through and Expenditure-Switching Revisited

Sarah Gertler

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Sarah Gertler*
Massachusetts Institute of Technology

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Abstract

Expenditure-switching is the main channel through which exchange rates transmit to the real economy. Conventional wisdom holds that this channel's strength is increasing in exchange rate pass-through into prices: assuming the import demand elasticity is independent of pass-through, larger effects of exchange rates on prices yield larger substitution of spending between domestic and foreign goods. In this paper, I show that this conventional wisdom does not hold. Using confidential US micro-data and a panel-data local projection technique, I show that quantity-exchange rate elasticities are similar across high and low pass-through environments. In essence, low pass-through is subject to a larger import demand elasticity than is high pass-through. I then propose an extension of a standard small open economy New Keynesian model by adding a layer of import buying (retail) firms, in which both exporting and importing firms are subject to price rigidities. I show empirically and theoretically that the "import buyer rigidity" dampens overall adjustment, but less so under low pass-through because in this case the pass-through is more persistent. The model thus accounts for why the quantity-exchange rate elasticities are similar across pricing regimes. I conclude by exploring the implications of this framework for monetary and exchange rate policy, actually finding a stronger expenditure-switching channel under low pass-through. *JEL* Codes: F41.

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"If countries' imports are priced in local currencies... exchange rate changes become powerless to alter the relative prices...the important allocative role of flexible exchange rates in [classical] models evaporates... The exchange rate has no expenditure-switching power, so exchange rate pessimism is justified."
– Maurice Obstfeld (2002)

1 Introduction

The key way exchange rates transmit to the real economy begins with exchange rate price pass-through: how exchange rates influence trade prices (defined as import prices, i.e. the price paid by the importer). Given pass-through, exchange rate variation then leads to expenditure-switching, meaning that the relative demand for home versus foreign goods changes. The exchange rate thus has an allocative role in real activity. Conventional wisdom, as described by the above quote by Obstfeld (2002), is that low pass-through, perhaps due to exports priced in local (importer) currency to start with, mutes the expenditure-switching channel relative to the high pass-through benchmark.

Contrary to this conventional wisdom, in this paper I present evidence that differences in quantity-exchange rate elasticities are substantially smaller than differences in pass-through. The import demand elasticity – the elasticity of trade quantities with respect to import prices – is higher under low pass-through, implying the aforementioned quantity-exchange rate effects. In contrast, underlying the conventional wisdom is that the import demand elasticity should be independent of pass-through.

To explain the result, I add to a small open economy New Keynesian model a layer of importing firms which intermediate between foreign exporters and households. These "import buyer" firms have sticky prices which both dampen overall adjustment across all levels of pass-through, but less under low pass-through, which explains the empirical facts. This is because the import buyer rigidity also causes dependence of retail prices upon the future path of marginal costs. Import buyers thus adjust their import demand relatively more when facing more persistent pass-through of exchange rates into trade prices. Though pass-through is decreasing in the exporter's trade price rigidity, pass-through persistence is increasing in the trade price rigidity. This is because sticky trade prices take longer to fully adjust to exchange rate shocks than do flexible trade prices. Thus, as it is more persistent, low exchange rate pass-through into trade prices induces a larger import demand elasticity than high exchange rate pass-through.[1]

[1]Section 6.3 contains a detailed explanation of this mechanism including how the import demand elasticity depends upon exchange rate pass-through.

Through quantitative simulations of the model, I actually find a relatively stronger expenditure-switching channel under low pass-through, implying a new perspective on monetary and exchange rate policies. As a result of the relatively stronger quantity elasticities, the real GDP response to monetary policy is actually stronger under low pass-through. Accordingly, exchange rate policy has a new role: to correct the greater demand-side inefficiency under high pass-through.

In the empirical analysis I leverage US firm-level trade data, specifically the Census Bureau Longitudinal Firm Trade Transactions Database (LFTTD). The data contain the universe of US exporting and US importing firms. The advantage of this dataset is that essentially all US trade is rigid in dollars, so that there is high pass-through to trade prices in US exports and low pass-through to trade prices in US imports (Gopinath and Rigobon (2008)). The variation is summarized as the classical currency pricing regimes, producer currency pricing (PCP, price set in exporter currency, i.e. US exports) and local currency pricing (LCP, price set in importer currency, i.e. US imports). PCP is canonically a high pass-through environment (zero trade price rigidity) and LCP is canonically a low pass-through environment (high trade price rigidity). Accordingly, the variation is useful for comparing high and low pass-through. Finally, as opposed to aggregate data, the LFTTD firm-level data allows me to identify the exact import quantity or price faced by a firm purchasing a product from a given country, rather than a sum or average. It also allows me to control for firm-specific trends.

My strategy to identify exchange rate-based elasticities, both for trade prices and trade quantities, involves combining macroeconometric local projections and panel-data techniques. I follow Jordà (2005) and more recently an application to tariffs, by Boehm et al. (2023). This strategy is attractive because it enables me to address endogeneity in identifying the effect of the exchange rate and also provides a clear interpretation applicable to studying implications for expenditure-switching. To address endogeneity, I first leverage the feature that conditioning on firm, country, product, and time-varying factors helps address observable bias in the local projection. Given the panel-data controls and fixed effects, leveraging a contemporaneous exchange rate shock as an instrument for longer-run changes (a local projection instrument) then helps address remaining simultaneity due to independence from future shocks. Applying local projections provides a clear interpretation of the resulting elasticities both suitable to identifying expenditure-switching and useful for general open-economy models, as the strategy captures the total influence of a single exchange rate shock. As I discuss in Section 4, this approach provides advantages over the traditional method of identifying pass-through (see e.g. Burstein and Gopinath (2014)).

Applying this method, I find that quantity-exchange rate elasticities do not reflect the pass-through differences between US imports and US exports, in contrast to conventional wisdom. The result can be summarized in general form as reflecting heterogeneity in the import demand elasticity, particularly that it is higher when pass-through is low. Next, I demonstrate that pass-through is more persistent when it is low. I then show that the rigidity of the importing firm – "import buyer rigidities" – attenuates more of the high pass-through elasticity than the low pass-through elasticity.

A series of robustness checks supports my interpretation of the results. First, the import demand elasticity heterogeneity result is robust across a range of regression specifications. It is larger in the low pass-through environment under a range of designs that vary the control set. The results are also not driven by the underlying exchange rate variation and are independent of time horizon. Second, the import buyer rigidity result is not sensitive to definition of variable construction or driven by underlying variation. I also provide evidence that the role of the import buyer rigidity is related to pass-through persistence. Although the rigidity does not meaningfully attenuate LCP exchange rate-based elasticities, it substantially attenuates the tariff-based elasticities in US imports similarly to those of high pass-through exchange rates.

I also consider concerns that the results could be driven by regression specification asymmetry, and simulate potential bias, showing it does not influence the results. Another concern could be that US imports and exports are subject to different underlying demand: I again leverage tariffs as a control shock, showing that tariffs across US exports and imports face similar demand elasticities, ruling out differential fundamental demand. Another concern is that US imports and exports contain different products, so I show that restricting to the same product set does not change the results. Finally, exchange rate hedging could disproportionately influence US imports or exports, so I include a control for it in an alternative specification, finding the results are robust to the control.

The paper then presents a variant of an open-economy New Keynesian model with trade in intermediates as well as import buyers described earlier. Households consume a CES aggregate of a domestic composite and a foreign composite. Domestic manufacturers produce the domestic composite. The foreign composite is produced by domestic import buyers who obtain intermediates from foreign exporters. Importantly, households' substitution between domestic and foreign goods depends on the import buyer's price and not the trade price. As described earlier, there are also pricing frictions that enhance the sensitivity of import buyers' prices to persistent movements in trade prices. The import buyer rigidity causes the import buyer to respond only partially to any trade price change, but also to adjust depending on the expected path of trade prices. Accordingly, the import buyer adjusts demand more for more persistent trade price pass-through. This pass-through persistence is increasing in the exporter's trade price rigidity, which captures the degree of LCP (in the limiting case of no rigidity approximates PCP) and is accordingly inversely related to pass-through. In the framework, the import demand elasticity is higher for low pass-through (LCP) than high pass-through (PCP) and the import buyer rigidity generates the import demand elasticity heterogeneity.

Calibrating the model using literature parameter estimates and observations from data, I find that the model can match the import demand elasticity heterogeneity originally described above. The model can also match the empirical heterogeneity according to the import buyer rigidity. Importantly, the form of pass-through persistence in the model matches its equivalent in the data. Also, predicting the import demand elasticity using pass-through persistence is consistent with the estimates observed in data.

Armed with this evidence that the model fits the data well, I consider the general equilibrium implications of this framework. Quantifying the general equilibrium model then lends insights into how pass-through shapes the expenditure-switching channel, and in particular the roles of currency choice, monetary policy, and exchange rate policy. Though all effects are weaker relative to the case without import buyer rigidities, I find the low pass-through environment of LCP has a stronger expenditure-switching channel than the high pass-through environment of PCP. As a result, LCP has a stronger real GDP effect from monetary policy. This is because under LCP, compared to PCP, substitution effects are significantly amplified relative to price effects. This is the opposite of the conventional wisdom, which expects substantially larger substitution under PCP. Lastly, I consider the role of exchange rate policy. This framework demonstrates a new demand-side inefficiency which is greater under PCP, a new possible motivation for exchange rate policy.

The next section summarizes related literature, then Section 3 discusses the data and Section 4 the design. Section 5 presents the main elasticity estimates, mechanisms, and robustness. I rationalize the estimates in the framework in Section 6. Section 7 explores the quantitative validity and implications of the model, and the paper finishes with concluding remarks in Section 8.

2 Related Literature

This paper first relates to a literature identifying price pass-through of exchange rates. Low pass-through has been identified and explored in work such as Campa and Goldberg (2005), Goldberg and Hellerstein (2008), Nakamura and Zerom (2010), Amiti et al. (2014), and Amiti et al. (2019a). In US data, papers such as Gopinath and Rigobon (2008), Gopinath et al. (2010), and Gopinath and Itskhoki (2010) have established the dynamics of pass-through under the canonical LCP and PCP currency pricing regimes. One canonical finding is low pass-through in the LCP environment of US imports and high pass-through in the PCP environment of US exports. I find consistent estimates using a new dataset, LFTTD, and a new methodology to identify pass-through.

There is also a small literature identifying quantity effects of exchange rates, containing substantially less work than the literature of price pass-through. Important exceptions are De Gregorio et al. (2024) and Amiti et al. (2022). The former estimates quantity effects of exchange rates with Chilean data, leveraging a regression specification symmetric to that of the aforementioned pass-through literature. Though De Gregorio et al. (2024) focuses on currency choice dynamics and has a different conclusion, our analyses are consistent in different settings. Amiti et al. (2022) estimate quantity dynamics of exchange rates aggregating across sticky-price determinants of pass-through. The authors highlight that their analysis is suggestive of quantity adjustment frictions. My paper differs from this literature in the following ways. First, I use a new methodology for estimating the effects of exchange rate movements applying local projection methods to panel data following Jordà (2005). The methodology has a clearer application to expenditure-switching given I identify a total effect of exchange rates as opposed to a partial effect. There are also advantages in the identification that I discuss later, which requires weaker assumptions than the conventional method. Second, I develop a new mechanism to explain the results in the context of a small open economy New Keynesian model, and perform a set of policy experiments.

My analysis relates to the so-called Exchange Rate Disconnect. The Exchange Rate Disconnect consists of a number of underlying puzzles, including that exchange rates appear uncorrelated with macroeconomic fundamentals (Meese and Rogoff (1983) and Backus and Smith (1993)). Some analysis has found that exchange rates have smaller effects on real activity than other cost shocks, supporting the Exchange Rate Disconnect (Fitzgerald and Haller (2018), Fontagné et al. (2018)). Together that body of work contributes to the "International Elasticity Puzzle" (Ruhl (2008)), that in order to match data exchange rate-based import demand elasticities may be smaller than those based on other shocks (e.g. tariffs). That analysis could imply a generally limited role for expenditure-switching, confounding the relationship with pass-through. Relative to this "shock heterogeneity" puzzle, this paper microfounds the general heterogeneity and provides a new source for it (trade price rigidities).

This paper revisits the original literature on exchange rate pass-through and expenditure-switching, adding elements of subsequent analysis to reach a new conclusion. In the workhorse model Galí and Monacelli (2005), expenditure-switching is a key vehicle of monetary transmission. In that framework and in many open-economy models since, the import demand elasticity is independent of pass-through. For example, the elasticity is uniform with respect to pass-through in recent research such as Gopinath et al. (2020), Camara et al. (2024), and Guo et al. (2023). As a result, in this type of standard framework, lower pass-through generates less expenditure-switching. In this paper, import buyer rigidities empirically and theoretically generate heterogeneity in the import demand elasticity. This import buyer rigidity is the firm-to-firm trade analog of the forward-looking household demand ("sluggish demand") in Auclert et al. (2024), which generates demand heterogeneity with respect to shock persistence.

The paper is also related to work studying how layers of frictions contribute to open-economy dynamics. The import buyer mechanism in this paper is related to the role of retailers in intermediating trade transactions. For example, Corsetti and Dedola (2005) consider how wedges in consumer versus import prices via retailers can dampen the real response to exchange rate fluctuations. Burstein et al. (2003) demonstrate how distribution costs improve fit of real exchange rate dynamics. Both Auer et al. (2021) and Cavallo et al. (2021) find incomplete pass-through of border (i.e. trade) prices to retail prices. The model in this paper is consistent with their identified border and retail price responses.

Finally, the supply-side (pricing) inefficiency of LCP has been well established. For example, Devereux and Engel (2003) highlight this inefficiency of LCP, arguing in favor of exchange rate management for that case and a freely floating exchange rate under PCP. In contrast, the analysis in this paper presents a demand-side inefficiency which is larger for PCP than LCP.

3 Data

This section contains a description of the data used in the main analysis. In all estimation, I leverage data from the Longitudinal Firm Trade Transactions Database (LFTTD). The data is for US firms, and contains both US export and US import transactions. The data provide quantity, value, and prices for each firm-country partner-product-month transaction. The first of the variables is a crucial advantage of this dataset: it enables linking price information with quantities. The quantity variable is the number of units imported, and I construct the price as the price paid at the border in the currency of the importing country. The price is directly measured as trade values in importer currency divided by trade quantities. I extract the exchange rate data from Bloomberg.

The estimation leverages a series of controls, and in Section 4 I describe the role of these controls more precisely. They include producer price index (PPI) and real gross domestic product (real GDP) from the International Monetary Fund (IMF) International Financial Statistics (IFS), at the country-month and country-quarter level, respectively. They also include tariffs, which are observable at the partner country-product-month level for both US imports and US exports from Fajgelbaum et al. (2019), which originally draws from the Census. Due to availability, the sample is monthly and ranges from 2013 January through 2019 April.

Nearly all of US trade is rigid in US dollars: there is LCP in US imports and PCP in US exports (Gopinath and Rigobon (2008)). In other words, the price is sticky in importer currency for US imports and in exporter currency for US exports. Accordingly, by comparing US imports and exports, we naturally vary the nature of the trade price rigidity with respect to the exchange rate. To consider the import buyer rigidities I link the firm-industry information from the Longitudinal Business Database (LBD), LFTTD, and Nakamura and Steinsson (2008) price stickiness data.[2]

For a robustness check regarding underlying demand composition of the import buyer rigidity I leverage sector-level trade elasticities from Caliendo and Parro (2014).[3] For a robustness check regarding exchange rate hedging, I leverage data from Bank of International Settlements (BIS) Triennial Central Bank Survey.

In the Appendix I show that the US export and US import samples are generally balanced in terms of average quantity change and exchange a rate change. There is a discrepancy for the average price change, with US exports having a larger average foreign import price change than US imports. This is mechanical: note by definition of PCP the price paid by foreigners for US goods is directly subject to the dollar exchange rate, amplifying benchmark price fluctuations.

4 Empirical Method

In this section I describe the econometric framework used in this paper to identify exchange rate-based elasticities. To do so, I first define the import demand elasticity, the metric for how quantity effects of exchange rates follow from pass-through, as a function of a general data generating process. The elasticity is composed of price pass-through and quantity-exchange rate elasticities. I discuss conditions under which heterogeneity in the import demand elasticity can arise and standard endogeneity concerns. A description of this paper's methodology follows, including how it properly identifies the three elasticities and addresses endogeneity concerns. Finally, I discuss identifying assumptions and mention supplementary designs, the latter of which will be expanded upon in Section 5.2.

[2] The price stickiness data were accessed via the replication package of Fajgelbaum et al. (2019).
[3] The trade elasticity data were accessed via the replication package of Fajgelbaum et al. (2019).

4.1 Data Generating Process

Consider the following data generating process to define the import demand elasticity. The process first consists of a pass-through equation in which the log trade price p_t depends on a general log shock. Henceforth, lowercases denote logs.

$$\Delta p_t = \nu \Delta shock_t + \varepsilon_t^p. \tag{1}$$

In Equation 1 pass-through ν is the total derivative of Δp_t with respect to $\Delta shock_t$. The total derivative is necessary to capture all channels through which the shock (i.e. the exchange rate) determines prices. Assuming the shock only influences log quantities Δq_t via prices, then the following equation

$$\Delta q_t = \gamma \Delta shock_t + \varepsilon_t^q \tag{2}$$

implies the import demand elasticity

$$\tilde{\sigma} = \gamma / \nu. \tag{3}$$

The import demand elasticity $\tilde{\sigma}$ is the total derivative of quantities with respect to prices, when the price change is from the shock. The total derivative is again desired to capture all channels through which changes in relative prices induce substitution.

Traditionally it is assumed that, apart from any endogeneity concerns which I discuss shortly, the shock is uncorrelated with model error, i.e. the demand curve is $\Delta q_t = \sigma \Delta p_t + \varepsilon_t^\sigma$ where $Cov(\nu \Delta shock_t, \varepsilon_t^\sigma) = 0$. Then, the import demand elasticity $\tilde{\sigma} = \sigma$ is independent of pass-through ν. However, if import demand depends on the path of prices then $\tilde{\sigma}$ will depend on both the shock and on pass-through. In that case, the fitted value ($\nu \Delta shock_t$) is correlated with the model error via p_t. The resulting heterogeneity with respect to $shock_t$ relates to results on the International Elasticity Puzzle. Namely, a tariff or exchange rate shock will face different import demand elasticities because they are differentially correlated with the price path due to different persistences (Auclert et al. (2024)). The innovation in this setup is that the pass-through elasticity ν is a characteristic of the price path and therefore generates a new source of heterogeneity in $\tilde{\sigma}$. The price path is correlated with the pass-through rate (such as via sticky prices) so that differences in ν also imply differences in $\tilde{\sigma}$.

Henceforth consider the case of the shock equal to the log exchange rate, i.e. $shock_t = e_t$. There is then a classical endogeneity concern in this framework. Let o_t be a general outcome, e.g. $\{q_t, p_t\}$. A general form of Equations 1 and 2 is

$$\Delta o_t = \alpha_1 \Delta e_t + \zeta_1 \Delta v_t + \varepsilon^o_{1,t}. \tag{4}$$

Here, prices and quantities are determined by the exchange rate and right-hand-side shocks (such as demand and supply) v_t. As the total derivative is desired, direct omitted variables bias via standard supply or demand channels is not a concern. However, there is a standard simultaneity concern due to codetermination of exchange rates, outcomes, and right-hand-side (supply and demand) factors:

$$\Delta e_t = \alpha_2 \Delta o_t + \zeta_2 \Delta v_t + \varepsilon^o_{2,t}. \tag{5}$$

The resulting exchange rate-based elasticities will be biased proportionally to the simultaneity due to $\alpha_2 \neq 0$ and $\zeta_2 \neq 0$.

The traditional pass-through specification (Burstein and Gopinath (2014)), which is to regress the outcome on current and lag exchange rate shocks and controls, also suffers from this bias. In that specification, the contemporaneous shock has the bias of OLS, and bias accumulates (though at a decaying rate) with each lag. Additionally, the resulting elasticities are partial derivatives which do not capture the full set of channels through which the exchange rate could generate expenditure-switching. In the Appendix I develop this analysis regarding the conventional specification further.

Due to nominal rigidities it's argued that prices are less correlated with right-hand-side shocks: prices are subject to nominal rigidities, which are less correlated with exchange rates than general demand shocks. Accordingly, it's argued that the standard method is reasonable for price pass-through but is challenged with regard to identifying quantity elasticities. In regards to endogeneity, Gopinath and Itskhoki (2022) explain that "[the] issue of endogeneity of the exchange rate is a bigger concern for the response of imports and exports to exchange rates than it is for prices. This is because quantity responses depend on the level of demand besides the relative price of imports and this can vary depending on the shock driving the exchange rate changes... That is, a decline in imports may reflect an overall decline in demand for certain goods in a country rather than an increase in the price of imports."

4.2 Estimation Procedure

To address concerns of interpretation and endogeneity, I propose to estimate panel-data-time-series-identified elasticities a la Boehm et al. (2023). Like a tariff, the time series of exchange rates tends to have an autocorrelative structure. In particular, the exchange rate can be approximated in an AR(1) form, with a persistence parameter less than but close to unity.[4] Accordingly, as with tariffs in Boehm et al. (2023) I leverage the contemporaneous exchange rate shock as an instrument for longer-run exchange rate changes.

The strategy involves two steps. Conditioning the contemporaneous exchange rate on a series of controls, fixed effects, and lags helps address simultaneity bias from right-hand-side shocks. Then, the local projection addresses outcome simultaneity and remaining unobservable bias, which I prove shortly.

The estimating equations are as follows.

$$\Delta p_{nt}^{m} = \nu \Delta_0 e_{jt} + \beta_p X_{nt} + \xi_{nt} + \varepsilon, \tag{6}$$

$$\Delta q_{nt}^{m} = \gamma \Delta_0 e_{jt} + \beta_q X_{nt} + \xi_{nt} + \varepsilon, \tag{7}$$

and

$$\Delta e_{jt} = \rho \Delta_0 e_{jt} + \beta_e X_{nt} + \xi_{nt} + \varepsilon. \tag{8}$$

Here, t refers to month, n is the unit of observation, and j is partner country. 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 ξ_{nt} are the full sets of controls and fixed effects respectively. They include a range of factors which each capture a subset of components $\{f, h, j\}$ of the n cell.

The pass-through elasticity is given by the instrumental variables estimates ν/ρ and the quantity elasticity by γ/ρ. Assuming the exchange rate only influences quantities via prices, the import demand elasticity is the instrumental variables estimate $\tilde{\sigma} = \gamma/\nu$. All three elasticities particularly leverage variation precisely originating from the single shock, the exchange rate local projection.[5] This estimation structure is particularly useful to capture expenditure-switching effects from monetary or exchange rate policy. In such cases, the shock to be studied has a specific source (i.e. a monetary policy shock). Also, the controls are contemporary and lagged with respect to the local projection, i.e. they are not contemporary to the longer-run outcome. Therefore, as the local projection does not impose restrictions, the specification approximates a total derivative.[6][7] Accordingly, the resulting elasticities do

[4]In Section 7 I report an estimate of the average monthly persistence parameter equal to 0.96.

[5]For comparison, an OLS representation of an elasticity averages across all consecutive fluctuations in the sample horizon, and accordingly confounds the desired exchange rate effect with the effect of the average pattern of data. The pattern of data is the shape of the exchange rate movement, i.e. how the exchange rate moves from appreciating to depreciating and vice versa; these patterns are extremely noisy and unique to individual series.

[6]The specification only approximates rather than explicitly captures a total derivative because of the inclusion of US firm trends and controls contemporaneous to the local projection. There is a trade-off in terms of interpretation and bias. The proposed specification improves in capturing a total derivative relative to models which directly control for the right-hand-side shocks Δv_t.

[7]An alternative to a local projection would be to use a VAR. However, as shown by Li et al. (2024) and

not rule out any channels by controlling for them contemporaneously.

The first step of the endogeneity solution is as follows. The set of included fixed effects and controls address observable simultaneity of right-hand-side shocks v_t. I include a firm-country-sector fixed effect which enables estimation within invariant demand and supply factors. Then, a firm-product-month fixed effect addresses both aggregate US trends, which have a large influence on the overall dollar exchange rate, and also demand shocks in US imports and supply shocks in US exports. To supplement the asymmetry, the specification includes current and 11 lags of PPI, GDP, and tariff monthly shocks as controls. The lag controls in total address a year of previous trends. These controls follow recommendations from the international macroeconomics and macroeconomic literature (Gopinath and Itskhoki (2022) and Ramey (2016)). In this setting, they address the "missing" demand (supply) shocks in US exports (imports) by addressing partner-country factors. I also include 11 lags of the monthly exchange rate shock following Ramey (2016) to address confounding trends in the shock. Also, note that there is an asymmetry in which the fixed effects in US imports enable identifying an elasticity holding fixed the CES price index, whereas they cannot capture the same in US exports. The Appendix contains a bias simulation which shows this specification asymmetry does not drive the results.

Given the control set, the second step of the endogeneity solution is that the local projection instrument further addresses endogeneity concerns. In the language of the example in this section, the local projection can be assumed to be (i) independent of correlated shocks v_t originating after time t. It is also plausibly (ii) not caused by shocks to the outcome o_t originating after time t. To see this, note a modified codetermining equation, which relative to Equation 5 includes the local projection:

$$\Delta_0 e_t = \alpha_2^0 \Delta o_t + \zeta_2^0 \Delta v_t + \varepsilon_{2,t}^o. \tag{9}$$

Given Equation 5, the simultaneity is attenuated proportionally to the autodecay of the confounding terms. In particular, the simultaneity bias terms in the local projection specification α_2^0 and ζ_2^0 can be written as a function of the OLS counterparts, down-weighted by the autodecay in o_t and v_t respectively.

$$\alpha_2^0 = \alpha_2 \frac{\Delta_0 o_t}{\Delta o_t}; \quad \zeta_2^0 = \zeta_2 \frac{\Delta_0 v_t}{\Delta v_t}. \tag{10}$$

In all analysis I evaluate a 10-month horizon, i.e. for log variable z $\Delta z_t = z_{t+10} - z_{t-1}$, using a contemporaneous local projection, i.e. $\Delta_0 z_t = z_t - z_{t-1}$, as the instrument. More

Montiel Olea et al. (2024) VAR analysis can suffer from additional bias relative to local projections.

generally, define $\Delta_k = z_{t+k} - z_{t-1}$ and ν_k, γ_k, and ρ_k as estimated over the k-horizon. This choice takes into account the propagation horizon of standard shocks (such as monetary policy) and feasibility within this framework. A 10 month projection captures the medium-term, which is a useful benchmark over which to consider policy implications. Also, at horizons beyond the 10 month projection it is difficult to precisely identify exchange rate effects in US imports with the proposed contemporaneous shock instrument due to the nature of LCP. Namely, because pass-through is low under LCP, it is difficult to identify a strong first-stage at longer time horizons. Also, due to data availability there is not sufficient variation to identify tariffs, which serve as a placebo experiment, beyond 10 months. I focus on $k = 10$ in the main analysis but consider other k horizons for robustness. Shorter horizons ($k < 10$), which I will report for robustness, are less useful for exploring the impact of shocks such as monetary policy. I also report longer horizons ($k > 10$) for robustness.

4.3 Identifying Assumptions

I make the following assumptions such that the proposed specification generates valid price- and quantity-exchange rate (and quantity-price) elasticities. First, the set of controls are not correlated with the error term such that they introduce new omitted variables bias. Second, conditional on these controls, the contemporaneous exchange rate shock is not driven by separate shocks driving future changes in trade quantities (and prices) after time t. Third, conditional on these controls the contemporaneous exchange rate shock only affects the longer-horizon quantity (and price) change via its own longer-horizon change. A fourth assumption is required for the quantity-price estimation, that the contemporaneous exchange rate shock only affects the longer-horizon quantity change via the longer-horizon price change. A final assumption is that the contemporaneous shock has a valid first-stage.

In Section 5 I run a series of robustness checks to address threats to the credibility and interpretation of the estimates. I directly test the initial assumption regarding the validity of the controls by varying the control set. The section will report a range of alternative specifications. The second assumption, regarding the independence of the instrument from future shocks, is addressed by incorporating lags on the right-hand-side. I also test adding and removing lag shocks and outcomes. It is difficult to concretely estimate threats to the exclusion restriction (the third and fourth assumptions), but I consider one alternative (the financial channel). Finally, I measure the strength of the first-stage. The contemporaneous shock instrument is strong at the 10-month horizon. I also note for which alternative specifications the first-stage weakens. As discussed earlier, I also include simulations in the Appendix showing that specification asymmetry does not explain the results. Moreover, I present the underlying exchange rate variation; it does not confound the estimates. Lastly, I show that the results are consistent across a range of estimation horizons.

5 Empirical Results

5.1 Pass-through, Quantity, and Import Demand Elasticities

In this section I present estimates of pass-through, quantity, and import demand elasticities with respect to exchange rates. I first show stark differences in pass-through magnitudes across US imports (LCP) and US exports (PCP). Despite the pass-through difference, quantity effects of exchange rates across the two environments are approximately equal. Accordingly, the low pass-through environment of LCP is subject to a greater import demand elasticity than the high pass-through environment of PCP. Sections 5.1.1-5.1.3 contain the price, quantity, and import demand elasticity estimates. I also conduct a series of sensitivity checks. Section 5.2 presents a mechanism: the importance of heterogeneous pass-through persistence due to sticky-price importers (import buyer rigidities), and rules out alternatives. Section 6 follows and develops a consistent theoretical framework.

5.1.1 Elasticity of Prices with respect to Exchange Rates

I estimate the pass-through elasticity $\frac{\nu}{\rho}$ using the instrumental-variables relationship between Equations 6 and 8. In all analyses in Section 5.1 I fix controls as described in Section 4 except where otherwise indicated. Table 1 contains the pass-through results comparing US exports to US imports.

Consistent with Gopinath and Rigobon (2008) and Gopinath et al. (2010) I find that pass-through is approximately complete (i.e. a coefficient $\frac{\nu}{\rho} = 1$) in the PCP environment of US exports. That is, the foreign importer pays the full bilateral exchange rate as it fluctuates. Also consistent, I find that pass-through is substantially lower in the LCP environment of US imports, meaning that US importing firms tend not to pay the full exchange rate increase even after 10 months. Moreover, the point estimates also match the robust earlier work on pass-through. For example, Gopinath and Rigobon (2008) find that US exports are PCP (prices set in exporter currency) and US imports are LCP (prices set in importer currency). Then, Gopinath et al. (2010) finds that the average 10-month pass-through elasticity in US imports is approximately 30%, and is approximately 100% for PCP. The results in Table 1 are exactly consistent with these numbers, despite being estimated in different data with a different regression specification. Accordingly, this analysis serves as a literature-consistent benchmark of high versus low pass-through from which this paper's methodology can derive

Table 1: Pass-through

	(1) US Exports "PCP"	(2) US Imports "LCP"
ν/ρ	0.9859***	0.3111***
	(0.08931)	(0.06304)
Firm-product-time	Y	Y
Firm-partner-sector	Y	Y
PPI, GDP, Tariff	Y	Y
Lag Controls (11)	Y	Y
N	800000	1958000

Note: Price-exchange rate "pass-through" elasticities $\frac{\nu}{\rho}$; 10 month exchange rate projection instrumented with the contemporaneous exchange rate shock. Equation 6 is the reduced form and Equation 8 is the first stage. 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 US 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-R11330). This is a part of clearance request #11330. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

the quantity effects of exchange rates.

In Appendix Table 8 I present a series of alternative specifications which yield consistent results to those in Table 1. Section 5.1.3 contains a detailed discussion of these alternative specifications. In the next Section 5.1.2, I show the corresponding quantity-exchange rate elasticities, then discuss the import demand elasticity and specification robustness in Section 5.1.3.

5.1.2 Elasticity of Quantities with respect to Exchange Rates

Next, I consider how quantity effects of exchange rates interact with the above pass-through variation. I estimate the quantity-exchange rate elasticity $\frac{\gamma}{\rho}$ using the instrumental-variables relationship between Equations 7 and 8.

Table 2 presents these results. I find that despite the pass-through differences seen in Table 1, US imports and exports have approximately equal *quantity* effects of exchange rates. The point estimate in US imports is actually slightly larger than that of exports, but this distinction is imprecise and I cannot reject with even 90% confidence that the two reduced-form elasticities are identical.

Table 2: Quantity-Exchange Rate Elasticity

	(1) US Exports "PCP"	(2) US Imports "LCP"
γ/ρ	-0.3936**	-0.5321**
	(0.1777)	(0.2189)
Firm-product-time	Y	Y
Firm-partner-sector	Y	Y
PPI, GDP, Tariff	Y	Y
Lag Controls (11)	Y	Y
N	800000	1958000

Note: Quantity-exchange rate elasticities $\frac{\gamma}{\rho}$; 10 month exchange rate projection instrumented with the contemporaneous exchange rate shock. Equation 7 is the reduced form and Equation 8 is the first stage. 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-R11330). This is a part of clearance request #11330. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

This result is surprising in light of conventional wisdom, which had assumed quantity effects depend linearly on pass-through. The result that quantity effects are no smaller under a LCP regime (US imports) runs contrary to that thought. It implies that the relationship between quantities and prices is stronger under low exchange rate pass-through than high pass-through. The focus of this empirical section is to both confirm and also explain this result.

Appendix Table 9 contains a series of alternative specifications which generate results consistent with this result from Table 2. I describe the details of these specifications in the following Section 5.1.3. The remainder of Section 5 establishes the exact import demand elasticity and sensitivity. It then considers mechanisms: I present descriptive evidence regarding the persistence of pass-through, and demonstrate that forward-looking importers (via import buyer rigidities) can explain the quantity-exchange rate and import demand elasticity results, rather than alternative explanations.

5.1.3 Import Demand Elasticity and Specification Robustness

Given the pass-through estimates and the estimated quantity-exchange rate elasticities, under low pass-through (LCP, US imports) there is a higher implied quantity-price "import demand" elasticity than under high pass-through (PCP, US exports). The import demand elasticity captures how importing agents adjust quantity demand in response to a price change, and the analysis showed that demand is more elastic under low pass-through. The result contrasts the standard uniformity assumption.

To confirm the implied import demand elasticities, I estimate the instrumental-variables relationship between Equations 6 and 7, identifying $\tilde{\sigma} = -\frac{\gamma}{\nu}$. Here the contemporaneous exchange rate shock serves as an instrument for the 10-month price change in the 10-month quantity-price elasticity estimation. The controls and fixed effects remain the same as in the previous sections.

The quantity-price elasticity (from the exchange rate) is substantially larger under the low pass-through (LCP) setting of US imports than the high pass-through (PCP) setting of US exports. Column 4 of Table 3 contains the estimates using the main specification described in Section 4. In the subsequent analysis in this paper, I explore robustness, mechanisms, and implications of this result.

To assess the robustness of the import demand elasticity heterogeneity result, Table 3 contains a series of alternative specifications. The main results are not sensitive to assumptions. Table 3 reports the specification and denotes that the import demand elasticity (import quantity-price elasticity) is always larger in US imports relative to exports.

In Table 3, Column 1 begins with a sparse specification of controls including only exchange rate lags, a firm-product-time fixed effect, and a firm-country-sector fixed effect. The table indicates that the main result is robust in this specification. Note that lags of the shock (exchange rate) are standard controls to identify local projections (Ramey (2016)) because they better extract a "surprise" in the shock variable. In particular, conditional on lag shocks the contemporaneous shock is more likely to be independent of shocks between t and $t+10$. The baseline set of fixed effects enable within-firm-product analysis and also separate the identified coefficient from time trends and partner-country-specific factors. These minimal controls are a step to address error-term factors such as exchange rate fundamentals and trends or aggregate demand and supply shocks.

Note the fixed effects identify demand factors in US imports and supply factors in US exports, but do not address demand and supply shocks in the trading partner country. The set of controls subsequently added relative to Column 1 in Table 3 address additional omitted variables bias from these relationship-specific demand and supply shocks. In Column 2 I add a control for the "missing" factors (supply in imports, and demand in exports). Namely, I add

Table 3: Import Demand Elasticity

	(1)	(2)	(3)	(4)	(5)	(6)
Exports "PCP"	-0.3771**	-0.4256**	-0.4002**	-0.3993**	-0.3682**	-0.3673**
	(0.1385)	(0.172)	(0.1537)	(0.1534)	(0.1555)	(0.1487)
N	1041000	863000	800000	800000	817000	800000
Imports "LCP"	-1.02	-1.323	-1.959**	-1.711**	-1.847**	-1.317*
	(1.441)	(1.29)	(0.7453)	(0.7417)	(0.7346)	(0.7511)
N	2347000	2211000	1958000	1958000	1997000	1958000
FE	Y	Y	Y	Y	Y	Y
Exchange Rate Lags (11)	Y	Y	Y	Y	Y	Y
Demand, Supply (12)	N	Y	Y	Y	Y	Y
PPI, GDP (12)	N	N	Y	Y	Y	Y
Tariffs (12)	N	N	N	Y	Y	Y
Lags Only (11)					Y	
Lags Outcome (11)						Y

Note: Import demand (quantity-price) elasticity $-\tilde{\sigma} = \frac{\gamma}{\nu}$; 10-month price projection instrumented with the contemporaneous exchange rate shock. Estimated for US imports relative to US exports. All standard errors clustered by HS product and partner country. Equation 7 is the reduced form and Equation 6 is the first stage. Column 1 includes a time fixed effect, 11 lags (corresponding to a year of changes) of exchange rate shocks, a firm-product-time fixed effect, and a firm-country-sector fixed effect. Column 2 adds a country PPI shock control (contemporaneous and 11 lags) in US imports and a country GDP shock control (contemporaneous and 11 lags) in US exports. Column 3 adds GDP for US imports and PPI for US exports. Column 4 adds tariff shocks (contemporaneous and 11 lags) and corresponds to the full specification in Equations 6 and 7 and Tables 1 and 2. Column 5 removes contemporaneous controls from the full instrumental-variables specification implied by Equations 6 and 7. Column 6 adds lags of log quantities to the full specification. All coefficients reflect a strong first-stage except Column 1 for US imports, which is weakly identified (Kleibergen-Paap F-statistic = 7.787). 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, CBDRB-FY24-P2874-R11608, and CBDRB-FY24-P2874-R11645). This is a part of clearance requests #11330, #11608, and #11645. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

a PPI control in the import estimation and a GDP control in the export estimation. Column 3 adds the counterpart. Column 4 adds the tariff control, and is the exact instrumental-variables combination of Tables 1 and 2. The main novel fact of the paper – that the US import quantity-price (instrumented with exchange rates) elasticity is larger than that of US exports – is consistent with these sparser specifications.

Furthermore, Columns 5 and 6 consider alternative specifications. Column 5 removes contemporaneous controls in order to fix the controls prior to the estimation horizon and with the objective of approximating more closely a total derivative. Column 6, relative to the benchmark specification, adds lag outcome (quantity) controls to further address concerns about simultaneity bias. The import demand elasticity heterogeneity is also consistent with these alternative specifications.

The Appendix contains the specification robustness for Tables 1 (Appendix Table 8) and 2 (Appendix Table 9). The results from the previous subsections are also consistent across alternative specifications.

5.1.4 Exchange Rate Variation

In this subsection I consider whether the nature of the exchange rate variation leveraged in the previous subsections could bias the results. This could be the case if exchange rates in US imports are more persistent than those in US exports. If the exchange rate is more persistent in US imports, that could generate larger demand elasticities independent of pass-through. In this subsection I show this is not the case.

In the Appendix I present a series of exhibits demonstrating the exchange rate variation employed in the analysis in this section. I consider the nature of exchange rate variation employed in the main analysis, as well as which components of the specification determine the nature of the variation.

In Appendix Figure 7 I show that in raw data (i.e. not restricted to controls) with only a time fixed effect and 11 exchange rate lags, the exchange rate approximates a random walk virtually identically in US imports and US exports. Then, employing the main specification described in Section 4 with controls and fixed effects, the exchange rate approximates an AR(1) with persistence less than unity in both US imports and US exports. Note that this variation is more persistent in US exports than it is in US imports. The exchange rate variation is less persistent in US imports because on the demand-side the US firm-product-time fixed effect explains more of the persistent component of the exchange rate than it does on the supply-side.[8]

Potential bias induced by this heterogeneity does not favor the heterogeneity in the demand elasticities observed in this section and is thus not a concern for this analysis. The variation for US exports is more persistent, which could plausibly increase demand effects, but I observe a lower import demand elasticity in US exports. Accordingly, the nature of

[8]In the Appendix I further explore why the variation differs. I show that in the sample with controls (PPI, GDP, tariffs) the exchange rate approximates a random walk in a specification with only a time fixed effect and 11 exchange rate shock lags. Adding a country fixed effect lowers the persistence away from a random walk, symmetrically in both US imports and exports. Indeed, I can measure in aggregate data at the country-level an average monthly exchange rate persistence of 0.96. Crucially, adding a firm-product-time fixed effect strips away a persistent component for US imports but not US exports, generating the heterogeneity in exchange rate variation observed for the regression sample in Appendix Figure 7. For the sample of countries with available PPI, GDP, and tariff data, which implicitly drops smaller countries which may be pegged to the US dollar, US firms explain a large share of the persistent component of the bilateral exchange rate more so on the demand-side than on the supply-side.

the exchange rate variation does not confound the observed heterogeneity in import demand elasticities.

5.1.5 Dynamics

Next, I consider sensitivity to the horizon choice in the Appendix. In Appendix Figure 8 I show that the economic takeaway from Table 1 (that US exports have higher pass-through than US imports) is not horizon-specific. Recall 10 months was chosen as an example to balance autoregressive local-projection instrument power with the time incidence of shocks such as monetary policy. In Appendix Figure 11 I also report elasticity estimates up through 24 months; the economic result regarding pass-through heterogeneity remains consistent. Both figures also report the corresponding local projections of the $k-$horizon price on the contemporaneous exchange rate shock. I do so to capture effects of exchange rates at both the same horizon (elasticity) and from the original shock (local projection). Reporting both is also useful to decompose the relationship between the price, quantity, and quantity-price estimates.

As with the previous analysis on prices, Appendix Figure 9 shows the quantity-exchange rate elasticity results from Table 2 display similar patterns for 1 through 10 month estimation horizons. Appendix Figure 12 illustrates that this is also true, though noisier, through 24 months.

Finally, as with the price- and quantity-exchange rate regressions, in Appendix Figure 10 I report the dynamics of the import demand elasticity. I report the Column 4 specification from Table 3 for 1 through 10 month analysis horizons. The heterogeneity I find over time – that the low pass-through environment of US imports is consistently subject to a larger import demand elasticity than the high pass-through environment of US exports – is implied by the earlier figures but is useful to visualize.

5.2 Mechanisms

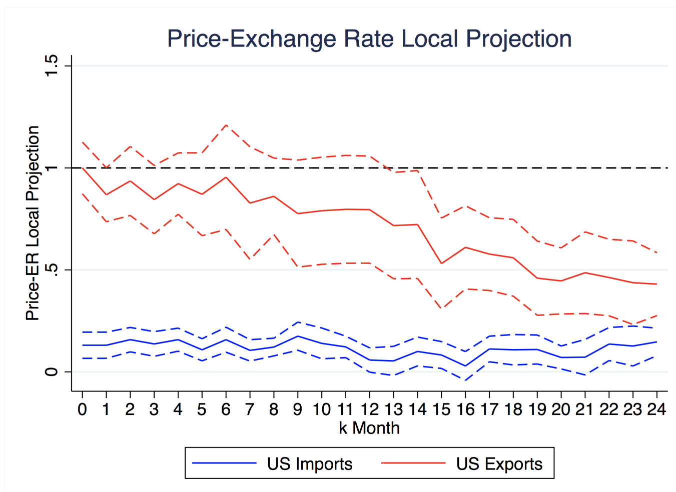
The previous section presented pass-through, quantity, and import demand elasticities which are altogether puzzling in light of conventional wisdom. Despite pass-through differences across US imports and US exports, quantity effects of exchange rates are approximately equal. The analysis implies that low pass-through is subject to a larger import demand (quantity-price) elasticity than high pass-through.

In this section, I consider potential explanations for that result. I first show that pass-through is more persistent under low pass-through (LCP) than high pass-through (PCP). Motivated by this evidence, I then show that import buyer rigidities, the price stickiness of the importing firm, intersects with the pass-through heterogeneity to explain the quantity-exchange rate and import demand elasticity results. I then rule out alternatives, including underlying demand, product composition, and exchange rate hedging.

5.2.1 Descriptive Pass-through Persistence Heterogeneity

I present descriptive facts regarding pass-through persistence which I later formalize in the model in Section 6. Consider the long-run exchange rate local projection into trade prices, in Figure 1. Over time, pass-through decays in an approximate AR(1) form for the high pass-through environment of PCP in US exports. In contrast, pass-through is more persistent (i.e. does not fall over time) in the low pass-through environment of LCP in US imports.

Figure 1: Exchange Rate Pass-through Persistence Variation



Note: Price-exchange rate local projection ν_k (Equation 6) estimated for $k = 1, ..., 24$ horizon changes. US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-R11330). This is a part of clearance request #11330.

This paper considers the variation presented in Figure 1 as a new source of heterogeneity in the import demand elasticity. This distinction in pass-through persistence is similar to the shock persistence distinction of of tariffs (permanent) versus exchange rates (transitory) which yields different demand responses in, for example, Fitzgerald and Haller (2018) and Auclert et al. (2024). In particular, the persistence of low pass-through under LCP could amplify demand effects in the face of forward-looking importers. On the other hand, lower pass-through persistence under PCP may attenuate demand effects in that case. The next sections will present evidence consistent with this intuition, then rule out alternatives.

5.2.2 Import Buyer Rigidities

In this section, I consider how a demand-side friction – the price rigidity of the importing firm – interacts with the pass-through variation presented in the previous sections. I discuss how I construct this "import buyer rigidity" and present results illustrating that this friction interacts with pass-through to explain the quantity-exchange rate and import demand elasticity results.

Import Buyer Rigidity – Benchmark.

I construct the general importing firm's price rigidity – the import buyer rigidity – by linking the LBD, LFTTD, and price rigidity information from Nakamura and Steinsson (2008). The LBD links the Census Bureau firm from the LFTTD data to the plant-level establishment level data which contains information on output industry composition of each purchasing firm. I then construct for each LFTTD importing firm its own employment corresponding to each NAICS-4 code it produces in. I then merge at the NAICS-4 level monthly price stickiness data from Nakamura and Steinsson (2008).[9][10] I construct the import buyer rigidity for each US importing firm as its employment-weighted price stickiness averaged across each industry it produces in. Denote the import buyer rigidity as κ_r; from that data, I compute κ_r as one minus the price flexibility variable from Nakamura and Steinsson (2008).[11] In the public dataset, the average monthly $\kappa_r = 0.82$, and of the US importing firms in the LFTTD dataset the approximate average monthly $\kappa_r = 0.9$. As a final step, I compute the employment-weighted average import buyer rigidity faced by each US imported HS-10 product. Accordingly, this measure can then also be applied to US exports, as it is a general product (rather than specific firm) characteristic. The advantage of this data structure is that the rigidity is aggregated across importing firms and their sub-industries. This aggregation smooths across potential spurious idiosyncratic shocks.

To ascertain the role of the import buyer rigidity, I estimate the quantity-exchange rate elasticity $\frac{\gamma}{\rho}$ split by above- and below-median import buyer rigidity, in US imports and US exports. In Table 4 I find heterogeneity with respect to the import buyer rigidity for US

[9] The price stickiness data were accessed via the replication package of Fajgelbaum et al. (2019).

[10] I drop agriculture-sector plants (NAICS 111) because prices are very flexible ($\kappa_r = 0.15$ but final demand and supply elasticities are acutely inelastic for independent reasons (Roberts and Schlenker (2013)). This correlation confounds the import demand elasticity heterogeneity identification due to fundamental demand structure, e.g. for reasons independent of the mechanism.

[11] The price flexibility variable is written as a percent out of one hundred, so I scale accordingly.

exports but not US imports.[12] Note in Appendix Table 13 that I do not find a significant

Table 4: Quantity-Exchange Rate Elasticity (Heterogeneous Effects)

	(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 7 is the reduced form and Equation 8 is the first stage. 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

effect of the import buyer rigidity on pass-through elasticities $\frac{\nu}{\rho}$. Thus, a potential explanation for the discrepancy in quantity-price elasticities in US imports relative to US exports is that import buyer rigidities attenuate the quantity-exchange rate effects under PCP but not LCP.

Next, is the estimate consistent across alternative specifications? And moreover, are the results from Section 5.1 indeed driven by the intersection of the import buyer rigidity with pass-through persistence? To address the first question, I consider the following alternative analyses. I then conduct a series of tests to provide evidence for the second question.

Import Buyer Rigidity – Robustness: Specification.

[12]Note the sample sizes are smaller than Table 2 due to availability of the import buyer rigidity data.

I consider five alternative measures of the import buyer rigidity to explore the sensitivity of the observed effects. In Appendix Table 14 I first consider four alternative constructions of the measure. That table shows the analysis is robust to constructing the import buyer rigidity using an input-output table rather than the structure of the LFTTD data, using quantity weights rather than employment weights to aggregate across firms and within products, and adjusting the cutoffs to determine the high-versus-low bins. In Appendix Table 15 I show that controlling for a continuous measure of the import buyer rigidity implies an import demand elasticity of $\tilde{\sigma} = 2.922$ in US exports, consistent with standard values for a tariff-based trade elasticity (i.e. Boehm et al. (2023)).[13]

Import Buyer Rigidity – Robustness: Tariffs.

Next, I consider whether the import buyer rigidity estimates could plausibly be explained by the intersection with currency choice (the intersection of import buyer and trade price rigidities, which the model in Section 6 will propose). I consider two tests: how tariffs interact with the import buyer rigidity, and the relationship between the import buyer rigidity and the final demand elasticity.

The tariff is automatically paid in full at the border by the importer unless the exporter lowers prices. Amiti et al. (2019b) and Fajgelbaum et al. (2019) find that this is particularly sharp in the US, with (similar to PCP) complete pass-through of the 2018 tariff escalation. In particular, the US import price is not fixed with respect to tariff costs (the way it is fixed in dollars), i.e. the tariffs certainly do not enter prices a la LCP. Therefore, a test whether LCP explains the lack of effect of the import buyer rigidity in US imports is to explore whether US import tariffs are materially impacted by import buyer rigidities. If they are, that is suggestive of the role of LCP in US imports for exchange rates.

Appendix Table 16 estimates the effect of the import buyer rigidity in US imports for tariffs. Indeed, in US imports the tariff-based demand elasticity is substantially influenced by the import buyer rigidity. Increasing the average monthly import buyer rigidity from 0.8002 to 0.9448 attenuates the quantity-tariff elasticity by a factor of 2 or 4 depending on measure used. In Appendix Figure 13 I show this result is consistent over time, and also controlling for price changes. Note that I do not have instrument power in the quantity-price estimation beyond 5 months.[14]

Import Buyer Rigidity – Robustness: Spurious Correlation.

[13] I do not have sufficient variation to report the analogous value in US imports.

[14] As tariffs are imported on fewer products and are more sensitive to noise in the measure, I report both the original US importing firm import buyer rigidity and the product aggregated version. The analysis is consistent with both versions.

An additional concern is that the import buyer rigidity comparative static is descriptive, so there could be spurious correlation between the firm's price rigidity and, for example, the demand for its own goods. Splitting the sample based on sector-level heterogeneity implies that I am restricting analysis based on product characteristics, which may influence the estimates. Confounding factors could lead to an underestimate or overestimate of the true parameter. On the latter, I am measuring a firm's κ_r as a function of its industry mix rigidity, which is less likely to generate endogeneity bias with firms' choice of rigidity. I show in Appendix Figure 14 that sector-level stickiness from Nakamura and Steinsson (2008) is not systematically correlated with the estimated Caliendo and Parro (2014) sector-level demand elasticities.[15]

5.2.3 Alternative Interpretations

In this subsection I consider alternative interpretations of the main estimates in Section 5.1. The elasticities could instead be driven by different underlying demand characteristics or product composition of US exports versus imports. Or, exchange rate hedging could play a differential role. Namely, the relationship between the Section 5.1 results may be independent of currency choice, and actually just specific to US data. In this section I explore such alternatives.[16]

I proceed to address these concerns. As in the case of the import buyer rigidity, I again leverage tariffs as a control shock, in this case for a demand benchmark. Second, I restrict to identical products in US imports versus exports. Third, I control for hedging.

Underlying Demand Elasticities.

If differing underlying demand elasticities are driving the quantity estimates, there should be a similar discrepancy in tariffs. If instead currency choice is driving the exchange rate elasticity discrepancy in the US, there should be no difference in tariffs' effects on quantities in US exports versus imports, as they enter prices symmetrically across both samples.

I test this by estimating the import demand elasticity but using tariffs as the shock instead of exchange rates. Note that the tariff varies at the country-product level, so following

[15] I again leverage price stickiness data from Nakamura and Steinsson (2008), but incorporate demand elasticity data from Caliendo and Parro (2014), and input-output table data from Acemoglu et al. (2016). The price stickiness and demand elasticity data were accessed via the replication package for Fajgelbaum et al. (2019). I crosswalked the data from NAICS to SIC and SIC87DD using crosswalks from Autor et al. (2013).

[16] I also note that recent work by De Gregorio et al. (2024) implies a similar result regarding LCP versus PCP for Chilean exports to a range of destinations. In particular, their point estimates for LCP destinations *excluding* the US are consistent with the result in Table 3. Additionally, their pooled estimates also imply that the PCP demand elasticity is lower than that of LCP.

Fajgelbaum et al. (2019) identification requires addressing country-specific trends with a country-time fixed effect. I then compare the quantity-price elasticity discrepancy in imports versus exports for exchange rates relative to tariff in Appendix Figure 15. I report for $k = 1, ..., 10$ month horizon changes for robustness, noting that at longer horizons the data lack appropriate tariff variation.

I find that tariff effects on quantities, holding prices constant, are approximately equal across US exports and US imports, i.e. the ratio of the elasticity in US imports to that of US exports is approximately 1. Any deviations are still substantially below that of the corresponding ratio for exchange rate-based elasticity.

Product Composition.

Another concern with the main estimation of elasticity heterogeneity is that it requires separate sampling, particularly comparing US imports to US exports. The US imports and exports different products, so the heterogeneity in quantity-price elasticities could reflect distinct product-specific characteristics. Accordingly, I restrict the samples to the HS-10 products which are both imported and exported by the US. The result holds with this restriction. I report the results from this analysis in Appendix Tables 17 and 18.

Note that when restricting the sample, Census Bureau restrictions mandate that I can only report the $k = 4$ rather than $k = 10$ horizon. However, Figure 10 illustrates that the benchmark result holds in the $k = 4$ horizon. Furthermore, I also report in Appendix Table 18 an interaction specification demonstrating in the $k = 10$ horizon that products which are present in both US exports and imports versus excluded from one or the other behave no differently in terms of import demand elasticities. In other words, the differences in estimated elasticities across US imports and exports is not driven by different product composition.

Exchange Rate Hedging.

Finally, I assess whether exchange rate hedging plays a role in the quantity demand elasticity estimation. A concern is that systematically different patterns in exchange rate hedging could drive the earlier results. Furthermore, econometrically, hedging is a threat to the exclusion restriction in the instrumental variables estimation, because the exchange rate may affect quantities and prices via firms' financial positions. To test this, I draw from hedging data obtained from the Bank for International Settlements (BIS) Triennial Central Bank Survey, and test whether there is such a systematic correlation.

I leverage a range of dollar hedging data by currency: forward contracts and all contracts net of spot, in total and for nonfinancials only. I extract the data at the start of my sample, the year 2013. I weight each measure by a country's total trade volume. I control for these variables by interacting them with the independent variable in turn in the main specifications. Note again due to restrictions on instrument power I report both the $k = 4$ horizon and $k = 10$ horizon, and that the analysis has a strong first-stage in the former but not the latter. Appendix Table 19 contains the estimates, and I do not find any estimate adjustment from the hedging control.

This section has shown that quantity effects of exchange rates are equal across the high pass-through environment of PCP in US exports and the low pass-through environment of LCP in US imports. The higher import demand elasticity under LCP relative to PCP is particularly related to the interaction of currency choice and import buyer rigidities. The model in the next section introduces these import buyer rigidities into a small open economy New Keynesian framework, which will replicate the empirical results.

6 Model

The framework is a variant of a small open economy New Keynesian model a la Galí and Monacelli (2005). There are two main differences. First, trade is in intermediate goods instead of final goods. Second, the import process has two stages due to the addition of a second type of firm, import buyers, who intermediate the flow of goods between foreign exporters and domestic households.

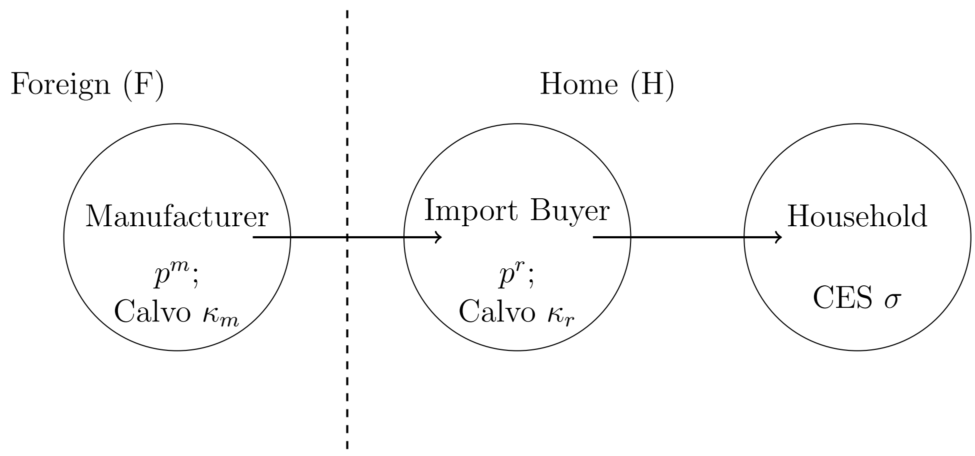
Households consume a domestic consumption composite C that is a CES aggregate of a domestic consumption composite C^h and a foreign composite C^r. Domestic manufacturers produce C^h using labor. The foreign composite C^r is produced in two stages. First, import buyers obtain an imported intermediate composite from foreign exporters. The import buyers then use this good as input to produce the foreign consumption good. Figure 2 illustrates this process. Note that demand for C^h relative to C^r will depend on the behavior of exchange rates.

Manufacturers are monopolistically competitive and there are two types. The first type produces domestic consumption goods as discussed; the second type produces intermediate goods for sale abroad Q^{m*}. Import buyers are also monopolistically competitive. As noted, they buy the composite output from foreign exporters Q^m. For all firms, nominal prices are sticky as in Calvo; I let the degree of rigidity vary by firm type and by currency pricing regime. In each period, a firm adjusts its price with i.i.d. probability $1-\kappa$, where κ measures the degree of price rigidity and is dependent on firm type.

The interaction of the import buyers' price stickiness with that of exporters will lead to an import buyer mechanism determining the import demand elasticity. I show that due to the import buyer rigidity, despite lowering pass-through, stickier trade prices lead to a stronger demand response. The framework lends itself to considering different currency invoicing regimes, particularly which generate heterogeneous pass-through patterns. In particular, a trade price rigidity of $\kappa_m = 0$ corresponds to producer currency pricing (PCP) when the exchange rate is the only marginal cost shock. As is standard for PCP, in that case the exchange rate enters import (trade) prices with high pass-through, fully and flexibly. Increasing κ_m increases the degree of local currency pricing (LCP), lowering the pass-through rate but increasing persistence.

In the next section I present the environment for households, import buyers, and manufacturers. It is symmetric for the foreign sectors. To illustrate how the import buyer mechanism works, I first solve a partial equilibrium version of the model that restricts attention to the import process. I then turn to general equilibrium simulations of this framework in Section 7.3 that are designed to derive expenditure-switching effects for the domestic country due to trade with foreign. Aggregate foreign variables are indexed with an asterisk.

Figure 2: Overview of Import Process



6.1 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 σ and domestic good share h:

$$C_t = \left(h\big(C_t^h\big)^{\frac{\sigma-1}{\sigma}} + (1-h)\big(C_t^r\big)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{11}$$

The aggregate price index P_t is given by

$$P_t = \left(h\big(P_t^h\big)^{1-\sigma} + (1-h)\big(P_t^r\big)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{12}$$

The parameter σ 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

$$U(C_t, N_t^h, N_t^{m*}) = \frac{(C_t)^{1-\omega}}{1-\omega} - \left(\frac{(N_t^h)^{1+\phi} + (N_t^{m*})^{1+\phi}}{1+\phi}\right), \tag{13}$$

with ω as household relative risk aversion and ϕ 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 ε_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 Π_t denote per-period profits of all domestic firms. Then the per-period budget constraint is given by

$$P_tC_t+\varepsilon_tB_{t+1}^*+\sum_{s'\in S}Q_t(s')B_{t+1}(s') \leq W_t^hN_t^h+W_t^{m*}N_t^{m*}+\Pi_t+\varepsilon_t\Psi_t^u(1+i_t^*)B_t^*+\sum_{s'\in S}B_t(s'). \tag{14}$$

I allow for frictions in international borrowing. Ψ_t^u denotes an i.i.d. shock to the cost of foreign borrowing.[17]

Import Buyers.

The foreign-good composite C_t^r is a CES aggregate of differentiated products Q_{it}^r produced by monopolistically competitive import buyers indexed by i, and given the substitution elasticity σ_r.

$$C_t^r = \left(\sum_i \left(Q_{it}^r\right)^{\frac{\sigma_r-1}{\sigma_r}}\right)^{\frac{\sigma_r}{\sigma_r-1}}. \tag{15}$$

The price index P_t^r will prove to be key for the import buyer mechanism. As I describe

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

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 buyer i produces goods Q_{it}^r using an imported intermediate composite Q_t^m according to the following linear technology:

$$Q_{it}^r = A^r Q_t^{mi}, \tag{16}$$

where Q_t^{mi} is the amount of the imported composite used by firm i.[18] 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 σ_m. Let Q_{jt}^m be the intermediate good sold by foreign exporter j. Then

$$Q_t^m = \left(\sum_j \left(Q_{jt}^m \right)^{\frac{\sigma_m - 1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_{m-1}}}. \tag{17}$$

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 Π_{it}^r are given by

$$\Pi_{it}^r = P_{it}^r Q_{it}^r - P_t^m Q_t^{mi}. \tag{18}$$

As noted earlier, import buyer prices are sticky as in Calvo. Each period, a fraction of firms $1 - \kappa_r$ adjust price while fraction κ_r 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 firm chooses 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 σ_h.

$$C_t^h = \left(\sum_i \left(Q_{it}^h \right)^{\frac{\sigma_h - 1}{\sigma_h}} \right)^{\frac{\sigma_h}{\sigma_h - 1}}. \tag{19}$$

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

$$Q_{it}^h = A^h L_{it}^h. \tag{20}$$

[18] 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.

Foreign exporters produce with a similar linear technology:

$$Q^m_{jt} = A^m L^m_{jt}. \tag{21}$$

Domestic manufacturers' profits are given as a function of their output price P^h_{it} and their sector wage W^h_t.

$$\Pi^h_{it} = P^h_{it} Q^h_{it} - W^h_t L^h_{it}. \tag{22}$$

Foreign exporters' profits are given as a function of their output price P^m_{jt} and their foreign sector wage W^m_t.

$$\Pi^m_{jt} = \frac{P^m_{jt}}{\varepsilon_t} Q^m_{jt} - W^m_t L^m_{jt}. \tag{23}$$

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 $g = \{r, h, r*, h*\}$, $Q^g_t = C^g_t$. Recall Q^m (and implicitly Q^{m*}) is defined by Equation 17. 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.

$$Q^g_{lt} = \left(\frac{P^g_{lt}}{P^g_t}\right)^{-\sigma_g} Q^g_t. \tag{24}$$

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

$$max_{\bar{P}^g_t} \sum_{s=t}^{\infty} \beta^{s-t} \Theta_{t,s} \kappa_g^{s-t} \left(\bar{P}^g_t Q^g_{lt+s} - MC^g_{t+s} \right), \tag{25}$$

subject to Equation 24. $\Theta_{t,s} = \beta^{s-t} \frac{C_s^{-\omega}}{C_t^{-\omega}} \frac{P_t}{P_s}$ is the stochastic discount factor between periods t and s given the structure of preferences. MC^g_t represents the marginal cost firm g.

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

$$P^g_t = \left((1-\kappa_g)\big(\bar{P}^g_t\big)^{1-\sigma_g} + \kappa_g \big(P^g_{t-1}\big)^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}. \tag{26}$$

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.

$$NX_t = \frac{1}{P_t}\left(\varepsilon_t P_t^{m*} Q_t^{m*} - P_t^m Q_t^m\right), \tag{27}$$

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

$$GDP_t = C_t + NX_t. \tag{28}$$

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

$$B_t(s') = 0, \forall s' \in S. \tag{29}$$

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 $\frac{B_t^*}{P_t}$ as follows:

$$i_t^* = \delta + \psi(exp(-\frac{B_t^*}{P_t}) - 1), \tag{30}$$

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 π_t, the steady state interest rate δ, and also allows for interest rate smoothing governed by the parameter ξ. Ψ_t^i is an i.i.d. shock.

$$i_t - \delta = (1-\xi)(i_{t-1} - \delta) + \xi(\phi\pi_t) + \Psi_t^i. \tag{31}$$

I assume first-order autogregressive processes for the two exogenous shocks Ψ_t^i and Ψ_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.

6.2 Decentralized Equilibrium

In a decentralized equilibrium, households maximize the expected path of utility subject to the budget constraint from Equation 14. Firms maximize expected profits described in Equations 18, 22, and 23. 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[19]

$$C_t^{-\omega} = \beta E_t \left[C_{t+1}^{-\omega} (1 + i_t) \frac{P_t}{P_{t+1}} \right]. \tag{32}$$

The Euler conditions imply an uncovered interest parity (UIP) condition that relates the change in the exchange rate to the interest rate differential.

$$E_t \left[C_{t+1}^{-\omega} (1 + i_t) \frac{P_t}{P_{t+1}} \right] = E_t \left[C_{t+1}^{-\omega} (1 + i_t^*) \frac{P_t}{P_{t+1}} \frac{\varepsilon_{t+1}}{\varepsilon_t} \Psi_t^u \right], \tag{33}$$

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 ε_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 foreign per one domestic. A decrease in the domestic interest rate causes a domestic exchange rate depreciation. Note the shock Ψ_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 (Ψ_t^i) or a UIP shock (Ψ_t^u). The subsequent propagation to trade prices and quantities is subject to the following demand and pricing conditions.

Labor Supply.

Labor supply for domestic manufacturers satisfies

$$\frac{W_t^h}{P_t} = (C_t)^\omega (N_t^h)^\phi. \tag{34}$$

Labor supply for domestic exporters satisfies

$$\frac{W_t^{m*}}{P_t} = (C_t)^\omega (N_t^{m*})^\phi. \tag{35}$$

[19]The condition for foreign bonds is given by

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

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

$$C_t^h = h\left(\frac{P_t^h}{P_t}\right)^{-\sigma} C_t, \tag{36}$$

and

$$C_t^r = (1-h)\left(\frac{P_t^r}{P_t}\right)^{-\sigma} C_t. \tag{37}$$

Note that expenditure-switching depends partly on the substitution between the domestic and foreign composites: the relationship between Equations 36 and 37. 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

$$MC_t^r = \frac{P_t^m}{A^r}. \tag{38}$$

The nominal marginal cost of domestic manufacturers is given by

$$MC_t^h = \frac{W_t^h}{A^h}. \tag{39}$$

The nominal marginal cost of domestic exporters is given by

$$MC_t^{m*} = \frac{W_t^{m*}}{\varepsilon_t A^{m*}}. \tag{40}$$

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

$$MC_t^m = \frac{\varepsilon_t W_t^m}{A^m}. \tag{41}$$

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 $g = \{r, m, h, r*, m*, h*\}$

is given by

$$E_t \sum_{s=t}^{\infty} \Theta_{t,s} (\kappa_g)^{s-t} Q^g_{s|t} (\sigma_g - 1) \left(\bar{P}^g_t - \frac{\sigma_g}{\sigma_g - 1} MC^g_s \right) = 0. \tag{42}$$

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

$$\bar{p}^g_t = (1 - \beta\kappa_g) E_t \{ \sum_{\tau=0}^{\infty} (\beta\kappa_g)^{\tau} (mc^g_{t+\tau} + \mu^g) \}, \tag{43}$$

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

$$p^g_t = (1 - \kappa_g)\bar{p}^g_t + \kappa_g p^g_{t-1}. \tag{44}$$

Define the decentralized equilibrium as an allocation of prices such that Equations 11 - 44 hold.

6.3 Import Demand Elasticity

In this section I provide an analytic example of the import demand elasticity $\tilde{\sigma}$ in the context of a partial equilibrium solution of the model which restricts attention to the import process. The example makes clear how the import demand elasticity $\tilde{\sigma}$ depends on price-setting by both foreign exporters and domestic import buyers. I assume the domestic wage is fixed, and the exchange rate is exogenous and obeys an AR(1): $e_t = \rho e_{t-1} + \varepsilon^e_t$.[20] I fix all productivities A at unity. These assumptions do not change the economic interpretation of the solution, rather generate a clear exposition of the demand elasticity formula. In Section 7.3, I show the results also hold for the full general model.

In line with the empirical analysis in Section 5, I focus on the elasticity of trade prices and quantities, p^m and q^m, with respect to exchange rates e_t. Then define the exchange rate-based import demand elasticity $\tilde{\sigma} = -\frac{dq^m_t}{de_t} \Big/ \frac{dp^m_t}{de_t}$, the influence of an exchange rate-induced change in import prices on import quantities. As the exchange rate equally influences all import buyers and foreign exporters, this elasticity can be simply decomposed as

$$\tilde{\sigma} = -\frac{dq^m_t}{de_t} \Big/ \frac{dp^m_t}{de_t} = \underbrace{\sigma}_{Final\ Demand} \times \underbrace{\frac{dp^r_t/de_t}{dp^m_t/de_t}}_{Price\ Adjustment} . \tag{45}$$

The solution for $\tilde{\sigma}$ is thus a direct function of $\frac{dp^r_t/de_t}{dp^m_t/de_t}$. Critically, the import buyer's own-

[20] This autoregressive form of the exchange rate will approximately hold in the model simulations in Section 7.3, given the AR(1) form of the i.i.d shocks introduced in the previous section.

price adjustment in response to exchange rate pass-through determines her imported input adjustment. This insight will prove crucial in this framework determining the relationship between the import quantity and import price responses to exchange rates. I now describe what determines this adjustment.

I first solve for exchange rate pass-through into import (trade) prices, dp_t^m/de_t. The manufacturer's optimal reset price is given by

$$\bar{p}_t^m = (1-\beta\kappa_m)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_m)^\tau\left(e_{t+\tau}\right)\}. \tag{46}$$

Given the AR(1) form of the exchange rate, the solution is

$$\bar{p}_t^m = \frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_t. \tag{47}$$

The import price index is given by

$$p_t^m = (1-\kappa_m)\bar{p}_t^m + \kappa_m p_{t-1}^m, \tag{48}$$

and exchange rate pass-through is

$$\frac{dp_t^m}{de_t} = (1-\kappa_m)\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_t. \tag{49}$$

The second step is to solve for the import buyer's price's response to the exchange rate, $\frac{dp_t^r}{de_t}$. The optimal import buyer reset price is given by

$$\bar{p}_t^r = (1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\left(p_{t+\tau}^m\right)\}, \tag{50}$$

and the import buyer's price index

$$p_t^r = (1-\kappa_r)\bar{p}_t^r + \kappa_r p_{t-1}^r. \tag{51}$$

The elasticity $\frac{dp_t^r}{de_t}$ is given by

$$\frac{dp_t^r}{de_t} = (1-\kappa_r)(1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\frac{dp_{t+\tau}^m}{de_t}\}. \tag{52}$$

Combining Equations 45, 49, and 52, $\tilde{\sigma}$ can be written as an increasing function of pass-through persistence $\rho_k^{PT} = \frac{E_t\{dp_{t+k}^m\}}{de_t} \Big/ \frac{dp_t^m}{de_t}$. Namely:

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\sum_{k=0}^{\infty}(\beta\kappa_r)^k\rho_k^{PT}. \tag{53}$$

Pass-through persistence ρ^{PT} is the persistence of the price change, when the price change is driven by the exchange rate shock. The formula is equivalent to an autocorrelated form of prices, where the lagged price is instrumented with the shock. Equation 53 shows that the import demand elasticity $\tilde{\sigma}$ is increasing in pass-through persistence for $\kappa_r \in (0,1)$. The full derivation can be found in the Appendix.

The next step is to derive the form of pass-through persistence in order to obtain the solution for the import demand elasticity $\tilde{\sigma}$. The local projection of the cost shock at time t into prices at time $t+k$, as a function of the time t pass-through, is given by

$$\frac{dE_t\{p_{t+k}^m\}}{de_t} = \sum_{s=0}^{s=k}\rho^s\kappa_m^{k-s}\frac{dp_t^m}{de_t}. \tag{54}$$

The derivation is in the Appendix. By the laws of finite power sums, the solution to Equation 54, which is the cost shock pass-through persistence, is given by

$$\rho_k^{PT} = \frac{\rho^{k+1}-\kappa_m^{k+1}}{\rho-\kappa_m}. \tag{55}$$

The solution for $\tilde{\sigma}$ follows by substituting Equation 55 into Equation 53. The derivation is in the Appendix, along with an alternative derivation directly from the pricing equations. The analysis in this section will then in turn provide a theoretical form for the estimates from Tables 1, 2, and 3. In particular, note that the theoretical counterpart to the estimated exchange rate pass-through elasticity from Table 1: $\nu/\rho = \frac{dp_t^m}{de_t}$ from Equation 49. Then the theoretical counterpart to the estimated quantity-exchange rate elasticity from Table 2: $\gamma/\rho = \frac{dq_t^m}{de_t} = \tilde{\sigma}\frac{dp_t^m}{de_t}$. In this framework, $\tilde{\sigma}$ as estimated in Table 3 is given by the following Proposition 1.

Proposition 1 [Import Demand Elasticity]: *The import demand elasticity* $\tilde{\sigma} = -\frac{dq_t^m}{de_t} \Big/ \frac{dp_t^m}{de_t}$ *is:*

$$\tilde{\sigma} = \sigma(1-\kappa_r)\frac{1-\beta\kappa_r}{(1-\beta\kappa_r\rho)(1-\beta\kappa_r\kappa_m)}. \tag{56}$$

Proposition 1 defines $\tilde{\sigma}$ as estimated in Section 5. The following Corollary 1 can also be derived from the formulae in Proposition 1. It is the theoretical equivalent for the patterns across high versus low pass-through in Tables 1, 2, 3, and 4.

Corollary 1: *The form of the import demand elasticity implies the following results:*

(i) *The import demand elasticity is increasing in trade price rigidity κ_m when $\kappa_r \in (0,1)$.*

(ii) *The derivative of the import demand elasticity with respect to the import buyer rigidity, $\frac{d\tilde{\sigma}}{d\kappa_r}$, is negative, and the absolute value of the derivative, $|\frac{d\tilde{\sigma}}{d\kappa_r}|$, is decreasing in κ_m.*

Corollary 1i matches the import demand elasticity $\tilde{\sigma}$ heterogeneity result in Table 3. In particular, in the data LCP has a higher import demand elasticity than PCP. LCP, by construction, has a higher κ_m ($\kappa_m > 0$) than PCP (for which $\kappa_m = 0$). Accordingly, by Corollary 1i LCP has a higher import demand elasticity than PCP. It is proven by differentiating the form of $\tilde{\sigma}$ from Proposition 1 with respect to κ_m. Corollary 1ii generates the import buyer rigidity mechanism result in Table 4 and, more broadly, as established in the overall Section 5.2. It says that $\tilde{\sigma}$ is decreasing in κ_r but the absolute value of that derivative is decreasing in κ_m. Accordingly, the import buyer rigidity attenuates the import demand elasticity but less so for higher values of κ_m. The solution is thus consistent with the empirical result that the import buyer rigidities attenuate the PCP elasticity more than the LCP. Corollary 1ii is proven by differentiating $\tilde{\sigma}$ with respect to κ_r, then by computing the derivative of $\left|\frac{d\tilde{\sigma}}{d\kappa_r}\right|$ with respect to κ_m.[21]

The import demand elasticity $\tilde{\sigma}$ is higher for low pass-through because the low pass-through is associated with a greater persistence of the price change. When the importer has her own rigidities, she adjusts her import demand more for prices which are more persistent. Accordingly, the conventional wisdom regarding how pass-through informs expenditure-switching reverses in light of this framework and evidence.

To summarize the intuition of the derivation, recall that (i) the import demand elasticity is increasing in pass-through persistence and note (ii) pass-through persistence is increasing in κ_m (the conceptual analog of Figure 1) and (iii) κ_m only increases the import demand elasticity via pass-through persistence. When the import buyer adjusts her own price sluggishly

[21] The formula in Proposition 1 contains additional supplementary predictions, which include but are not limited to (i) *The import demand elasticity is increasing in shock persistence ρ.* (ii) *The import demand elasticity is increasing over time and is uniform as $k \to \infty$.* (iii) *The growth of the import demand elasticity is decreasing in the trade price rigidity κ_m and shock persistence ρ.* (iv) *The difference in the import demand elasticity with respect to the import buyer rigidity κ_r is hump-shaped over time, increasing in short-run and going to zero as $k \to \infty$.* The Appendix contains corresponding tests.

($\kappa_r \in (0,1)$) she adjusts her price more for more persistent import price changes ("pass-through persistence"). This is because she does not adjust fully to contemporaneous shocks; rather, she is forward-looking and accounts for the future path of the import price changes. Then, when import prices are stickier (higher κ_m), import price pass-through is lower but also lasts longer. Accordingly, the import buyer adjusts her own price, and therefore import quantities, relatively more for low pass-through.

Proposition 1 and Corollary 1 are new relative to earlier work, and draw from the previous pass-through persistence derivation. Previous research had not considered the interaction of import buyer rigidities with trade price rigidities. Accordingly, conventional wisdom (i.e. Obstfeld (2002)) has assumed a uniform import demand elasticity $\tilde{\sigma} = \sigma$. Proposition 1, Corollary 1, and the counterpart empirical analysis in this paper has found that the import demand elasticity is not uniform because of import buyer rigidities.

The next section contains the quantitative estimation of the model.

7 Quantitative Analysis

7.1 Calibration

In this subsection I identify the underlying model parameters to calibrate the quantitative simulations of the model. The exogenous parameters are $\{\omega, \beta, \kappa_r, \kappa_m, \kappa_h, \kappa_{m*}, \kappa_{r*}, \sigma, h, \phi, \rho, A, \psi\}$.

In Table 5 I report monthly parameter values, which where appropriate can be converted to longer-horizons (such as quarterly) as in the following example. Monthly exchange rate persistence ρ converted to quarterly is ρ^3, and so on.

First, I estimate in aggregate data that the quarterly average exchange rate AR(1) shock persistence $\rho = 0.89$, implying a monthly value of 0.96. Following Gopinath and Rigobon (2008) I calibrate $\kappa_m = 0$ for PCP and $\kappa_m = 0.9$ for LCP (approximate 10-month price rigidity). The average κ_r in LFTTD data on importers is 0.9. Accordingly, I employ this value in all calibration.

In all simulations I assume a standard $\sigma = 5$, drawn from classical analysis such as Anderson and van Wincoop (2004). Note that I use a larger value of σ than is estimated in Boehm et al. (2023). This is for two reasons. First, the findings in this paper show that the import buyer rigidity mechanism attenuates previous estimates of the trade elasticity plausibly beyond their finding of 2. Second, the elasticity they measure is a quantity-tariff elasticity, not quantity-price; differential pass-through patterns (e.g. if pass-through is less than unity) may affect their estimates. Also note that given classical trade models used values of σ between 10 and 15 (Ruhl (2008)) the choice of $\sigma = 5$ is a compromise between older work and newer evidence. Finally, the qualitative takeaways of Sections 7.2 and both qualitative and quantitative results of 7.3 do not depend on this parameter choice.[22]

I assume $h = 2/3$ to approximate the world average import share from World Bank (2024). Finally, consistent with the small open economy assumption I hold fixed the foreign nominal price level, consumption, labor, and nominal wage. The calibration includes standard values of $\omega = 1$, $\beta = 0.99$, $\phi = 1$, $A = 1$, and $\psi = .000001$. I later consider sensitivity on the calibration and parameter assumptions.

Table 5: Calibration

(1) Parameter	(2) Monthly Value	(3) Source
κ_m (PCP)	0	Gopinath and Rigobon (2008)
κ_m (LCP)	0.9	Gopinath and Rigobon (2008)
κ_{m*}	0	Gopinath and Rigobon (2008)
κ_r	0.9	Estimated (LFTTD)
κ_{r*}	0.9	Estimated (LFTTD)
κ_h	0.9	Estimated (LFTTD)
ω	1	Log Utility
β	0.99	Standard
σ	5	Anderson and van Wincoop (2004)
ϕ	1	Labor Supply Assumption
ρ	0.96	Estimated (Bloomberg)
A	1	Normalization
h	2/3	World Bank (2024)
ψ	0.000001	Gopinath et al. (2020)

Note: This table presents the model calibration for counterfactual simulations. Column 1 reports the desired parameter. Column 2 reports the monthly value. Column 3 reports the parameter source.

7.2 Goodness-of-Fit

7.2.1 Main Results

In this section I consider how well the form of $\tilde{\sigma}$ from Proposition 1 matches the data. I calibrate with the parameter values from Table 5. Because the data are static in the short-run (Figures 8, 9, and 10) I hold fixed the monthly parameter values extracted and described in the previous subsection.

[22] As an addendum, even in the short-run recent papers such as Fajgelbaum et al. (2019) have found larger elasticities.

Panel A compares the estimated $\tilde{\sigma}$ to the model value. Panel B reports the model-implied effect of reducing the import buyer rigidity as compared to the results from Table 4. In that counterfactual I consider the effect of changing 10-month versions of κ_r, but report alternative counterfactuals in the table notes. The model matches the data well. In particular, with

Table 6: Goodness-of-Fit

(1) Result	(2) Data	(3) Model
Panel A: Import Demand Elasticity $\tilde{\sigma}$ (Table 3)		
US Exports (High pass-through; "PCP", $\kappa_m = 0$)	-0.3993	-0.3768
US Imports (Low pass-through; "LCP", $\kappa_m = 0.9$)	-1.711	-1.9021
Panel B: Heterogeneity of Quantity-ER Elasticities (Table 4)		
US Exports (High pass-through; "PCP", $\kappa_m = 0$)	66.66%	57.81%
US Imports (Low pass-through; "LCP", $\kappa_m = 0.9$)	6.53%	17.33%

Note: Table testing goodness-of-fit of model with respect to estimates from Section 5. Panel A reports the import demand elasticity $\tilde{\sigma}$ in the data compared to the model. Panel B reports the amount that the import buyer rigidity κ_r explains of the result in the data (in Table 4, the "difference" as a fraction of the low-import-buyer-rigidity estimate) versus the model. Panel A uses monthly calibration and Panel B accounts for falling κ_r over the 10-month horizon (i.e. comparing the 10 month counterparts: $(\kappa_r)^{10} = 0.95^{10} = 0.6$ and $(\kappa_r)^{10} = 0.8^{10} = 0.1$). Not accounting for the falling values (i.e. comparing $\kappa_r = 0.95$ to $\kappa_r = 0.8$) would imply in Column 3 a model explanatory power of 82.32% and 66.82% for US exports and US imports respectively. The average effect of a 15 percentage point change in κ_r in the model is 36.47% for US exports and 18.06% for US imports. Counterfactual analysis of the data using monthly calibration implies the critical value of $\kappa_r = 0.5$ to equate $\tilde{\sigma}$ across US exports and imports. In the model, $\kappa_r = 0$ is the critical value. 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 requests #11330 and #11645.

this calibration it approximates the import demand elasticities for both US imports and US exports within the respective confidence intervals of all estimated parameters. Note that the qualitative results are independent of calibration.

Moreover, note that the model improves relative to the standard $\kappa_r = 0$. Namely, this model better-matches point estimates and the differences across high and low κ_m. For $\kappa_r = 0$, the import demand elasticity is uniform and equal to the CES elasticity, i.e. $\tilde{\sigma} = \sigma = 5$ (as calibrated and independent of κ_m). Accordingly, regardless of directly matching exact point estimates this model improves relative to the standard.

However, the model understates the empirical magnitude of Corollary 1ii, i.e. that $|\frac{d\tilde{\sigma}}{d\kappa_r}|$ is decreasing in $\tilde{\kappa}_m$. Namely, in the model values of $\tilde{\sigma}$ as a function of both high and low values of κ_m are significantly decreasing in κ_r. In the data there is little effect for the former.

However, the model across all calibrations captures that κ_r has a larger effect on US exports than it does on US imports. Recall it is set to zero in the standard model.

Whether the model exacts empirical point estimates is dependent on calibration. However, the selected calibration is reasonably consistent given literature and estimated parameter values. Perhaps additional modifications to the model assumptions could improve fit.

7.2.2 Pass-through Persistence

In this subsection I consider how well the form of pass-through persistence in the model matches the empirical counterpart. The model well-matches the estimated $\tilde{\sigma}$, but the form of pass-through persistence should also match in data if it is indeed the correct mechanism. Is the model prediction that pass-through persistence is larger for LCP than PCP true in data? In this section, I show that the answer is yes.

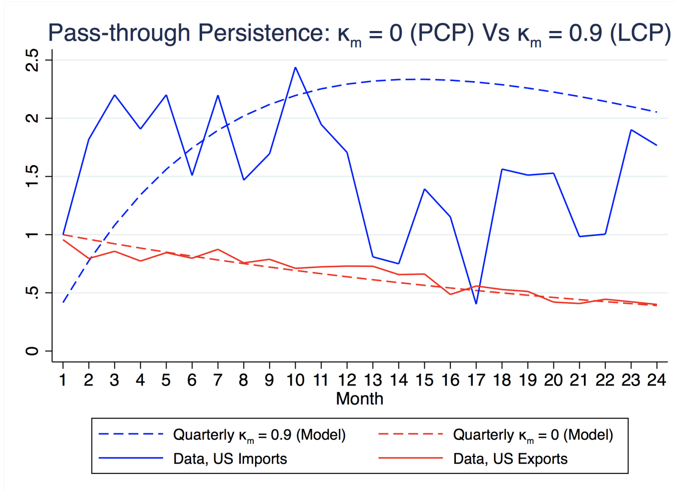
In Figure 3 I report the estimated pass-through persistence ρ_k^{PT} relative to the model-implied values. Pass-through persistence can simply be calculated as $\rho_k^{PT} = \frac{\nu_k}{\nu_0}, k > 0$, where ν_k and ν_0 are identified by the form of Equation 6.

Note that the relationship is not necessarily linear; the form is in Section 6. If $\rho > 0$ and $\kappa_m > 0$ it is hump-shaped, whereas there is no hump if either are zero. For some level of price stickiness, as shown earlier the exchange rate is not fully passed-on into trade prices at time t. Over time, more firms adjust their prices with respect to the exchange rate, and average pass-through increases. With some degree of exchange rate persistence, the time t exchange rate shock is correlated with the longer-horizon shocks. Accordingly, for some time the coefficient on the $t + k$ local projection of the t exchange rate shock may be larger than the contemporaneous pass-through, generating the hump shape. Figure 3 matches these predictions. The dashed lines contain the model predictions, and the solid lines contain data; blue represent LCP (i.e. $\kappa_m > 0$, US imports), and red represents PCP (i.e. $\kappa_m = 0$, US exports). The data well-reflect the model in two regards. First, they indicate that LCP is more pass-through persistent than PCP. Note that the area under the curves enter the import demand elasticity formula; it is thus clear in that lens how LCP would have a larger import demand elasticity.

Second, the data approximately (though not perfectly) reflect the model's predictions regarding the shape of aggregate pass-through persistence. Particularly, they capture the hump-shape for LCP relative to the consistent decay of PCP. However, the figure does not as well approximate the magnitude of the former's object. Note the model abstracts from wages, which may bias the simulated estimate of pass-through persistence upward for LCP.[23]

[23]Note that computing the import demand elasticity $\tilde{\sigma}$ as a function of pass-through persistence matches the qualitative empirical result, but better matches the empirical point estimates of $\tilde{\sigma}$ with a slightly lower

Figure 3: Pass-through Persistence



Note: This figure plots pass-through persistence as predicted by the model (dashed lines) and estimated in data (solid lines). The blue lines reflect $\kappa_m = 0.9$ monthly in simulation and US imports in estimation, and the red lines reflect $\kappa_m = 0$ in simulation and US exports in estimation. 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). This is a part of clearance request #11330.

In summary of this section, the model's pass-through persistence prediction matches the data. The qualitative predictions are exactly consistent. The model predicts that changing currency rigidities (PCP or LCP) while also changes the level of pass-through, also changes the persistence of pass-through. As a result, LCP is subject to a larger import demand elasticity than PCP. It is also a further strength of the model that it can approximate the quantitative shape of pass-through persistence in data.

7.3 Counterfactuals

In this section, I consider the general equilibrium implications of the paper's mechanism. Namely, how does the introduction of the import buyer rigidity change shock propagation for LCP relative to PCP? What are the welfare gains of switching currency invoicing regime in light of this new mechanism? US trade is PCP exports and LCP imports – how is expenditure-switching "different" for the US relative to an all-PCP economy, and also relative to conventional wisdom?

I first focus on the effectiveness of monetary policy, i.e. a negative shock to the Taylor rule for the domestic interest rate i_t via the exogenous Ψ^i_t. Expenditure-switching is the

$\kappa_r = 0.82$ (rather than 0.9) more closely following Nakamura and Steinsson (2008).

classical mechanism via which an interest rate-induced exchange rate fluctuation influences the macroeconomy. Recall the conventional wisdom is that relative to PCP, LCP mutes real GDP gains from monetary policy via a weaker expenditure-switching channel. The analysis in the following Section 7.3.1 tests how the paper's import buyer rigidity mechanism changes this conventional wisdom. Namely, I show that via this mechanism real GDP gains from expansionary monetary policy are greater under LCP than PCP.

After having explored robustness of the monetary policy result, the quantitative model can then generate a new insight regarding the nature of exchange rate policy. Classical thinking (i.e. Devereux and Engel (2003)) argued that given the pricing inefficiency the exchange rate should be managed under LCP but a free float under PCP. This paper has shown a new source of *quantity*-inefficiency which is greater for PCP than LCP. Accordingly, the classical justification for managing the exchange rate under LCP reverses.

I consider counterfactuals adjusting κ_m between 0 (PCP when considering exchange rate shocks) and 0.9 (consistent with the estimated monthly value in Section 7.1 for LCP); for $\kappa_r = 0.9$ versus $\kappa_r = 0$. I experiment with different interest rate shock persistences to approximate smoothing in a Taylor rule. In the following results I focus on a calibrated persistence of 0.5, but the analysis is not sensitive to that choice.

7.3.1 Monetary Policy

I focus on the impact of κ_m on the propagation of monetary policy. Recall the US has LCP imports (κ_m positive) and PCP exports ($\kappa_m = 0$), so I consider the counterfactual of changing imports to PCP given the model mechanism.[24] I consider outcomes: expenditure-switching and real GDP, with respect to the exchange rate change.[25] I define expenditure-switching as share of spending on domestic goods (domestic consumption plus net exports) divided by total spending (domestic consumption plus exports). Recall domestic consumption includes imported inputs, so the numerator (including net exports) captures only spending on domestic goods. I show later that the result is not sensitive to definition. I then show the resulting implications for real GDP as GDP_t defined in Section 6.

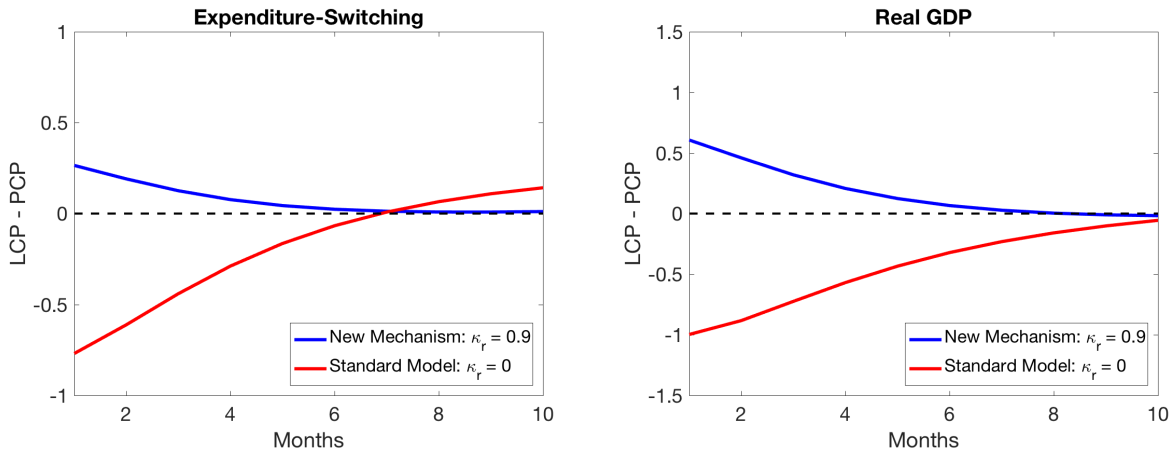
Each figure line reports the effect of the shock for LCP minus the effect of the shock for PCP, given high κ_r (blue) versus low κ_r (red). The difference-in-difference counterfactual structure helps control for the income effects in this framework.

Conventional wisdom says that the expenditure-switching channel and real GDP response of monetary policy is weaker under LCP (low pass-through) than PCP (high pass-through).

[24] I hold the domestic component of marginal costs rigid such that $\kappa_m = 0$ directly corresponds to PCP.

[25] Normalizing by the exchange rate fluctuation allows for a relative comparison in terms of magnitude, but the results are not sensitive to the normalization.

Figure 4: US Monetary Policy Counterfactual



Note: This figure simulates the propagation of a domestic interest rate cut on expenditure-switching (left) and real GDP (right), normalized by the exchange rate fluctuation. The blue lines represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the red lines $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).

I find the opposite. I show that in this framework ($\kappa_r = 0.9$) expenditure-switching and real GDP effects of monetary policy are amplified under LCP relative to PCP. Lowering κ_r to approximate a standard model generates conventional wisdom's opposite result, as substitution is large under PCP. Increasing κ_r mutes overall adjustment relative to the frictionless benchmark, but much more so for PCP.[26] Compared to PCP, given κ_r, under LCP there is greater substitution relative to inflationary effects, generating the new result.

7.3.2 Robustness

In this section I consider sensitivity to the quantitative analysis. I test an alternative shock (UIP), alternative calibrations, and alternative outcomes. First, the result is consistent for a UIP shock. In this framework a pure UIP shock induces an exchange rate fluctuation exogenous to the domestic economy. In this quantitative setting testing the propagation of a UIP shock is equivalent to testing the exchange rate's propagation.

It is also appropriate to consider further sensitivity to the calibration and assumptions of the quantitative model. I consider a range of alternative assumptions and how they could influence the main takeaway of this section. In particular, I consider the degree of openness in the economy. I consider alternative assumptions on the underlying substitution elasticity

[26] I report the level effects in Appendix Figure 23. Two things are of note to highlight. First, there are strong income effects in this framework yielding overall negative effects of an expansionary shock on expenditure-switching and real GDP. Recall the difference-in-difference structure "differences out" these income effects. Second, introducing the import buyer rigidity κ_r strongly dampens expenditure-switching under PCP, and only slightly dampens under LCP. This yields the results from Figure 4.

σ and on the domestic manufacturer's share h. The results are not sensitive to choice of σ or h.

Finally, I consider alternative outcomes. The result also applies to net exports and alternative definitions of expenditure-switching. These definitions include the domestic expenditure share excluding exports, domestic expenditure minus foreign expenditure as a share of GDP, and total domestic expenditure.

In summary, the results are not sensitive to type of shock, reasonable calibration assumptions, or outcomes chosen. Given the robustness of the monetary policy results, I consider implications for exchange rate policy in the next subsection.

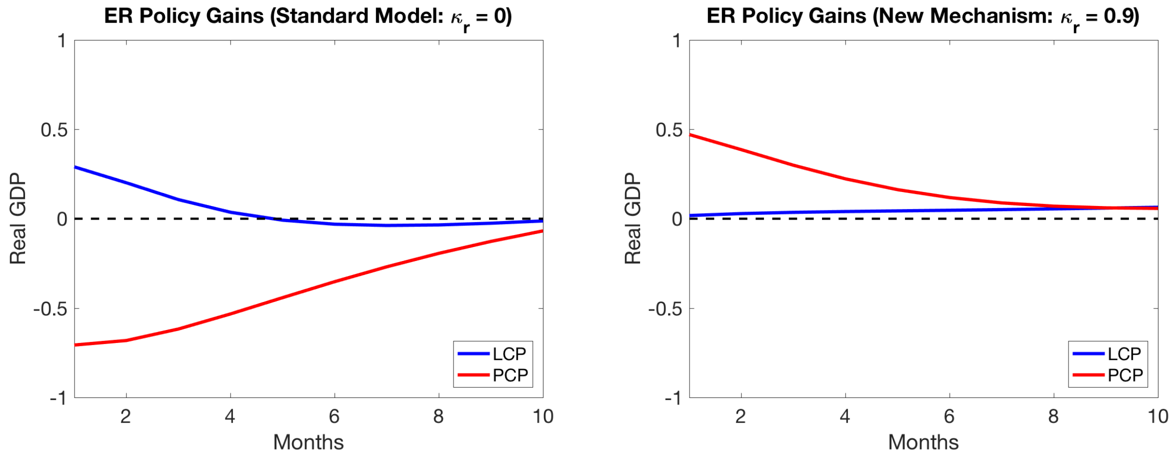
7.3.3 Exchange Rate Policy

The previous section presented and tested sensitivity of expenditure-switching and real GDP effects of monetary policy given the paper's import buyer rigidity mechanism. I now consider the role of exchange rate policy (managing the exchange rate with monetary policy). Devereux and Engel (2003) argue that LCP presents a pricing inefficiency rendering monetary policy less effective and justifying exchange rate management. Under PCP, there is no inefficiency so the exchange rate can free float. The previous section showed that monetary policy and other types of shocks are in fact more effective under LCP than PCP, as there is actually less of an inefficiency in the former. In particular, the import buyer rigidity κ_r introduces a wedge attenuating the import demand elasticity $\tilde{\sigma}$ relative to the CES elasticity σ. This wedge is larger under PCP than LCP: the PCP $\tilde{\sigma}$ is further from σ than the LCP $\tilde{\sigma}$ is. Therefore, this new demand-side inefficiency is larger under PCP than under LCP, so the optimal role of exchange rate policy may actually be different given this framework.

To test this, I incorporate the log exchange rate e_t into the Taylor rule. Under this system, when the exchange rate depreciates the domestic interest rate increases to offset it. Figure 5 reports the real GDP effects of a monetary policy shock, managing the exchange rate under LCP versus PCP. In the left exhibit I replicate the classical analysis that there are greater gains from exchange rate policy under LCP (blue line) than PCP (red line). In the right exhibit, I show that given the import buyer rigidity mechanism there are now actually relatively strong gains from managing the exchange rate under PCP.

As shown in the previous two subsections, the import buyer rigidity effect generates an inefficiency that causes an amplification of the LCP exchange rate's expenditure-switching effect relative to that of PCP. Accordingly, in contrast to conventional wisdom there is a greater role for exchange rate policy under PCP, not LCP.

Figure 5: Exchange Rate Policy



Note: This figure plots the simulation of the real GDP effects of a monetary policy shock when the exchange rate enters the Taylor rule, minus the simulated effect with a freely floating exchange rate. GDP is normalized by the size of the exchange rate fluctuation. The left figure plots the standard model approximation of $\kappa_r = 0$. The right figure plots the new mechanism, $\kappa_r = 0.9$. The blue lines represent the calibration of $\kappa_m = 0.9$ (LCP) and the red lines $\kappa_m = 0$ ($\approx PCP$).

8 Conclusion

Conventional wisdom states that low exchange rate pass-through mutes the expenditure-switching channel relative to the high pass-through benchmark. This paper studies the relationship between exchange rate pass-through and expenditure-switching, generating a conclusion contrary to the conventional wisdom. The analysis exploits dollar pricing in the US, in which there is producer currency pricing (PCP) in exports yielding high pass-through and local currency pricing (LCP) in imports yielding low pass-through. Leveraging confidential US micro-data and a macroeconometric technique applied to panel data, I find that the quantity-exchange rate elasticities across US imports and exports do not reflect the pass-through differences. The main analysis, along with the sensitivity analysis, implies that low pass-through is subject to a higher import demand (quantity-price) elasticity than high pass-through. In contrast, the conventional wisdom requires that this elasticity is independent of pass-through. The empirical analysis in this paper is evidence for the contrary.

I explain the results by adding a layer of importing firms with sticky prices, which I refer to as import buyer rigidities, into a small open economy New Keynesian model. Given import buyer rigidities, the importer responds only partially to trade price changes; the import demand elasticity is always dampened relative to the frictionless household demand parameter. However, because she adjusts depending on the path of trade prices, the importer will respond relatively more when the trade price change is more persistent. Given that low pass-through is more persistent than high pass-through, in contrast to conventional wisdom the import demand elasticity is relatively larger in response to low pass-through.

The model also well-approximates the estimated import demand elasticities and the empirical role of the import buyer rigidity. In addition, in the empirical analysis I also provide evidence for this mechanism, both import buyer rigidities and pass-through persistence. In the latter case, I show both descriptive evidence that low pass-through is more persistent, and also later verify the model's form of pass-through persistence.

Given the empirical validity of the model, I consider its implications for monetary and exchange rate policies. Contrary to conventional wisdom, I find a weaker expenditure-switching channel, and accordingly weaker real GDP effects of monetary policy, under high pass-through. Given dampening, low pass-through improves the output-inflation tradeoff relative to high pass-through. Moreover, this paper presents a new result regarding exchange rate policy. I show that there is a greater role for managing the exchange rate under high pass-through, rather than the traditionally considered low pass-through. This is because this framework introduces a new demand-side inefficiency which distorts the propagation of high pass-through more than that of low.

Future work could further consider how the import buyer rigidity might apply to the incidence of tariffs, resolve the International Elasticity Puzzle, or provide new insights to domestic adjustment. It would also be interesting to consider alternatives to the import buyer rigidity that generate heterogeneity in quantity-price elasticities. One possibility would be the sluggish demand mechanism in Auclert et al. (2024). In addition, this paper's result regarding exchange rate policy – that there is a greater distortion to correct under high pass-through – could be further explored. In particular, it would be interesting consider the general issue of optimal exchange rate policy given this demand-side inefficiency.

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A Empirical Appendix

A.1 Methodology

A.1.1 Conventional Pass-through Method

The conventional strategy in international macroeconomics pass-through literature is to regress prices on the contemporaneous and lags of the exchange rate shock. The summation of the coefficients of the lag terms represent the dynamic effect of the exchange rate on prices or quantities. The advantage of such an approach is that it identifies the effect of a single exchange rate shock over time. One can then analyze, for example, the pass-through rate of a contemporaneous exchange rate shock into prices at future time horizons. The method is given formally by

$$\Delta_0 o_t = \sum_{s=0}^{N} \alpha_1^s \Delta_0 e_{t-s} + \sum_{s=0}^{N} \zeta_1^s \Delta_0 v_{t-s} + \varepsilon_{1,t}. \tag{57}$$

The cumulative sum of $\sum_{s=0}^{k} \alpha_1^s$ is interpreted as the k-horizon elasticity. Depending on availability, controls typically include PPI, GDP, and fixed effects (depending on sample: a mixture of firm, product, country, and time). This specification has been standard in price pass-through estimation given $Cov(p_t^m, v_t)$ and $\hat{\alpha}_2^p$ are thought to be low due to nominal rigidities. Accordingly, there is a clear interpretation and small endogeneity concerns. Equation 57 is more problematic for quantity estimation given $Cov(q_t^m, v_t) > Cov(p_t^m, v_t)$ and $\hat{\alpha}_2^q > \hat{\alpha}_2^p$. I discuss how in the rest of this section.

There are two key problems with Equation 57. First, given the reduced-form nature of the specification the structural interpretation is ambiguous. Second, there are significant endogeneity concerns. On the first point, the interpretation of the k-horizon cumulative effect is not directly "the k-horizon influence of the exchange rate on the outcome." Rather, it is "the k-horizon influence of the exchange rate on the outcome holding fixed correlated contemporaneous factors." Using contemporaneous controls $\sum_{s=0}^{N} \Delta_0 v_{t-s}$ results in elasticities which not capture how the exchange rate influences trade prices or quantities via aggregate price levels or aggregate demand channels.

The simultaneity bias of the exchange rate comes from simultaneity with the specified outcome α_2^s and correlation between confounding shocks, the outcome, and the exchange rate, as in

$$\Delta_0 e_{t-s} = \alpha_2^s \Delta_0 o_t + \zeta_2 \Delta_0 v_t + \varepsilon_{2,t}^s. \tag{58}$$

For $s = 0$, the simultaneity with respect to the outcome $\Delta_0 o_t$ is again α_2. Then, for $s > 0$, the simultaneity with respect to $\Delta_0 o_t$ is proportional to the serial correlation in $\vec{o}$:

$\alpha_2^s \propto \alpha_2 \frac{\Delta_0 \vec{o}_{t-s}}{\Delta_0 o_t}$.

Additional simultaneity bias from imperfect controls depends on the serial correlation in the corresponding shocks. Accordingly, the realized simultaneity bias for each lag $s \in 0, ..., N$ is

$$\hat{\alpha}_2^s \propto \alpha_2 \frac{\Delta_0 \vec{o}_{t-s}}{\Delta_0 o_t} + \zeta_2 \frac{\Delta_0 v_t}{\Delta_0 o_t} \frac{\Delta_0 v_{t-s}}{\Delta_0 v_t}. \tag{59}$$

The endogeneity in the cumulative elasticity is the *sum* of the omitted variables and simultaneity biases in each lag. This bias starts at the level as described in Section 4.1 and accumulates (though likely at a decaying rate) with each lag.[27]

A.1.2 Asymmetry Bias

Using an extension of the model from Section 6, where import buyers purchase a CES aggregate of intermediates now asymmetrically influenced by the exchange rate, I plot the bias due to asymmetry across US imports and US export estimation. The concern is that while the firm-product-time fixed effect controls for the CES price index in US imports, it cannot capture the foreign firm's import price index in US exports. Using the model structure I simulate the bias in the resulting coefficient.

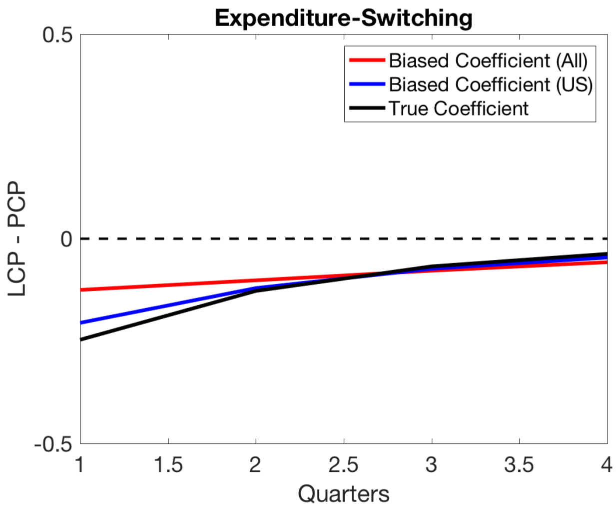
I calibrate the red line to reflect the dollar's share of world trade, and the blue line to account for the US share of world trade. The red line may over-state the bias because it also includes dominant currency (third-party) pricing and fully dollarized economies, and the blue line may under-state as it only includes US trade. Within those bounds, however, the bias cannot explain the import demand elasticity heterogeneity found in Section 5.

Also note a few additional sources of robustness. First, in Table 3 adding and removing controls does not meaningfully change the point estimate of the import demand elasticity. These controls, such as GDP, PPI, and tariffs, are correlated with the importer's price index, suggesting bias from the importer's price index is small. Moreover, in terms of asymmetry note a specification with only a time fixed effect and exchange rate lags still yields substantial import demand elasticity heterogeneity (0.5131 for US imports versus 0.1701 for US exports).[28] Finally, tariff-based import demand elasticities as discussed in Section 5.2 are

[27] One solution to this problem would be to also include outcome lags as controls. The idea is that this would address any correlation between the exchange rate lags $\Delta_0 e_{t-s}, s > 0$ and contemporaneous outcome $\Delta_0 o_t$. However, such a specification is not ideal either. First, it would be necessary to control for as many lags of the outcome as lags of the exchange rate. This is plausible, but may be impractical. Furthermore, the contemporaneous exchange rate shock (i.e. $s = 0$) is still biased. Also, it is then hard to compare pass-through to import demand elasticities because they would be specified differently. Finally and importantly, including outcome lags would not address imperfect controls. This is because the outcome lags address serial correlation in the outcome, not the serial correlation in the correlated shocks.

[28] 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

Figure 6: Asymmetric Specification: Bias Simulation



Note: Figure 6 simulates the change in the import demand elasticity due to not accounting for the CES price index. The red line calibrates for the world average import share to GDP (30%, from World Bank (2024)) multiplied by the share of world trade invoiced in dollars (50%, from Maronoti (2022)). The blue line calibrates for US exports' share of world GDP which is approximately 4% (World Bank (2023)).

much more similar across US exports and US imports despite the same asymmetry bias.

In summary, empirical sensitivity suggests that this bias is small, and model simulations from Figure 6 show that even if it were large it would not be large enough to drive the observed $\tilde{\sigma}$ heterogeneity.

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

A.2 Summary Statistics

Table 7: Summary Statistics

	(1) US Exports	(2) US Imports
Panel A: 10-Month Values		
$\Delta^{10} q_{nt}^{m}$	-0.07473	-0.0758
	(1.417)	(1.298)
$\Delta^{10} p_{nt}^{m}$	0.06568	0.008591
	(0.9221)	(0.008591)
$\Delta^{10} e_{jt}$	0.04452	-0.03315
	(0.1061)	(0.08591)
Panel B: Contemporaneous Exchange Rate Shock		
$\Delta_0 e_{jt}$	0.004285	-0.003189
	(0.02722)	(0.02208)

Note: Summary statistics of monthly US export (left) and US import (right) samples. Means and standard errors (parentheses) reported. Panel A reports 10-month constructed changes as described in the text, and Panel B reports the contemporaneous exchange rate shock. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and US 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-R11330). This is a part of clearance requests #11330 and #11645.

A.3 Estimation Appendix

A.3.1 Specification Robustness

Table 8: Exchange Rate Pass-through: Specification Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
Exports "PCP"	0.9288***	0.9659***	0.9832***	0.9859***	0.974***	0.9689***
	(0.07378)	(0.0864)	(0.08938)	(0.08931)	(0.08912)	(0.08558)
N	1041000	863000	800000	800000	817000	800000
Imports "LCP"	0.2237***	0.2704***	0.285***	0.3111***	0.3306***	0.2857***
	(0.0672)	(0.064760)	(0.06205)	(0.06304)	(0.06646)	(0.06357)
N	2347000	2211000	1958000	1958000	1997000	1958000
FE	Y	Y	Y	Y	Y	Y
Exchange Rate Lags (11)	Y	Y	Y	Y	Y	Y
Demand, Supply (12)	N	Y	Y	Y	Y	Y
PPI, GDP (12)	N	N	Y	Y	Y	Y
Tariffs (12)	N	N	N	Y	Y	Y
Lags Only (11)					Y	
Lags Outcome (11)						Y

Note: Price-exchange rate "pass-through" elasticities $\frac{\nu}{\rho}$; 10-month exchange rate projection instrumented with the contemporaneous exchange rate shock. Estimated for US imports relative to US exports. All standard errors clustered by HS product and partner country. Equation 6 is the reduced form and Equation 8 is the first stage. Column 1 includes a time fixed effect, 11 lags (corresponding to a year of changes) of exchange rate shocks, a firm-product-time fixed effect, and a firm-country-sector fixed effect. Column 2 adds a country PPI shock control (contemporaneous and 11 lags) in US imports and a country GDP shock control (contemporaneous and 11 lags) in US exports. Column 3 adds GDP for US imports and PPI for US exports. Column 4 adds tariff shocks (contemporaneous and 11 lags) and corresponds to the full specification in Equation 6 and 8 and Table 1. Column 5 removes contemporaneous controls from the full instrumental-variables specification implied by Equations 6 and 8. Column 6 adds lags of log quantities to the full specification. All coefficients 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-R11330, CBDRB-FY24-P2874-R11608, CBDRB-FY24-P2874-R11645, and CBDRB-FY24-P2874-R11894). This is a part of clearance requests #11330, #11608, #11645, and #11894. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

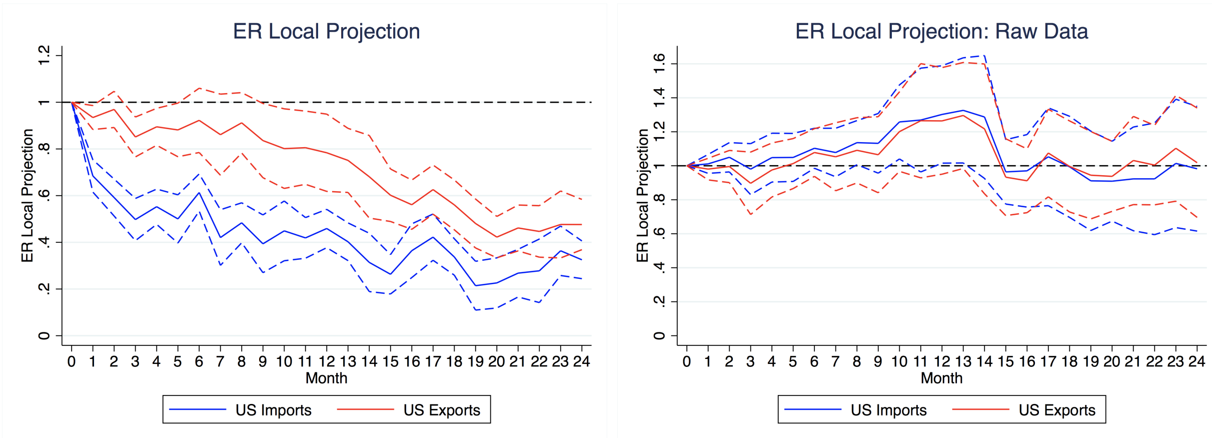
Table 9: Quantity-Exchange Rate Elasticity: Specification Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
Exports "PCP"	-0.3502**	-0.4111**	-0.3935**	-0.3936**	-0.3586**	-0.3559**
	(0.1487)	(0.1955)	(0.1776)	(0.1777)	(0.1748)	0.1666
N	1041000	863000	800000	800000	817000	800000
Imports "LCP"	-0.2282	-0.3577	-0.5581**	-0.5321**	-0.6105**	-0.3762*
	(0.3028)	(0.3212)	(0.2071)	(0.2189)	(0.2362)	(0.2096)
N	2347000	2211000	1958000	1958000	1997000	1958000
FE	Y	Y	Y	Y	Y	Y
Exchange Rate Lags (11)	Y	Y	Y	Y	Y	Y
Demand, Supply (12)	N	Y	Y	Y	Y	Y
PPI, GDP (12)	N	N	Y	Y	Y	Y
Tariffs (12)	N	N	N	Y	Y	Y
Lags Only (11)					Y	
Lags Outcome (11)						Y

Note: Quantity-exchange rate elasticities $\frac{\gamma}{\rho}$; 10-month exchange rate projection instrumented with the contemporaneous exchange rate shock. Estimated for US imports relative to US exports. All standard errors clustered by HS product and partner country. Equation 7 is the reduced form and Equation 8 is the first stage. Column 1 includes a time fixed effect, 11 lags (corresponding to a year of changes) of exchange rate shocks, a firm-product-time fixed effect, and a firm-country-sector fixed effect. Column 2 adds a country PPI shock control (contemporaneous and 11 lags) in US imports and a country GDP shock control (contemporaneous and 11 lags) in US exports. Column 3 adds GDP for US imports and PPI for US exports. Column 4 adds tariff shocks (contemporaneous and 11 lags) and corresponds to the full specification in Equation 7 and 8 and Table 2. Column 5 removes contemporaneous controls from the full instrumental-variables specification implied by Equations 7 and 8. Column 6 adds lags of log quantities to the full specification. All coefficients 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-R11330, CBDRB-FY24-P2874-R11608, CBDRB-FY24-P2874-R11645, and CBDRB-FY24-P2874-R11894). This is a part of clearance requests #11330, #11608, #11645, and #11894. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.3.2 Exchange Rate Variation

Figure 7: Exchange Rate Local Projections



Note: Exchange rate autoregressive local projection coefficients ρ_k estimated for $k = 1, ..., 24$ horizon changes. The left reflects the full specification with controls from Equation 8, corresponding to analysis in Tables 1 and 2, and Column 4 of Table 3. The right is a sparse specification in raw data (i.e. not restricted to control availability) with only a time fixed effect and 11 exchange rate lag shock controls (corresponding to a year of changes). US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-11894). This is a part of clearance request #11894.

Table 10: Exchange Rate Variation

	(1)	(2)	(3)	(4)	(5)	(6)
Exports "PCP"	1.083***	0.8114***	1.135***	0.9104***	0.8256***	0.8014***
	(0.07755)	(0.09101)	(0.07417)	(0.06585)	(0.0676)	(0.08698)
N	2075000	2075000	1045000	1045000	1041000	800000
Imports "LCP"	1.162***	0.916***	0.6944***	0.5359***	0.4881***	0.4491***
	(0.09024)	(0.09943)	(0.07103)	(0.05755)	(0.05297)	(0.06527)
N	3905000	3905000	2349000	2349000	2347000	1958000
Exchange Rate Lags (11)	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Country FE	N	Y	N	Y	Y	Y
Firm-product-time FE	N	N	Y	Y	Y	Y
Firm-country-sector FE	N	N	N	N	Y	Y
Controls	N	N	N	N	N	Y

Note: Exchange rate local projections ρ: 10-month exchange rate projection regressed on the contemporaneous exchange rate shock. Estimated for US imports relative to US exports. All standard errors clustered by HS product and partner country. Equation 8 is the estimating equation. Column 1 includes a time fixed effect and 11 lags (corresponding to a year of changes) of exchange rate shocks. Column 2 adds a country fixed effect. Relative to Column 1, Column 3 includes a firm-product-time fixed effect. Column 4 adds a country fixed effect to the Column 3 specification. Column 5 adds a firm-country-sector fixed effect. Column 6 corresponds to the full specification with firm-product-time and firm-country-sector fixed effects and current and 11 lags of PPI, GDP, and tariff shock controls in Equation 8. 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, CBDRB-FY24-P2874-R11608, CBDRB-FY24-P2874-R11645, and CBDRB-FY24-P2874-R11894). This is a part of clearance requests #11330, #11608, #11645, and #11894. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Exchange Rate Variation: Raw Data

	(1)	(2)	(3)
Exports "PCP"	1.201***	0.8956***	0.5875***
	(0.1193)	(0.1373)	(0.09859)
N	3322000	2577000	2572000
Imports "LCP"	1.258***	0.8144***	0.5639***
	(0.1112)	(0.1263)	(0.0963)
N	5052000	4063000	4061000
Exchange Rate Lags (11)	Y	Y	Y
Time FE	Y	Y	Y
Firm-product-time FE	N	Y	Y
Firm-country-sector FE	N	N	Y

Note: Exchange rate local projections ρ: 10-month exchange rate projection regressed on the contemporaneous exchange rate shock. Estimated for US imports relative to US exports, in the raw sample without restricting to control availability. All standard errors clustered by HS product and partner country. Equation 8 is the estimating equation. Column 1 includes a time fixed effect and 11 lags (corresponding to a year of changes) of exchange rate shocks. Column 2 includes a firm-product-time fixed effect. Column 3 adds a firm-country-sector fixed effect. 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-R11608, CBDRB-FY24-P2874-R11645, and CBDRB-FY24-P2874-R11894). This is a part of clearance requests #11608, #11645, and #11894. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

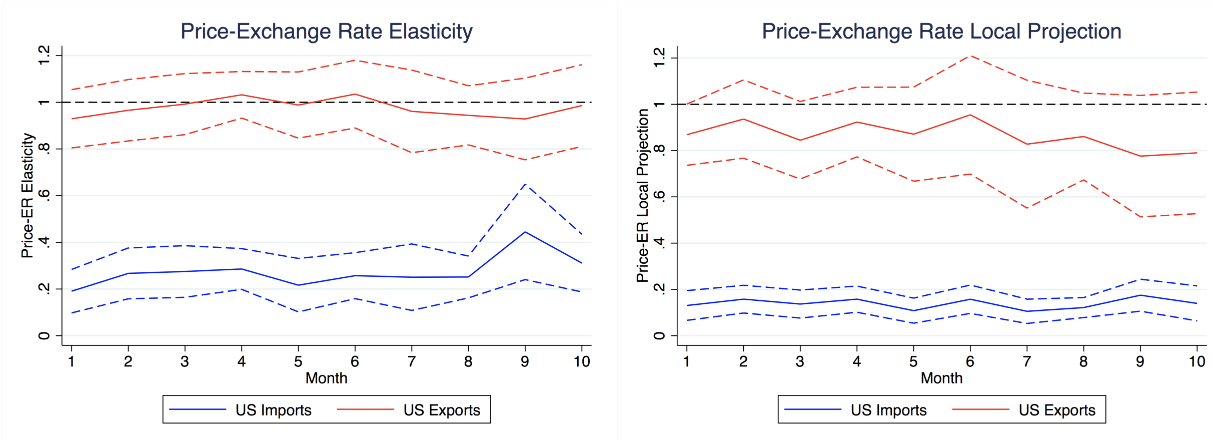
Table 12: Import Demand Elasticity: Raw Data

	(1)	(2)	(3)
Exports "PCP"	-0.1701**	0.1338	0.2713
	0.06014	(0.1605)	(0.2522)
N	3322000	2577000	2572000
Imports "LCP"	-0.5131	-1.427	-1.514
	(0.5911)	(1.371)	(1.509)
N	5052000	4063000	4061000
Exchange Rate Lags (11)	Y	Y	Y
Time FE	Y	Y	Y
Firm-product-time FE	N	Y	Y
Firm-country-sector FE	N	N	Y

Note: Import demand (quantity-price) elasticity $-\tilde{\sigma} : \frac{\gamma}{\nu}$; 10-month price rate projection instrumented with the contemporaneous exchange rate shock. Estimated for US imports relative to US exports, in the raw sample without restricting to control availability. All standard errors clustered by HS product and partner country. Equation 8 is the estimating equation. Column 1 includes a time fixed effect and 11 lags (corresponding to a year of changes) of exchange rate shocks. Column 2 includes a firm-product-time fixed effect. Column 3 adds a firm-country-sector fixed effect. All coefficients reflect a strong first-stage except Column 1 for US imports, which is weakly identified (Kleibergen-Paap F-statistic = 8.515). 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-R11608, and CBDRB-FY24-P2874-R11645). This is a part of clearance requests #11608 and #11645. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

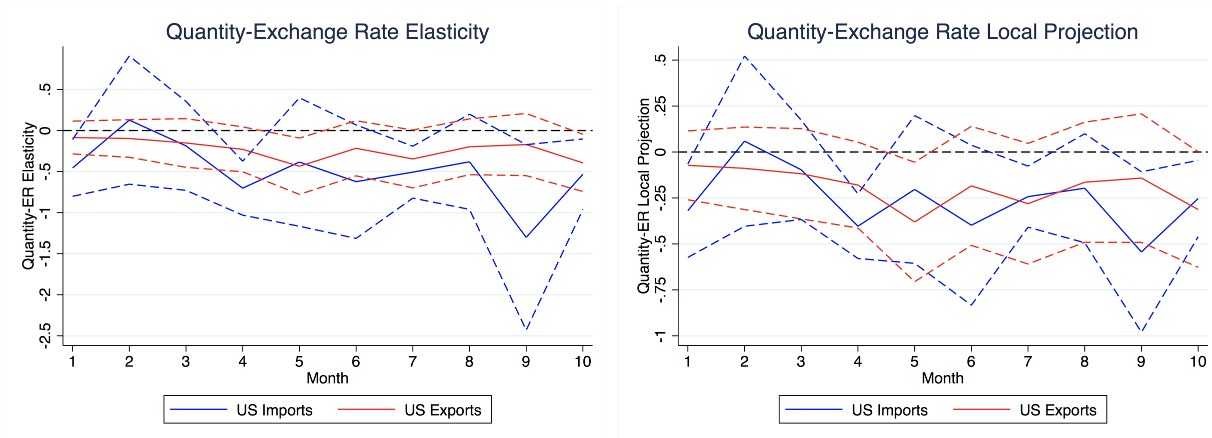
A.3.3 Dynamics

Figure 8: Price Elasticities over Different Horizons



Note: Price-exchange rate elasticity $\frac{\nu_k}{\rho_k}$ (left) and price local projection ν_k (right) estimated for $k = 1, ..., 10$ horizon changes. The left uses Equation 6 as the reduced form and Equation 8 as the first stage, and the right estimates Equation 6. US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-R11330). This is a part of clearance request #11330.

Figure 9: Quantity Elasticities over Different Horizons



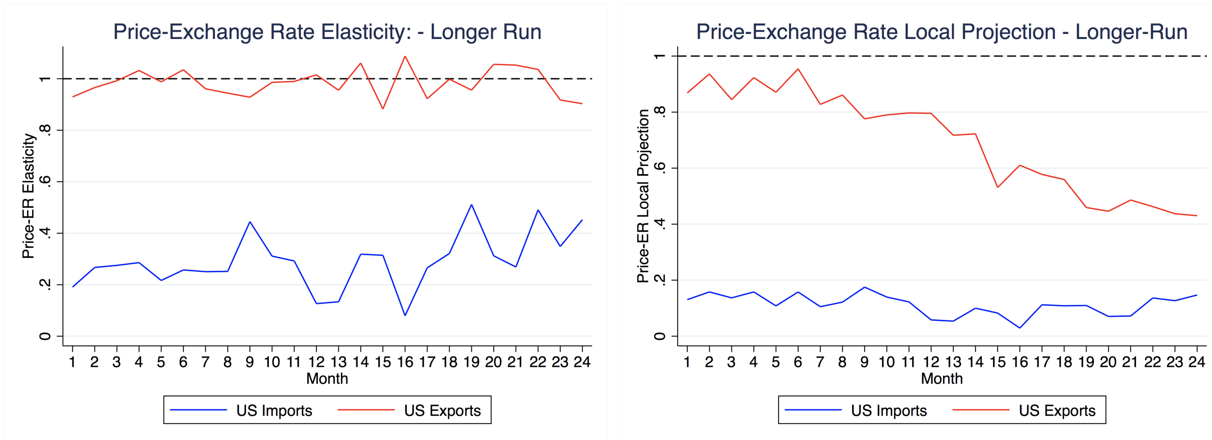
Note: Quantity-exchange rate elasticity $\frac{\gamma_k}{\rho_k}$(left) and quantity local projection γ_k (right) estimated for $k = 1, ..., 10$ horizon changes. The left uses Equation 7 as the reduced form and Equation 8 as the first stage, and the right estimates Equation 7. US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-R11330). This is a part of clearance request #11330.

Figure 10: Import Demand Elasticities over Different Horizons

Note: Import demand (quantity-price) elasticities $-\tilde{\sigma}_k = \frac{\gamma_k}{\nu_k}$ estimated for $k = 1, ..., 10$ horizon changes. Equation 7 is the reduced form and Equation 6 is the first stage. 95% confidence intervals reported. Large green dots represent k-horizon estimates which are distinct across US imports and US exports at the 5% level, and small blue dots reflect the 10% distinction. 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). This is a part of clearance request #11330.

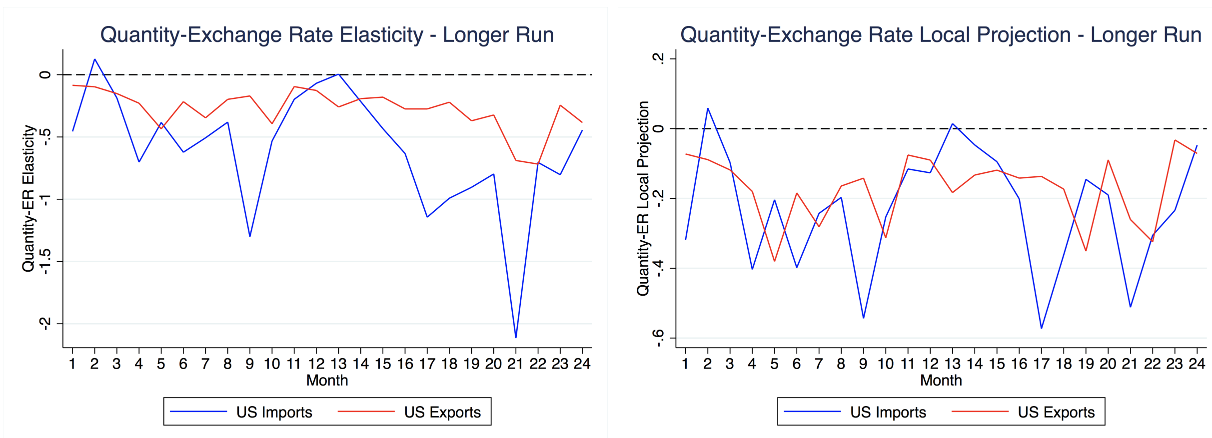
A.3.4 Longer-Run Results

Figure 11: Price-Exchange Rate Dynamics - Longer-Run (24 Months)



Note: Price-exchange rate elasticity $\frac{\nu_k}{\rho_k}$ (left) and local projection ν_k (right) estimated for $k = 1, ..., 24$ horizon changes. The left uses Equation 6 as the reduced form and Equation 8 as the first stage, and the right estimates Equation 6. US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-R11330). This is a part of clearance request #11330.

Figure 12: Quantity-Exchange Rate Dynamics - Longer-Run (24 Months)



Note: Quantity-exchange rate elasticity $\frac{\gamma_k}{\rho_k}$ (left), and local projection γ_k (right) estimated for $k = 1, ..., 24$ horizon changes. The left uses Equation 7 as the reduced form and Equation 8 as the first stage, and the right estimates Equation 7. US exports plotted in red and US imports plotted in blue. 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-FY24-P2874-R11330). This is a part of clearance request #11330.

A.3.5 Import Buyer Rigidity Robustness

Prices.

Table 13: Import Buyer Rigidity: Prices

	(1) US Exports "PCP"	(2) US Imports "LCP"
Low	0.9693***	0.2928***
	(0.09296)	(0.06489)
High	0.9556***	0.3954***
	(0.167)	(0.1005)
Difference	-0.01366	0.1027
	(0.1577)	(0.09284)
Firm-product-time	Y	Y
Firm-partner-sector	Y	Y
PPI, GDP, Tariff	Y	Y
Lag Controls (11)	Y	Y
N	505000	1957000

Note: Price-exchange rate elasticities $\frac{\nu_k}{\rho_k}$ 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 6 is the reduced form and Equation 8 is the first stage. 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. 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Construction.

Table 14: 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 7 is the reduced form and Equation 8 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Continuous.

Table 15: 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 7 is the reduced form and Equation 6 is the first stage. 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.

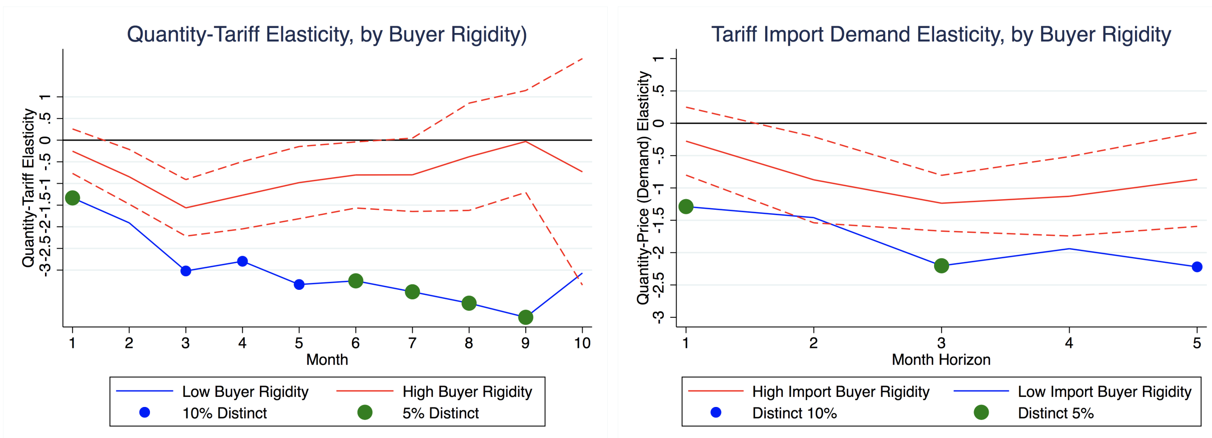
Tariffs as Benchmark.

Table 16: Import Buyer Rigidity: Tariff-Based Elasticities, US Imports

	(1) Low (0.8)	(2) High (0.95)
Firm-specific	-3.068*	-0.7311
	(1.597)	(1.334)
N	316000	684000
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 7 is the reduced form and 8 is the first stage, but using tariffs as the shock instead of exchange rates, 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). The top row reports heterogeneity analysis using LFTTD firm-aggregated bins, and the bottom row reports 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

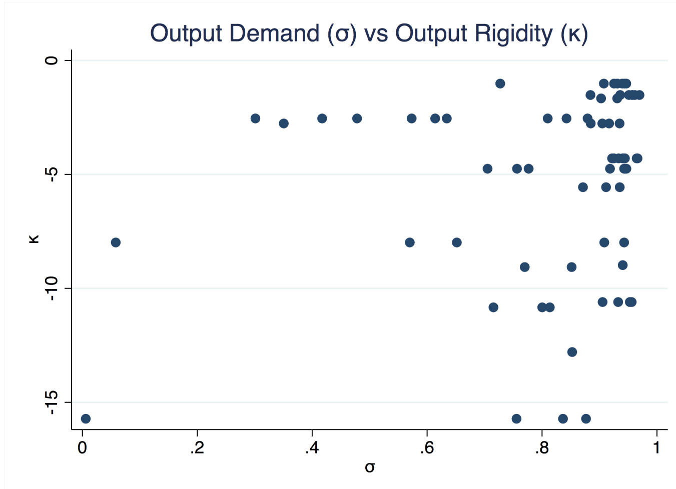
Figure 13: Tariff-Based Elasticities by Import Buyer Rigidity, US Imports



Note: Quantity-tariff (left, $\frac{\gamma_k}{\rho_k}$) and tariff-based quantity-price elasticities (right, $\frac{\gamma_k}{\nu_k}$) estimated for $k = 1, ..., 10$ horizons. Equation 7 is the reduced form, 8 is the first stage in the left exhibit, and 6 is the first stage in the right exhibit, but using tariffs as the shock instead of exchange rates, and including a country-time fixed effect. The analysis is split by above- and below-median import buyer rigidity. The above-median monthly import buyer rigidity is on average 0.8002 and the below-median monthly import buyer rigidity is on average 0.9448. 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). This is a part of clearance request #11330.

Demand Elasticity and Rigidity Correlation.

Figure 14: Import Buyer Rigidity and Final Demand Elasticity Correlation

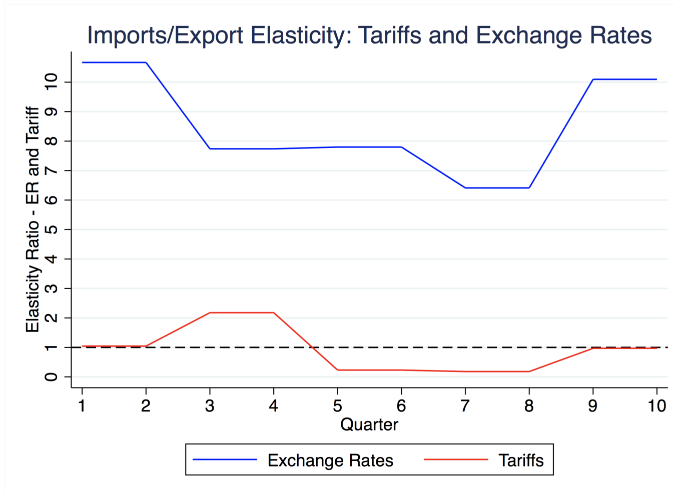


Note: This binscatter figure plots output demand elasticities relative to output price rigidities. The figure uses sector-level demand elasticities from Caliendo and Parro (2014) and information on price stickiness from Nakamura and Steinsson (2008). The price rigidity is a Calvo probability of holding prices constant, between 0 and 1; the demand elasticity is negative, so moving vertically upward in the graph implies a decrease in demand elasticity. I drop Sector 3241 (Petroleum and Coal Products Manufacturing) because it is estimated in Caliendo and Parro (2014) to have an outlier $\sigma = -51.085$ (the average otherwise is -5.23).

A.3.6 Alternative Interpretations Appendix

Underlying Demand Elasticities.

Figure 15: Import/Export Ratio of Import Demand Elasticities



Note: Import demand (quantity-price) elasticities $\frac{\gamma_k}{\nu_k}$ estimated using contemporaneous exchange rate (blue line) and tariff (red line) shocks as instruments respectively. Each point corresponds to the exchange rate- or tariff-identified elasticity of US imports divided by that of US exports. The estimation horizon varies from $k = 1, ..., 10$, where $k = 10$ corresponds to the benchmark analysis in Table 2. The estimating equations correspond to Equation 7 as the reduced form and Equation 6 as the first stage. The red line uses those equations but with tariffs as the shock and a country-time fixed effect. Coefficients are binned within two-month groups. 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). This is a part of clearance request #11330.

Product Composition.

Table 17: Product Sampling Robustness - Restricted Sample

	(1) US Exports "PCP"	(2) US Imports "LCP"
γ_4/ν_4	-0.1797	-1.924***
	(0.142)	(0.4142)
Firm-product-time	Y	Y
Firm-partner-sector	Y	Y
PPI, GDP, Tariff	Y	Y
Lag Controls (11)	Y	Y
N	541000	796000

Note: Sample restricted to only products present in both US imports and US exports. Import demand (quantity-price) elasticity $\frac{\gamma_k}{\nu_k}$ estimated for $k = 4$ month horizon, instrumented with the contemporaneous exchange rate shock. Equation 7 is the reduced form and Equation 6 is the first stage. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and US 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-R11330). This is a part of clearance request #11330. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

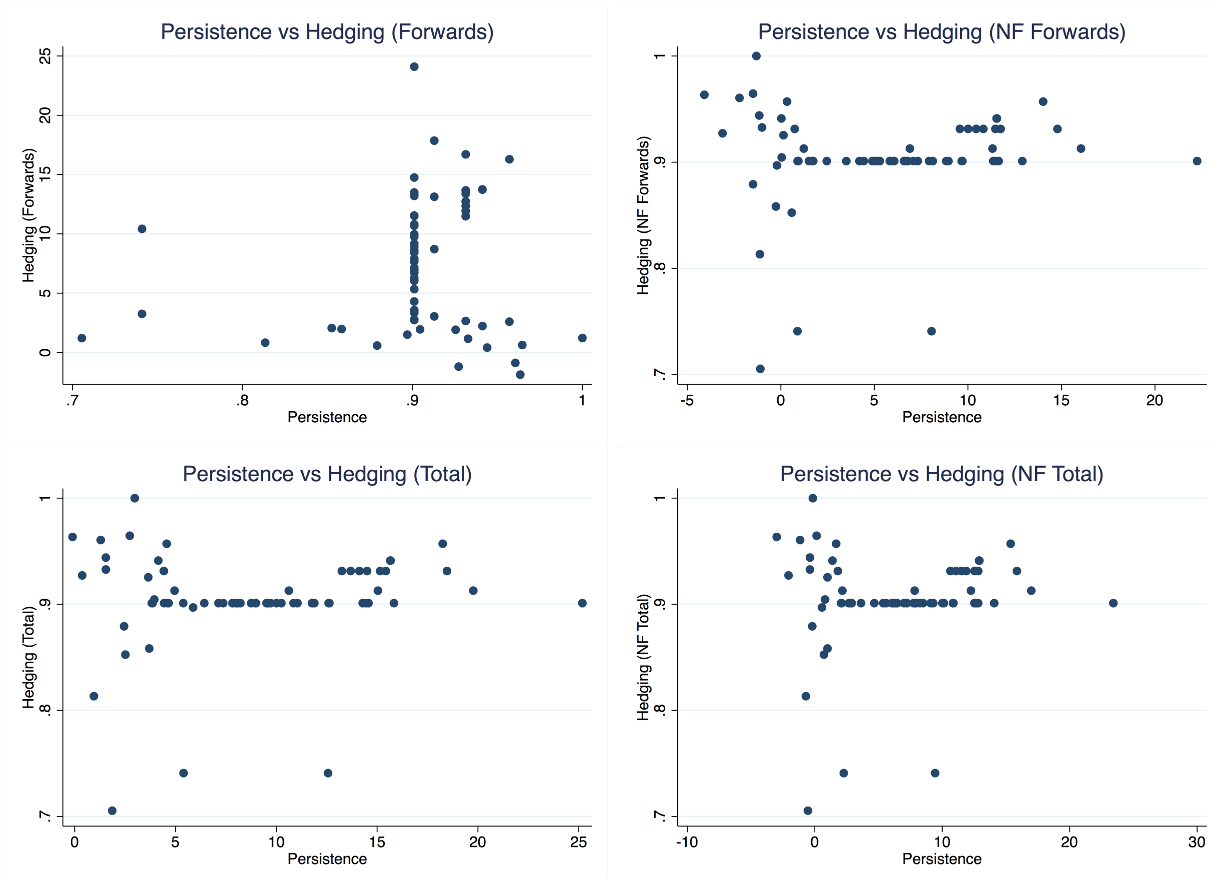
Table 18: Product Sampling Robustness - Interaction

		(1) US Exports "PCP"	(2) US Imports "LCP"
Panel A:	**Prices**		
Sample only		1.015***	0.2952***
		(0.1227)	(0.07125)
Both effect		-0.04537	0.0391
		(0.1221)	(0.06946)
Panel B:	**Quantities**		
Sample only		-0.3427	-0.4774**
		(0.2613)	0.208
Both effect		-0.07925	-0.1347
		(0.2141)	(0.1513)
Firm-product-time		Y	Y
Firm-partner-sector		Y	Y
PPI, GDP, Tariff		Y	Y
Lag Controls (11)		Y	Y
N		800000	1958000

Note: Price-exchange rate and quantity-exchange rate elasticities $\frac{\nu_k}{\rho_k}$ and $\frac{\gamma_k}{\rho_k}$ estimated for $k = 10$ month horizon. 10-month exchange rate instrumented with the contemporaneous exchange rate. In Panel A, Equation 6 is the reduced form and 8 is the first stage. In Panel B, Equation 7 is the reduced form and 8 is the first stage. In each specification there is an interaction term for whether the product is present in both US imports and exports. The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and US 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Exchange Rate Hedging.

Figure 16: Persistence Versus Exchange Rate Hedging



Note: Scatterplots of four measures of exchange rate hedging relative to exchange rate persistence. The data were extracted from the Bank of International Settlements (BIS) Triennial Central Bank Survey for the year 2013 for 68 countries. The data reflect hedging activity of each currency and the US dollar. The top left reflects forward contracts, the top right forward contracts for nonfinancial customers, bottom left all hedging contracts, and bottom right all hedging contracts for nonfinancial customers. All measures are weighted by total US exports to that country in the year 2013. The correlation between forward contracts and persistence is 0.08 (persistence bins -0.01); nonfinancial forward contracts and persistence is 0.09 (persistence bins -0.02); total contracts and persistence is 0.1 (persistence bins 0.04); and nonfinancial total contracts 0.1 (persistence bins -0.02). The correlations range between -1 and 1, with values closer to zero reflecting lack of correlation.

Table 19: Hedging Control

	(1) US Exports "PCP"	(2) US Imports "LCP"
γ_k/ν_k, $k=4$	-0.2471	-2.515**
	(0.1614)	(0.7833)
N	686000	1839000
γ_k/ν_k, $k=10$	-0.3015	-2.061*
	(0.235)	(1.062)
N	642000	170400
Hedging Control	Y	Y
Firm-product-time	Y	Y
Firm-partner-sector	Y	Y
PPI, GDP, Tariff	Y	Y
Lag Controls (11)	Y	Y

Note:Import demand elasticity $\frac{\gamma_k}{\nu_k}$ estimated for $k=4$ horizon (top) and $k=10$ horizon (bottom), instrumented with the contemporaneous exchange rate shock. Equation 7 is the reduced form and Equation 6 is the first stage. All columns interact the price change with country hedging activity from the Bureau of International Settlements (BIS). The analysis is constructed with confidential US Longitudinal Firm Trade Transactions Database (LFTTD) for US exports and US imports. All first-stage F-statistics for the $k=4$ horizon reflect a strong first stage but the $k=10$ horizon are weakly estimated (Kleibergen-Paap F-statistics $= 4.482$ in imports and $= 0.074$ in exports). 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. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

B Theoretical Appendix

B.1 Supplementary Equilibrium Conditions

Price Indices.

P_t^r is the price index of the import buyer goods, given by

$$P_t^r = \left(\sum_i (P_{it}^r)^{1-\sigma_r} \right)^{\frac{1}{1-\sigma_r}}, \tag{60}$$

where P_{it}^r is domestic import buyer firm i's price at time t.

P_t^h is the price index of the domestic manufacturer goods, given by

$$P_t^h = \left(\sum_i (P_{it}^h)^{1-\sigma_h} \right)^{\frac{1}{1-\sigma_h}}, \tag{61}$$

where P_{it}^h is domestic manufacturer firm i's price at time t.

Finally, P_t^m is the price index of the foreign exporter goods, is symmetric across all import buyers i, and is given by

$$P_t^m = \left(\sum_i (P_{jt}^m)^{1-\sigma_m} \right)^{\frac{1}{1-\sigma_m}}, \tag{62}$$

where P_{jt}^m is foreign exporting firm j's price at time t.

B.2 Derivation of Pass-through Persistence

Computing the effect of the shock on prices one period ahead, we can expand Equation 49 to find lagged cost shock pass-through is given by

$$\frac{dE_t\{p_t^m\}}{de_{t-1}} = (1-\kappa_m)\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}\rho + \kappa_m(1-\kappa_m)\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}, \tag{63}$$

and in general form:

$$\frac{dE_t\{p_{t+k}^m\}}{de_t} = \rho\frac{dE_t\{p_{t+k-1}^m\}}{de_t} + \kappa_m^k\frac{dp_t^m}{de_t}. \tag{64}$$

Then the local projection of the cost shock at time t into prices at time $t+k$, as a function of the time t pass-through, is given by

$$\frac{dE_t\{p^m_{t+k}\}}{de_t} = \sum_{s=0}^{s=k} \rho^s \kappa_m^{k-s} \frac{dp^m_t}{de_t}, \tag{65}$$

Equation 54 in the text.

B.3 Derivation of Import Demand Elasticity

B.3.1 Pass-through Persistence Method

The log reset price of the foreign exporter is given by

$$\bar{p}^m_t = (1-\beta\kappa_m)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_m)^\tau(e_t + \mu^m - a^m)\}. \tag{66}$$

Given the AR(1) form of the exchange rate, it is equivalent to

$$\bar{p}^m_t = \frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_t + \mu^m - a^m. \tag{67}$$

The equation of motion for the imported input price is then

$$p^m_t = (1-\kappa_m)\left(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_t + \mu^m - a^m\right) + \kappa_m p^m_{t-1}. \tag{68}$$

Taking the domestic wage as given, the log reset price of the domestic import buyer-importer is given by

$$\bar{p}^r_t = (1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau(p^m_t + \mu^r - a^r)\}, \tag{69}$$

and the equation of motion for the import buyer's price is

$$p^r_t = (1-\kappa_r)\bar{p}^r_t + \kappa_r p^r_{t-1}. \tag{70}$$

Note that given Equations 69 and 70, the derivative of p^r_t with respect to e_t is given by

$$\frac{dp^r_t}{de_t} = (1-\kappa_r)(1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau \frac{dp^m_{t+\tau}}{de_t}\}. \tag{71}$$

Writing in the form of pass-through persistence, we have

$$\frac{dp_t^r}{de_t}\Big/\frac{dp_t^m}{de_t} = (1-\beta\kappa_r)(1-\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\frac{dp_{t+\tau}^m}{de_t}\Big/\frac{dp_t^m}{de_t}\}. \tag{72}$$

The import demand elasticity is then given by

$$\tilde{\sigma} = -\frac{dq_t^m}{de_t}\Big/\frac{dp_t^m}{de_t} = \sigma(1-\kappa_r)(1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\frac{dp_{t+\tau}^m}{de_t}\Big/\frac{dp_t^m}{de_t}\}, \tag{73}$$

Equation 53 in the main text. Substituting Equation 55 into Equation 73 (Equation 53 in the main text) yields the following solution:

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\left(\frac{\rho^{\tau+1}-\kappa_m^{\tau+1}}{\rho-\kappa_m}\right), \tag{74}$$

which simplifies to

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\sum_{\tau=0}^{\infty}\left((\beta\kappa_r\rho)^\tau(\frac{\rho}{\rho-\kappa_m}) - (\beta\kappa_r\kappa_m)^\tau(\frac{\kappa_m}{\rho-\kappa_m})\right), \tag{75}$$

then

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\left(\frac{1}{1-\beta\kappa_r\rho}(\frac{\rho}{\rho-\kappa_m}) - \frac{1}{1-\beta\kappa_r\kappa_m}(\frac{\kappa_m}{\rho-\kappa_m})\right). \tag{76}$$

Combining fractions,

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\left(\frac{\rho(1-\beta\kappa_r\kappa_m)-\kappa_m(1-\beta\kappa_r\rho)}{(1-\beta\kappa_r\rho)(1-\beta\kappa_r\kappa_m)(\rho-\kappa_m)}\right). \tag{77}$$

The expression simplifies to:

$$\tilde{\sigma} = \sigma(1-\kappa_r)(1-\beta\kappa_r)\left(\frac{1}{(1-\beta\kappa_r\rho)(1-\beta\kappa_r\kappa_m)}\right), \tag{78}$$

Equation 56 in the main text.

B.3.2 Calvo Method

An alternative to deriving the import demand elasticity is to solve via the Calvo equations. First, note the exchange rate price pass-through is given by

$$\frac{dp_t^m}{de_t} = (1-\kappa_m)(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}). \tag{79}$$

Substituting this price pass-through into the import buyer's Calvo pricing function from Equation 43, the optimal reset price of the domestic import buyer firm can be rewritten as

$$\bar{p}_t^r = (1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\left(\mu^r-a^r+\mu^m-a^m+(1-\kappa_m)(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_{t+\tau})+\kappa_m p_{t-1+\tau}^m\right)\}. \quad (80)$$

Expanding, we have

$$\bar{p}_t^r = (1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\left(\mu^r-a^r+\mu^m-a^m+(1-\kappa_m)(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_{t+\tau})+\kappa_m\left((1-\kappa_m)(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_{t+\tau-1}+\right.\right.$$

$$\kappa_m\left((1-\kappa_m)((\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho}e_{t+\tau-2}+...\right. \quad (81)$$

The solution can be written as a finite sum within the infinite sum:

$$\bar{p}_t^r = (1-\beta\kappa_r)E_t\{\sum_{\tau=0}^{\infty}(\beta\kappa_r)^\tau\sum_{s=0}^{\tau}\kappa_m^s\rho^{\tau-s}(1-\kappa_m)(\frac{1-\beta\kappa_m}{1-\beta\kappa_m\rho})e_t\}. \quad (82)$$

Substituting into Equation 51 and given the form of demand, the solution is equivalent to that of the pass-through persistence derivation.

B.4 Derivation of Local Projection Instrument

In this section I derive the local projection instrument from the model in the main text. The elasticity is identified simply by

$$\tilde{\sigma} = -\frac{dq_t^m}{de_t}\Big/\frac{dp_t^m}{de_t}. \quad (83)$$

Note that evaluated for a k-horizon change it is equivalent to write

$$\left(\tilde{\sigma}\right)_k = \left(\left(\frac{dq_t^m}{de_t}\right)\Big/\left(\frac{dp_t^m}{de_t}\right)\right)_k = \frac{q_{t+k}^m - q_{t-1}^m}{e_{t+k}-e_{t-1}}\Big/\frac{p_{t+k}^m - p_{t-1}^m}{e_{t+k}-e_{t-1}}, \forall k. \quad (84)$$

This follows because the numerator and denominator in Equation 83 do not depend on the k horizon. Then, note I can multiply and divide by the "intermediary stage" of the local projection of the t shock on to the $t+k$ shock, yielding

$$\tilde{\sigma} = \left(\frac{q_{t+k}^m - q_{t-1}^m}{e_{t+k}-e_{t-1}}\frac{e_{t+k}-e_{t-1}}{e_t - e_{t-1}}\right)\Big/\left(\frac{p_{t+k}^m - p_{t-1}^m}{e_{t+k}-e_{t-1}}\frac{e_{t+k}-e_{t-1}}{e_t - e_{t-1}}\right), \forall k. \quad (85)$$

Note that the "intermediary stage" is nonzero by the AR(1) assumption on the shock, implying the validity of the approach. The expression simplifies, implying the local projection instrumental-variables estimator in the text:

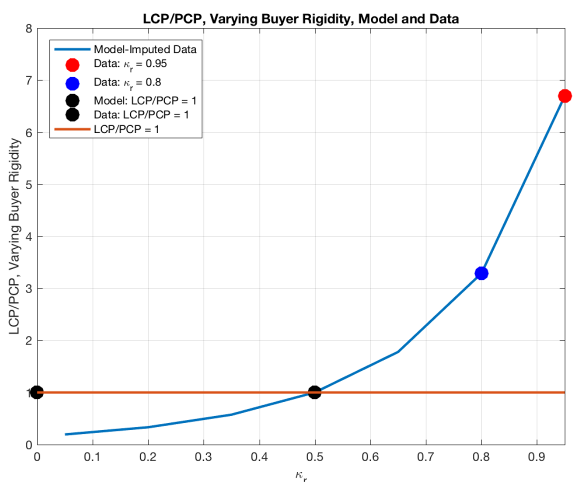
$$\tilde{\sigma} = \left(\frac{q^m_{t+k} - q^m_{t-1}}{e_t - e_{t-1}} \right) \bigg/ \left(\frac{p^m_{t+k} - p^m_{t-1}}{e_t - e_{t-1}} \right), \forall k. \tag{86}$$

C Quantitative Appendix

C.1 Goodness-of-Fit

Model Predictions.

Figure 17: Mechanism Verification - Import Buyer Rigidity



Note: This figure measures the difference in the import demand elasticity ratio of LCP to PCP, varying the import buyer rigidity κ_r. Note if LCP and PCP import demand elasticities are equal the ratio = 1 (orange line). The blue line uses the model Equations 49 and 56 to extrapolate the effect of reducing κ_r given the data estimates from Table 4 and Appendix Table 13. The red and blue dots report the data ratio estimates for high and low κ_r respectively, and the black lines report the κ_r cutoffs to generate equal import demand elasticities from the model (cutoff $\kappa_r = 0$) and data (cutoff $\kappa_r = 0.5$). 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.

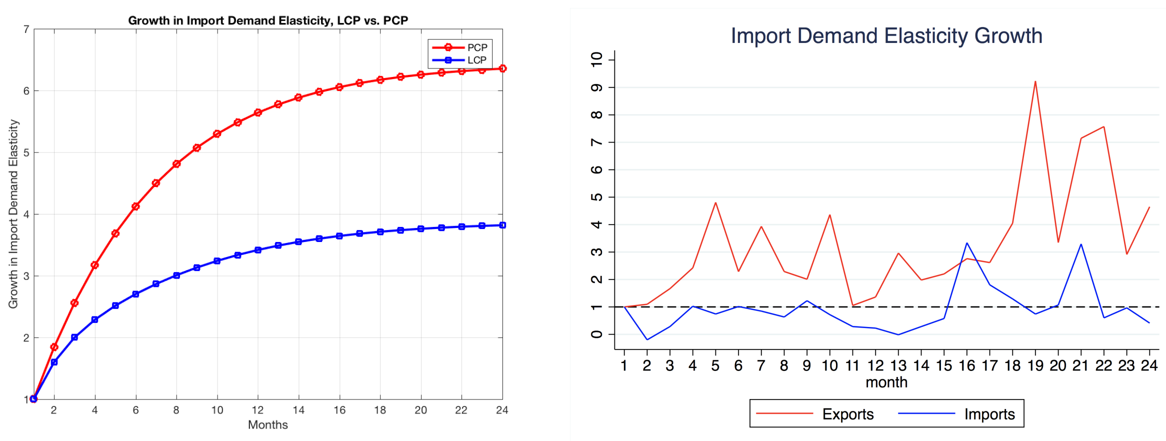
C.2 Overidentifying Tests of Model

The model from Section 6 contains a number of supplementary predictions. The predictions are less central to the main analysis but useful to test to verify the validity of the model structure. They also help inform the scope of the model.

C.2.1 Dynamics

This section focuses on the model's prediction for import demand elasticity dynamics under LCP (i.e. US imports) versus PCP (i.e. US exports). Validity of the import buyer rigidity mechanism would imply that the two elasticities converge over time, because over longer horizons the import buyer rigidity falls. Intuitively, a small fraction of firms may adjust prices within one month, but a greater fraction will adjust over the course of a year. Corollary 1 thus implies the dynamic growth rate of the import demand elasticity under PCP (US exports) should be larger than that of LCP (US imports). At infinite horizons the elasticities should converge to the true uniform underlying CES σ.

Figure 18: Growth Rates, PCP vs. LCP



Note: Import demand elasticity growth rates simulated (left) and estimated (right) for local currency pricing ($\kappa_m = 0.9$, US imports, blue) and producer currency pricing ($\kappa_m = 0$, US exports, red). The import demand elasticity is normalized by the first-period value, so subsequent points reflect growth from the initial estimation horizon. 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). This is a part of clearance request #11330.

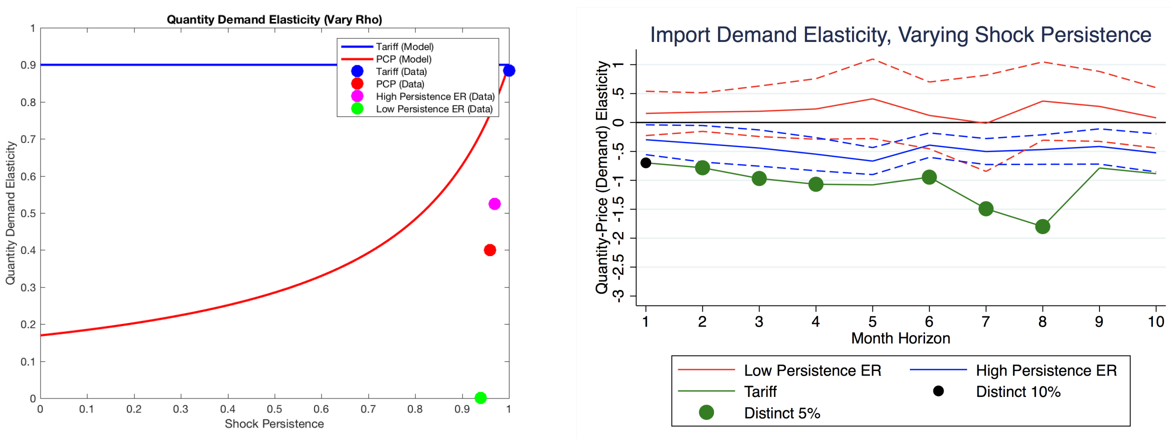
C.3 Shock Persistence

The model also has supplementary predictions for the role of shock persistence and its dynamics in this framework. There are also implications for the dynamics of the import buyer rigidity.

Shock persistence increases the elasticity estimates and amplifies the other results. This is because it increases pass-through persistence; the intuition is that price changes from more persistent shocks are relatively more permanent. Note also that the theoretical results are dependent on some autocorrelative structure of the exchange rate; without that, the results would require a different framework.

To test this mechanism, I estimate the AR(1) coefficients of three shocks. I had previously estimated the exchange rate quarterly $\rho^e = 0.89$. I split the exchange rate into countries with high (on average quarterly $\rho^{e,high} = 0.924$) or low (on average quarterly $\rho^e = 0.835$) persistence. I also estimate the AR(1) coefficient of the tariff and find $\rho^t = 1$. I find that the corresponding import demand elasticities estimated by these three shocks are exactly increasing in the shock persistence. Figure 19 contains the estimates along with the model predictions. The data closely approximates what the model predicts regarding persistence: it increases demand effects.

Figure 19: Shock Persistence

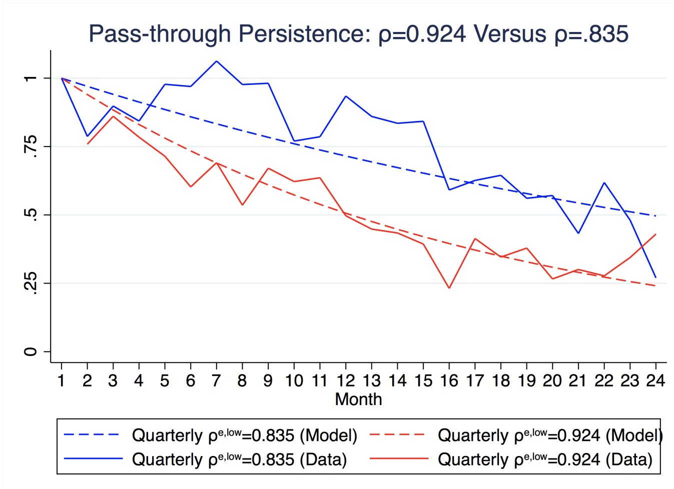


Note: This figure reports the relationship between shock persistence ρ and the import demand elasticity. The left figure simulates the effect of increasing ρ holding κ_m fixed at zero, relative to $\rho = 1$. The colored points reflect data estimates from the right figure. The right figure plots the import demand elasticity for below-median quarterly persistence exchange rates $\rho^{e,low} = 0.835$ (red), above-median quarterly persistence exchange rates $\rho^{e,high} = 0.924$ (blue), and tariffs $\rho^t = 1$ (green). The exchange rate estimates also report 95% confidence intervals, and the green dots indicate when the tariff is statistically distinct from the pooled quarterly $\rho = 0.89$ elasticity. 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). This is a part of clearance request #11330.

The underlying driver of these effects is again pass-through persistence. If import buyers did not have rigidities, all import demand elasticities would be equal. Given these rigidities, import buyers do not adjust their prices fully on impact for import price changes and instead take into account the current and future path of these input costs. Accordingly, they adjust more when an import price change is more persistent because there is more bandwidth to adjust to longer-lasting shocks. In Figure 20 I report the pass-through persistence for $\rho^{e,high}$

and $\rho^{e,low}$. I find that the general prediction holds: more persistent exchange rate shocks are more pass-through persistent.

Figure 20: Pass-through Persistence, by Shock Persistence

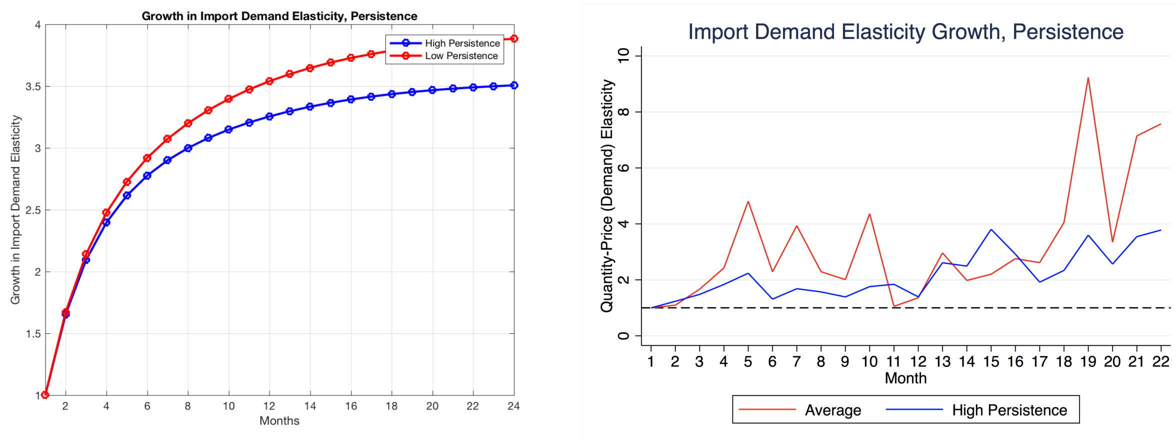


Note: This figure plots pass-through persistence as predicted by the model (dashed lines) and estimated in data (solid lines). The blue lines reflect quarterly $\rho^{e,high} = 0.924$ and $\kappa_m = 0$ in simulation and above-median persistence exchange rates in US exports in estimation, and the red lines reflect quarterly $\rho^{e,low} = 0.835$ and $\kappa_m = 0$ in simulation and below-median persistence exchange rates in US exports in estimation. 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). This is a part of clearance request #11330.

Although the form of $\tilde{\sigma}$ predicts specific heterogeneity depending on underlying parameters, this heterogeneity decays over time. This is because over time, the import buyer rigidity falls. Intuitively, a small fraction of firms may adjust prices within one month, but a greater fraction will adjust over the course of a year. Similar to the currency choice analysis in the main text, import demand elasticities from less persistent shocks should grow at a higher rate over time than more persistent shocks. Indeed, Figure 21 which reports the high-persistence exchange rate relative to the full sample reflects that mechanism.[29]

[29]It is difficult to materially identify long-run effects of low-persistence exchange rates.

Figure 21: Growth Rates, Shock Persistence



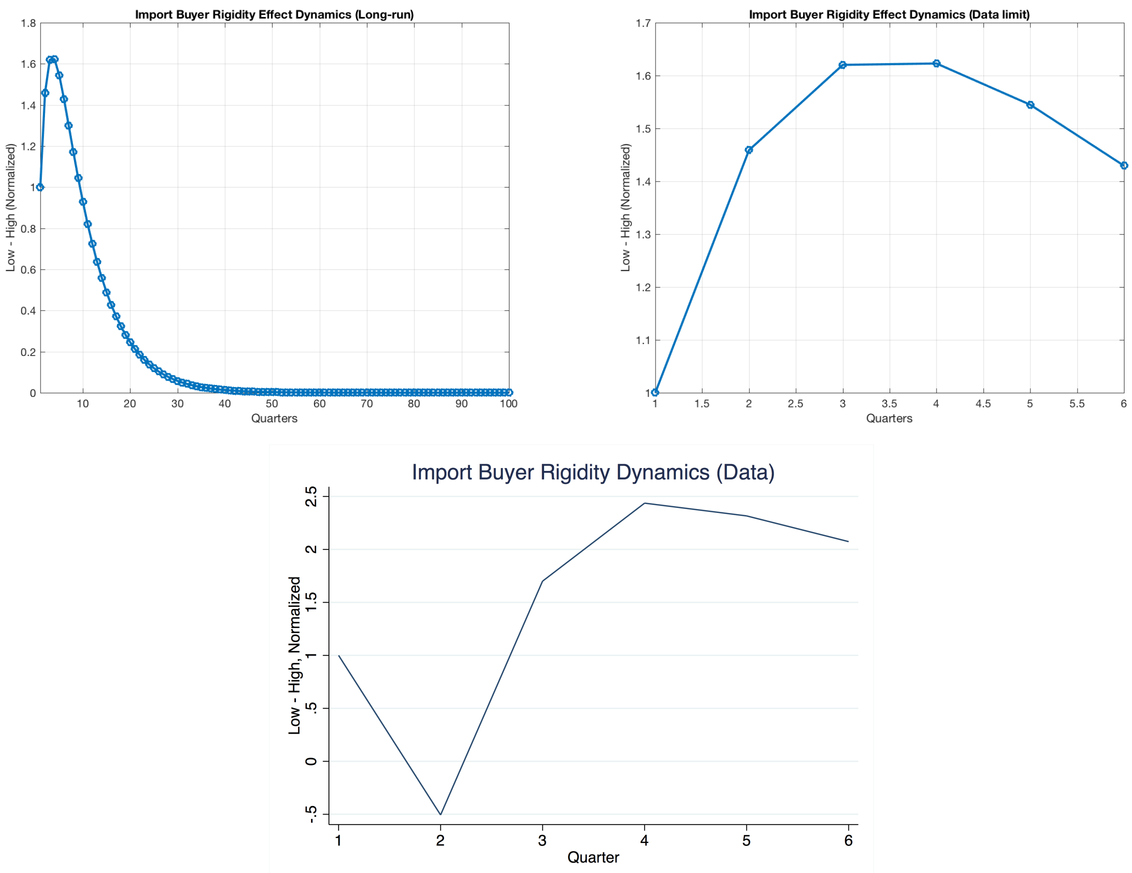
Note: Import demand elasticity growth rates simulated (left) and estimated (right) for high exchange rate persistence (quarterly $\rho^{e,high} = 0.924$, blue) and average exchange rate persistence (quarterly $\rho^{e} = 0.89$, red). The import demand elasticity is normalized by the first-period value, so subsequent points reflect growth from the initial estimation horizon. 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). This is a part of clearance request #11330.

C.3.1 Import Buyer Rigidity Dynamics

The next figure plots the dynamic effects of the import buyer rigidity as implied by the model: the effect of the import buyer rigidity is hump-shaped over time. It increases in the short-to-medium run and then falls as the estimation horizon $k \to \infty$. The top left exhibit reports the (approximate) infinite-horizon dynamics. The top right exhibit truncates the x-axis to match the available data, which I only have a valid first-stage for six quarters (eighteen month horizon). The bottom exhibit reports the data estimates from US exports. The data approximately replicate the model's prediction regarding the hump-shaped effect over time.

The validity of this exercise suggests further validity of the model. It is also informative of the scope of the import buyer rigidity effect.

Figure 22: Growth Rates, Import Buyer Rigidity

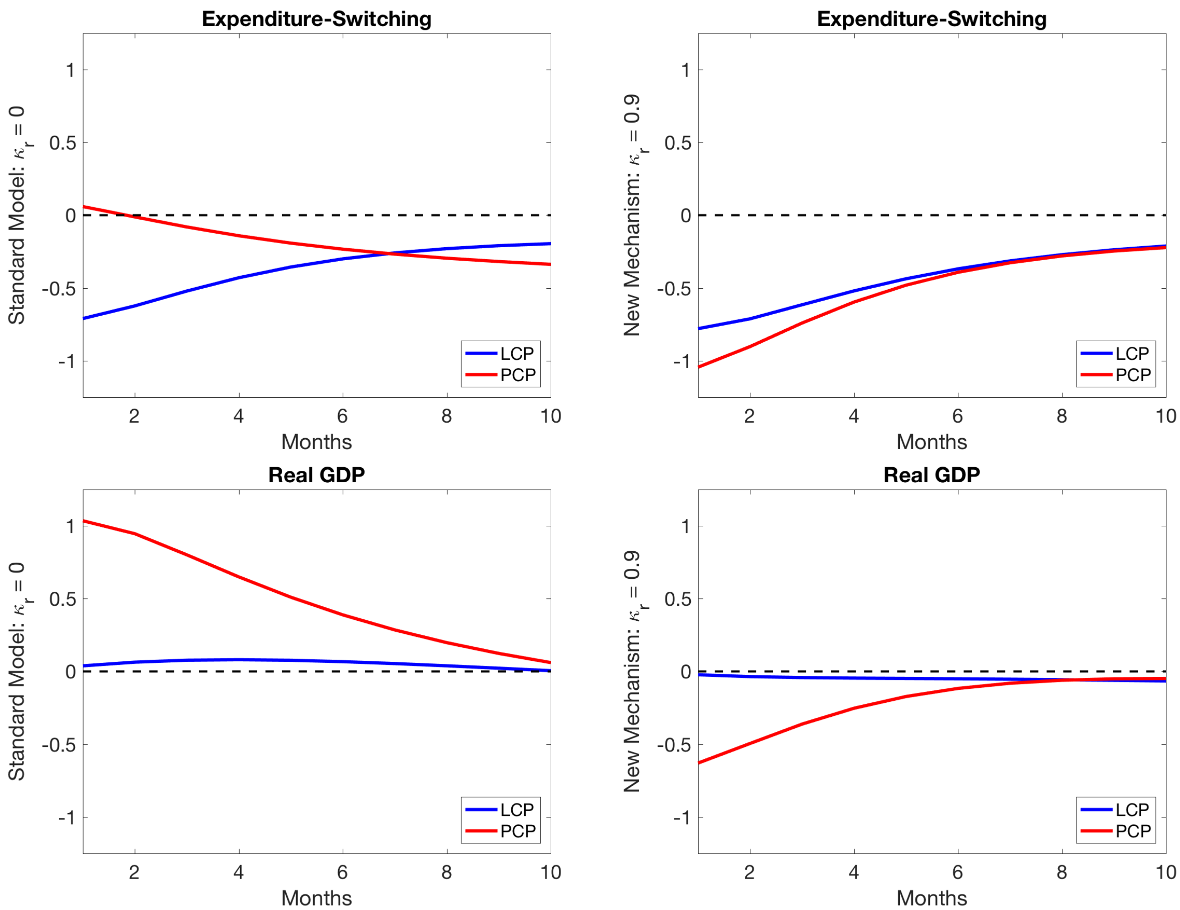


Note: Effect of increasing the monthly import buyer rigidity from $\kappa_r = 0.8$ to $\kappa_r = 0.95$ over time. The effect is defined as the estimated quantity elasticity for $\kappa_r = 0.8$ minus that for $\kappa_r = 0.95$. The effect plotted is normalized by the first-period value. The left figure illustrates the dynamics over the (approximately) infinite horizon and the right figure illustrates the dynamics over six quarters (eighteen months), the longest horizon with a valid instrumental variables first-stage in data. The bottom figure reports the corresponding US export data estimates. The estimation drops the bottom tercile of exchange rate persistence from the sample. 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.

C.4 Counterfactual Appendix

C.4.1 Monetary Policy Level Effects

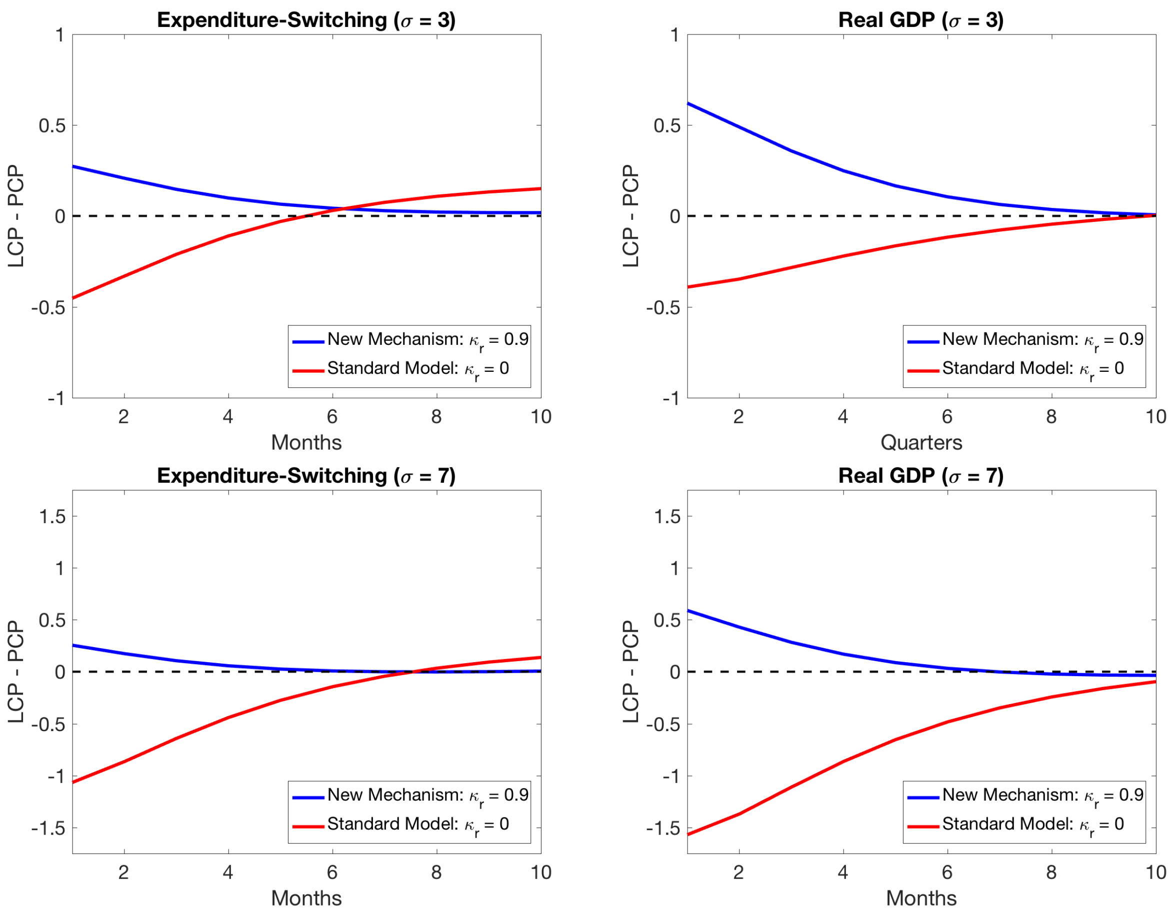
Figure 23: US Monetary Policy Counterfactual: Level Effects



Note: This figure simulates the propagation of a domestic interest rate cut on expenditure-switching (top) and real GDP (bottom), normalized by the exchange rate fluctuation. The right figures represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the left figures $\kappa_r = 0$ (approximation to standard model). The blue plot the effect for $\kappa_m = 0.9$ (LCP) and the red lines for $\kappa_m = 0$ (PCP).

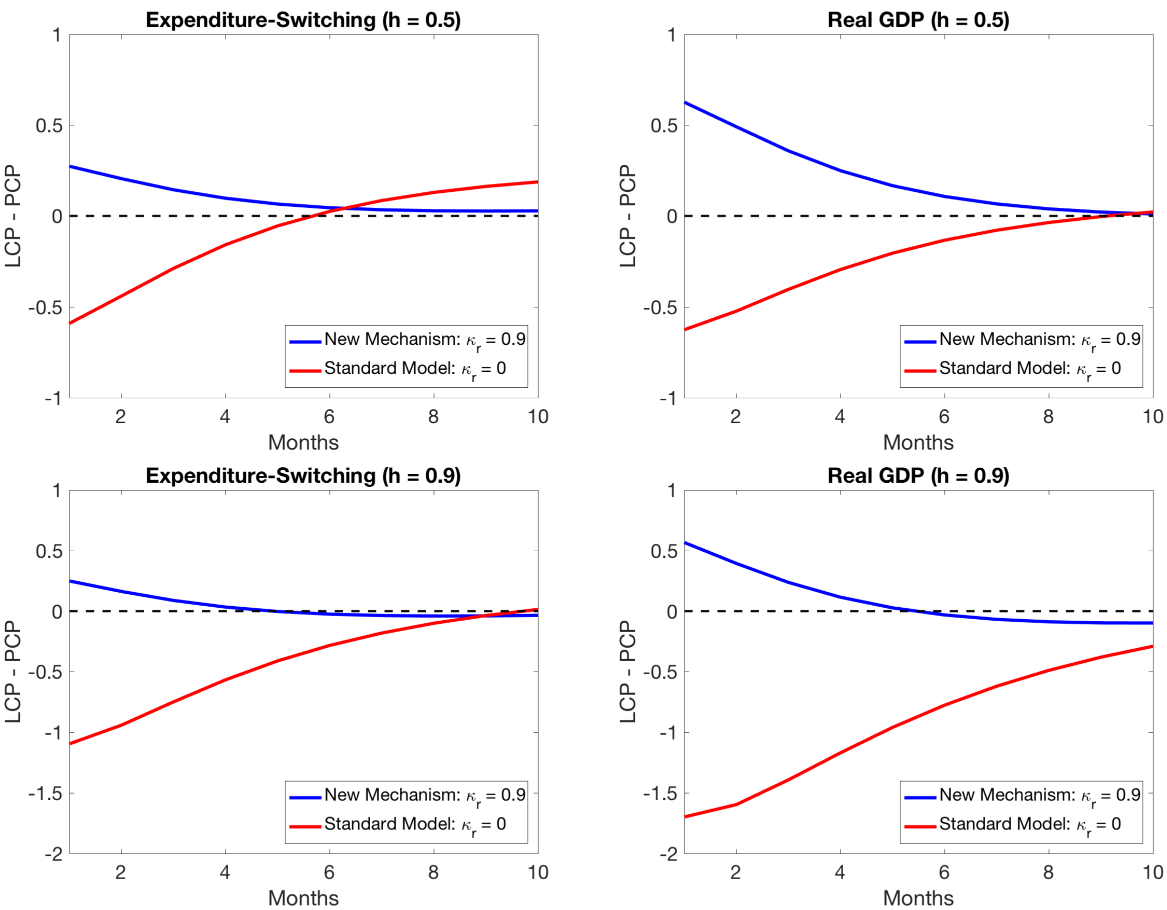
C.4.2 Monetary Policy Counterfactual Sensitivity

Figure 24: Counterfactual Sensitivity: CES Substitution



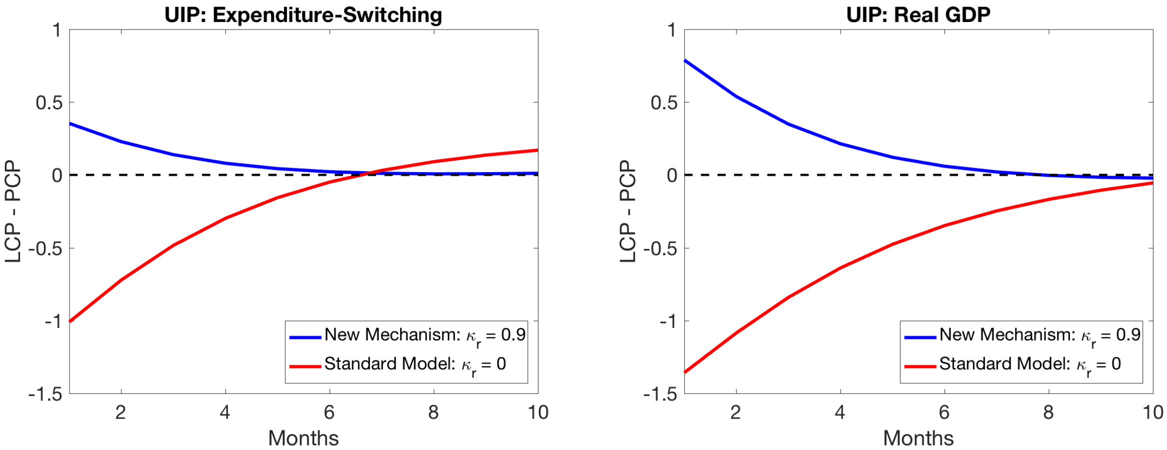
Note: This figure simulates the propagation of a domestic interest rate cut on expenditure-switching (left) and real GDP (right), normalized by the exchange rate fluctuation. $\sigma = 3$ (top) and $\sigma = 7$ (bottom) calibrated instead of $\sigma = 5$. The blue lines represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the red lines $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).

Figure 25: Counterfactual Sensitivity: Domestic Consumption Share



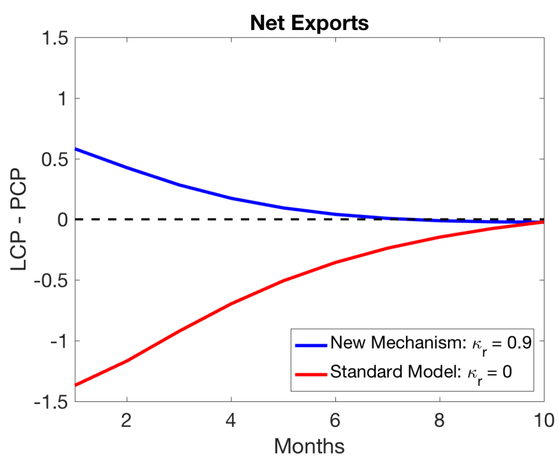
Note: This figure simulates the propagation of a domestic interest rate cut on expenditure-switching (left) and real GDP (right), normalized by the exchange rate fluctuation. This figure calibrates domestic manufacturer's retail share as $h = 0.5$ (top) and $h = 0.9$ (bottom) instead of $h = 2/3$. The blue lines represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the red lines $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).

Figure 26: Counterfactual Sensitivity: Alternative Shock (UIP)



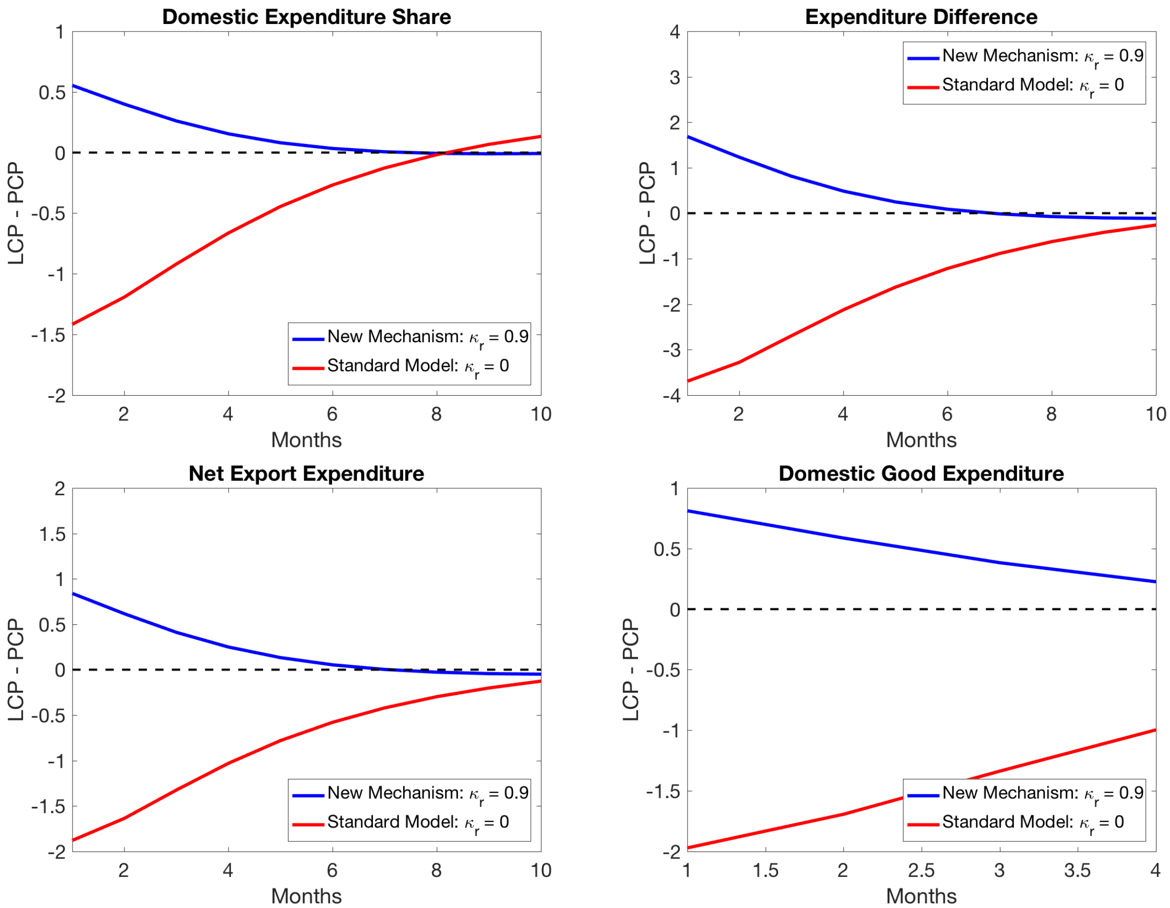
Note: This figure simulates the propagation of a UIP shock on expenditure-switching (left) and real GDP (right), normalized by the exchange rate fluctuation. The blue lines represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the red lines $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).

Figure 27: Counterfactual Sensitivity: Net Exports



Note: This figure simulates the propagation of a domestic interest rate cut on net exports, normalized by the exchange rate fluctuation. The blue line represents the calibration of $\kappa_r = 0.9$ (new mechanism) and the red line $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).

Figure 28: Counterfactual Sensitivity: Expenditure-Switching Definition



Note: This figure simulates the propagation of a domestic interest rate cut on expenditure-switching using alternative definitions to the main text, normalized by the exchange rate fluctuation. The top left figure reports the domestic expenditure share excluding exports. The top right figure reports the expenditure difference, i.e. domestic expenditure minus foreign expenditure. The bottom left figure reports total domestic expenditure (i.e. nominal GDP). The bottom right figure reports total expenditure on domestic goods. The blue lines represent the calibration of $\kappa_r = 0.9$ (new mechanism) and the red lines $\kappa_r = 0$ (approximation to standard model). All lines plot the effect for $\kappa_m = 0.9$ (LCP) minus the effect for $\kappa_m = 0$ (PCP).