

# The Origin of Exchange Rate Shocks, Market Structure, and Pass Through\*

Raphael Auer and Raphael Schoenle<sup>†</sup>  
Swiss National Bank and Brandeis University

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## Abstract

In this paper, we aim to understand whether market structure and the way in which it affects pricing decisions of profit-maximizing firms is behind the incompleteness of long run exchange rate pass through (PT). Our analysis focuses on identifying how different exchange rate shocks affect the market environment differentially for different trade partners. Our analysis proceeds in three steps. In the first step, we decompose bilateral exchange rate movements into US Dollar (USD) movements against the rest of the world on the one hand and trade-partner currency (TPC) movements against the rest of the world on the other hand. We show that USD movements are associated with a much higher PT rate than are TPC movements. Second, we document that the TPC PT rate is increasing in the trade partner's sector specific market share and that the USD PT rate is decreasing in the market share of domestic producers. Our findings are economically quite significant. For example, nearly two thirds of the average 2-year pass through rate in our sample is attributed to the fact that a trade partner market share is nonnegligible. Last, we analyze whether a model of oligopolistic competition featuring variable markups can rationalize these patterns. In particular, we show that a model following Atkeson and Burstein (2008) can explain the empirically observed variation in pass through rates across sectors, trade partners, and sector-partner pairs when it is calibrated using our exchange rate decomposition and information on trade partner market shares.

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<sup>†</sup>Contact: Raphael Auer, Swiss National Bank, Börsenstr. 15 P.O. box Ch-8022 Zürich Switzerland. Phone: +41 44 631 38 84, e-mail: raphael.auer@snb.ch. Raphael Schoenle, Mail Stop 021, Brandeis University, P.O. Box 9110, 415 South Street, Waltham, MA 02454. Phone: +1-617-680-0114, email: schoenle@brandeis.edu.

# 1 Introduction

Recent advances in the literature estimating exchange rate pass-through at the good level have yielded important insights for how firms price to market and also, for why, how and to what extent they react to exchange rate shocks.<sup>1</sup> While the results have also uncovered much heterogeneity along multiple dimensions such as firm or good characteristics, a common finding is that on average, pass through, even when estimated over long horizons, is very incomplete.

In this paper, we aim to understand whether the market structure and the way in which it affects pricing decisions of profit-maximizing firms are behind the incompleteness of long run pass through, i.e., we seek to identify “real rigidities” in international pricing (see Gopinath and Itskhoki (2011)) that can shed light on why the rate at which the optimal price of a firm commoves with its costs is generally smaller than 1. Our focus is on identifying the importance of market environment and the local “toughness” of competition for pricing, a channel pointed out in Gust et al. (2010 and 2011), Atkeson and Burstein (2008), and Chen et al. (2009).

To clearly identify this channel, our empirical strategy is the following. We first construct trade-partner specific exchange rate shocks, second construct the sector specific US import share of each trade partners, and third examine whether simple models of firm-pricing decisions can match empirically observed pass through rates when they are calibrated using the interaction of the partner-sector specific data we construct.

Accordingly, our analysis proceeds in three steps. In the first step, we decompose bilateral exchange rate movements into US Dollar (USD) movements against the rest of the world (ROW) on the one hand and trade-partner currency (TPC) specific movements against the ROW on the other hand.

Using micro data on US import prices collected by the BLS, we find that the rate of pass through at horizons up to two years is estimated to equal between  $x\%$  and  $x\%$  following a USD movement,

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<sup>1</sup>While some of these studies focus on structural analysis of exchange rate pass through in single industries (see Knetter (1989) and Knetter (1992) and Goldberg and Verboven (2001) and Goldberg and Verboven (2005) for the car industry, Hellerstein (2008) for the beer industry and Nakamura and Zerom (2010) for the case of the coffee industry), our approach is related to the more reduced form analysis of pass through rates in datasets spanning many industries (see Gopinath and Rigobon (2008), Gopinath and Itskhoki (2010), Gopinath et al. (2010)), and Nakamura and Steinsson (2008a).

but only between  $x\%$  and  $x\%$  following a TPC movement. The difference in pass through rates following these two shocks implies that “market toughness” has important implications for firms’ pricing decisions: a general USD appreciation moves the relative costs of all importers and thus affects the toughness for all imported goods, whereas the TPC movement only affects the costs of a few importers.

In the second step of the analysis, we analyze whether pass through rates vary with a trade partner’s market share. We find that for TPC movements, the rate of pass through is increasing in the trade partner’s sector-specific market share. This finding also holds when controlling for the general importance of the trade partner in US imports, thus documenting that what matters for pass through is not the trade partner’s overall importance (which could also be attributed to these economies just being large and thus also affecting commodity prices that in turn affects US prices) but, rather, the sector-specific one (i.e., Icelandic fish producers have a higher rate of pass through than Icelandic Banana producers).

The importance of market share is economically very large. For example, over longer horizons, the rate of pass through of a trade partner with a market share near zero equals 0.1, while the pass through rate equals 0.7 for a trade partner with a market share of 100%. Nearly two thirds of the average 2-year pass through rate in our sample (equal to 0.28) is explained by the fact that trade partner market share is quite large on average (30%). The underlying reason for this large average market share is that most firms originate from trade partners with large market shares and hence the average market share is high.

We also document that the rate of pass through following USD movements against the ROW is increasing in the general importance of imports in a US sector, thus again implying that market share is important for the rate of pass through.

In the third and final step of our analysis, we analyze whether models of firm pricing can rationalize these patterns. We use the TPC movements, information on partner-sector specific market shares, as well as other information on sector characteristics such as estimates of the elasticity of substitution. We then examine whether a model of oligopolistic competition following Krugman (1987) and Atkeson and Burstein (2008) can explain the empirically observed variation in pass

through rates across sectors, trade partners, and sector-partner pairs when it is calibrated using this data.

This model of oligopoly-pricing relates the pass through rate following a TPC movement to both the firm's individual market share and the total market share of all exporters from the same trade partner. For given average firm size, if a large number of firms originate from the same trade partner, a firm's market share reacts less to changes in the marginal costs since many firms face the same cost shock. For given number of firms originating from the same trade partner, a larger firm responds more to its competitors and less to changes in its own marginal cost.<sup>2</sup>

We find that the variation in partner-sector specific pass through rates can very well be explained by the observed partner market shares: theoretical prediction and empirical estimate are positively correlated, and often so at a rate not too distant from one. In particular, our results are the most consistent when we assume that firm size is constant across the import partners so that the only channel through which ;

In contrast with Atkeson and Burstein (2008), we find that the generally low magnitude of pass through rates can be explained by the dominance of large firms.

Overall, we thus conclude that understanding how the exchange rate affects the competitive pressure faced by firms and how this, in turn, alters equilibrium prices is of first order importance for understanding the evolution of firms' optimal price. This conclusion also has implications for the nature of firm's pricing decision in the literature on price setting in the domestic economy: if the optimal price of a firm does not move much following a cost shock, already small menu costs can substantially reduce the frequency of price changes (see, for example, Bils and Klenow (2004) and Nakamura and Steinsson (2008) for evidence on how frequently change prices.

Second, the analyzed models also highlight the importance of understanding price complementarities, may they arise from strategic motives (see Kimbal (1995) and Dotsey and King (2005)) or form the shape of the utility functions (see Gust et al. (2010) using the preferences developed by Ottaviano et al. (2001)) to model price complementarities. Guerrieri et al. (2010) analyze

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<sup>2</sup>This exercise is related to Pennings (2011), who undertakes a similar calibration to evaluate the cross-currency rate of pass through, i.e., the effect of the USD/Euro exchange rate on the prices Japanese firms charge in the US (also see Bergin and Feenstra (2008) for the effect of one currency on the prices of goods from other firms).

the effect of a certain level of pricing complementarities to gauge the extent of the real rigidity associated with between firms on .

Also from a policy maker’s perspective, our findings are relevant given the economic magnitude of the uncovered relations. For example, the finding that pass through following general USD movements is very large gives rise to a much larger role for the exchange rate on inflation dynamics than is commonly estimated: all import prices commove substantially when such exchange rate shocks hit (large import price movements, in turn, might also affect the price of domestic firms, see for example Auer (2011)).

Additionally, our findings unveil that the aggregate rate of pass through is large when the trade partner is either large or concentrated in specific sectors. For example, the observed decline in US exchange rate pass through (Marazzi et al. (2005), Marazzi and Sheets (2006), Campa, Goldberg, and Minguez-Gonzalez (2005)) could partly be explained by exports currently being more diversified than was the case in the 1970s.

Consistent with theories that argue for the importance of market share, it is true that if a trade partner , idiosyncratic

=; idea: can take “the share of value added”

## 2 Data description

We use exchange rate data from the IMF’s IFS data, unit labor cost estimates from the OECD, monthly US import data from the USITC/Census, and, most importantly, import prices at the goods level from the BLS that have been the topic of intense study since the original analysis of this dataset by Gopinath and Rigobon (2008). For quantities, we use bilateral US import data disaggregated at either the 6-digit Harmonized System (HS) or the 6-Digit North American Industry Classification System (NAICS) obtained from the US Census. For domestic production, we rely on the manufacturing data from the Annual Survey of Manufacturers, which is available from the US census at the 6-digit NAICS level.

We refer the reader to Gopinath and Rigobon (2008) for details of the US import price micro

data. In this paper, we have extended the data range to span the years from 1994 through 2007. We apply our analysis to the following countries: Australia, Austria, Canada, China, Denmark, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom.

### **3 How are USD and Trade-Partner Specific Exchange Rate Movements Passed Through into US Import Prices?**

We start our analysis with a very simple decomposition of the exchange rate and relating its components to US import prices. We investigate whether pass-through is different if the USD moves against all of its trade partners or rather, if the change in the bilateral nominal exchange rate is caused by a trade partner movement against the rest of the world.

This exercise is motivated by theoretical considerations relating pass through to how the market environment changes with the exchange rate. For example, if we think along the lines of Atkeson and Burstein (2008), where market power determines pass-through, pass-through should be very different if all foreign firms face the same cost shock as opposed to when only a small set of firms from a country such as Switzerland faces a cost shock. Also theoretical models that highlight price complementarities (see Chen et al. (2010) or Gust et al. (2009)) would predict that if the USD appreciates against all sectors, pass-through should be much higher since all exporter experience the same cost shock. In contrast, if only the trade partner currency moves, pass through should be much smaller since only a small set of consumers moves.

To cleanly identify USD movements and trade partner currency movements, we do the following. For each trade partner we define the USD/ROW Exchange Rate Change as the trade-weighted average change of the log USD exchange rate against all countries other than the trade partner in question. That is, if TP indexes the trade partner, the change of the ROW Exchange Rate Change for trade partner TP equals

$$\Delta USD_{ROW-TP,t} = \sum_{c \neq TP} \omega_{c,t} \Delta USD_{c,t} \quad (1)$$

where country  $c$ 's weight is its shares of US imports excluding country TP. To make sure that the weights are not contemporaneously related to current exchange rate movements, we take last year's import share as current weights:

$$\omega_{c,t} = \frac{IM_{c,t-1}^{US}}{\sum_{c \neq TP} IM_{c,t-1}^{US}} \quad (2)$$

It is important to note that the USD/ROW Exchange Rate Change differs for each trade partner. Finally, we define the "TP/ROW exchange rate movement" as the difference between the bilateral exchange rate change and the USD/ROW exchange rate change.

We measure pass-through by estimating a stacked regression where we regress monthly import price changes on monthly lags of the respective measure of the exchange rate:

$$\Delta p_{i,c,t} = \alpha_c + \sum_{j=1}^n \beta_j \Delta e_{c,t-j+1} + \gamma t + \epsilon_{i,c,t} \quad (3)$$

where  $i$  denotes a good,  $\alpha_c$  is a country fixed effect,  $t$  a linear time trend,  $n$  varies from 1 to 25, and  $e_{c,t-j+1}$  is one the three exchange rate measures. To obtain the  $n$ -month pass-through, we sum the coefficients up to the respective horizon.

To test the robustness of our results and to further break down the sources of pass-through of the different exchange rates, we estimate pass-through of our three exchange rate measures by country of origin and for the different three-digit NAICS sectors in the data.

### 3.1 Results: Trade-Partner and USD Exchange Rate Movements

When we estimate pass-through of our three exchange rate measures, we find the striking result that aggregate pass-through of global USD movements is up to four times as large trade-partner pass-through, with an estimate of 0.88 at the 24-month horizon. Second, our results show geographic heterogeneity in the rate of pass-through of trade-partner movements. Finally, our results are robust to estimation at the three-digit industry level.

First, our estimates of pass-through of the three measures of the exchange imply that pass-through of global USD movements into U.S. imports prices is substantially larger than pass-through of nominal or trade-partner exchange rate movements. Figure 3 summarizes this finding, based on separate pass-through estimations. It shows the pass-through estimates that can be attributed to a movement of the USD against all partner currencies, a movement of the trade partner currency against the rest of the world or simply a nominal exchange rate movement. While USD pass-through is larger at all monthly horizons, it is at approximately 0.75 at the 24-month horizon. Trade-partner pass-through at that horizon is at 0.21 and nominal exchange rate pass-through at 0.3. Our results also show that nominal exchange rate pass-through is always higher than trade-partner specific pass-through, but economically only by a small magnitude.

When we jointly estimate pass-through of our two components of the nominal exchange rate, of global USD and trade-partner specific movements, we find an even stronger impact of global USD movements on U.S. import prices. Now, the long-horizon estimate of USD pass-through is 0.88, while the estimate of trade-partner pass-through is 0.2. Figure 4 summarizes the result and additionally shows 95% confidence bands. USD pass-through is statistically significantly higher at all monthly horizons.

Second, we present estimates of USD and trade-partner pass-through by country of origin in Table 2. Is the trade-partner response heterogenous across the different trade partners? The table shows substantial heterogeneity across trade partners. At the same time, pass-through of USD movements continues to be generally larger than trade-partner movements. Given the recent debate about the valuation of the Chinese Yuan, it is remarkable to see that movements in the trade-partner specific exchange rate of China are passed through into U.S. import prices at a rate of 0.81 at the 6-month and at a full rate at the 12-month horizon. These results confirm the findings in Auer (2011).

Finally, when we control for sectoral heterogeneity of pass-through, we find robustness of our results: pass-through of global USD movements is larger than trade-partner or nominal exchange rate pass-through when controlling for sectoral effects at the three-digit NAICS level. Figures 5 to 15 show our estimates. Figure 5 gives an example for pass-through of USD and trade-partner



movements for two particular industries at all horizons, namely for food manufacturing (NAICS 311) and nonmetallic mineral product manufacturing (NAICS 327). In both cases, global USD movements are passed through into U.S. import prices at a substantially higher rate than trade-partner movements.

Figure 6 to 15 show estimates of pass-through at various horizons in different 3-digit NAICS industries relative to nominal exchange rate pass-through. Here, our results also indicate that trade-partner movements get passed through into U.S. prices much less than do general USD movements while USD movements continue to have higher rates of pass-through than nominal exchange rate movements. The figures also indicate that there is sectoral heterogeneity of USD and trade-partner pass-through.

## 4 What is the Role of Market Share?

### 4.1 Empirical Specification

The previous section has demonstrated that pass through is larger following a general movement of the USD than when only the currency of a single trade partner moves against the USD.

In this section, we examine the extent to which this is driven by the sizeable effect that a USD appreciation has on the general market environment. By a similar token, we then whether examine the TPC pass through rates is increasing in the import share of the country the firm is exporting from.

In Graph X, we investigate whether the pass through following USD movements varies with the importance of imports in the sector. We define the total import share as

$$m_{US,k} = \frac{Domestic\ Shipments_c}{Domestic\ Shipments_c + World\ Imports_c}$$

and we then estimate an augmented, reduced-form pass-through specification where we interact our three measures of market power with exchange rate movements:

$$\Delta p_{i,k,t} = \alpha_c + \sum_{j=1}^n \beta_j \Delta USD_{ROW-TP,t-j+1} + \sum_{j=1}^n \gamma_j (m_{US,k} \Delta USD_{ROW-TP,t-j+1}) + \epsilon_{i,k,t} \quad (4)$$

The three lines displayed in Graph X reflect the pass through rate following a USD shock for three sectors in which where the US producers make up 0% (red dotted line),  $y\%$  (which is equal to the average of  $m_{US,k}$  in our data, see blue solid line) and (nearly, so that at least one importer exists) 100% (green dash-dotted line). For each lag length  $n$ , the red dotted line corresponds to the sum of the coefficients on the main effect  $\sum_{j=1}^n \beta_j$  in Equation (4) (i.e., the reported coefficients). The difference between the green dash-dotted line and the red dotted line corresponds to the sum of the interaction coefficients  $\sum_{j=1}^n \gamma_j$  in Equation (4).

As a next step, we examine whether also the response to TPC movements is dependent on the market share of the respective importers. We thus define the sector specific market share of trade partner  $c$  as

$$m_{c,k} = \frac{Imports_k}{Domestic Shipments_k + World Imports_k}$$

Then, we run an augmented, reduced-form pass-through specification where we interact our three measures of market power with exchange rate movements:

$$\Delta p_{i,c,k,t} = \alpha_c + \sum_{j=1}^n \beta_j \Delta e_{c,t-j+1} + \sum_{j=1}^n \gamma_j m_{c,k} \Delta e_{c,t-j+1} + \epsilon_{i,c,k,t} \quad (5)$$

where  $i$  denotes a good,  $\alpha_c$  is a country fixed effect,  $k$  a sector,  $n$  varies from 1 to 25, and  $e_{c,t-j+1}$  is one of the three exchange rate measures, and  $m_{c,k}$  denotes one of the (sector-specific) market share measures: (1) the share of country  $c$  among all countries in a given six-digit NAICS sector  $k$  for the year 2002, (2) the share of country  $c$  in terms of sectoral GDP in a given six-digit NAICS sector  $k$  for the year 2002 and (3) the share of all countries in terms of sectoral GDP in a given six-digit NAICS sector  $k$  for the year 2002.

To obtain the  $n$ -month, direct rate of pass-through, we sum the coefficients  $\beta_j$  up to the respec-

tive horizon. To obtain the indirect effect working through the measure of market power, we sum the coefficients  $\gamma_j$  up to the respective horizon. When we multiply the sum of  $\gamma_j$  with the average respective market share from the data, this yields the effective interaction with the right economic magnitude.

Graph Z demonstrates our results

## 5 A Structural Relationship Between Pass-Through and Market Power

In the above analysis, we have documented the reduced-form relations between the source of the exchange rate movement and the rate of pass through and we have interacted this with the relevant market share. We have also informally argued that the uncovered patterns are broadly consistent with pricing theories that argue for the importance of pricing to market and price complementarities. To formalise these statements, we now proceed to formulate a simple model of pricing to market that is based on Krugman (1987) and, in its loglinearized version, on Atkeson and Burstein (2008) (see also Yang (1997)).

The aim of this section is twofold. First, we want to confirm whether the reduced-form relations we have identified above can indeed be explained by a model of pricing to market, and if so under what conditions. Therefore, we rely on the preferences of Krugman (1987) in which markups are variable since a firm's market share affects the perceived elasticity of substitution. This captures two main economic forces: first, pass through is less than one as the markup adjusts to a cost shock and second, not only costs matter, but the entire market environment (which, in this formulation can be added into a single variable measuring the toughness of competition).

Second, we also want to evaluate to what extent the rather simple model of Atkeson and Burstein (2008) can quantitatively match pass through rates when it is calibrated using the constructed exchange rate fluctuations, partner-sector specific market shares, and other information on sector characteristics such as estimates of the elasticity of substitution. As Atkeson and Burstein (2008),

we do not view the proposed model as a general model of pricing to market, but rather as an as simple as possible departure from the case of constant elasticity demand. Demonstrating how far the calibrated model is from the data can thus teach us whether more complex theories of pricing to market are necessary to reconcile theory and data.

## 5.1 The Krugman-Atkeson-Burstein Model

We thus briefly describe the Krugman (1987) preferences and the loglinearization and estimation of the model in Atkeson and Burstein (2008). In each sector, a number of firms compete final consumption is produced by a competitive firm aggregating input goods into

$$c = \left( \int_0^1 y_k^{(\eta-1)/\eta} dk \right)^{\eta/(\eta-1)}$$

the final producer's optimization yields

$$y_k = \left( \frac{P_k}{P} \right)^{-\eta} c, \quad (6)$$

where  $P_i$  is the unit price of the final output and equal to  $\left( \int_0^1 P_k^{(\eta-1)} dk \right)^{1/(\eta-1)}$ . In each sector  $k$ , each input is produced by a set of  $n \in N$  monopolists, but the sector itself is again competitive and produces using only the inputs with a production function given by

$$y_k = \left( \sum_{n=1}^N q_{n,k}^{(\rho-1)/\rho} \right)^{\rho/(\rho-1)}$$

Cost minization yields the price of the sector-composite in as  $P_{i,k} = \left( \sum_{n=1}^N p_{n,k}^{(\rho-1)} \right)^{1/(\rho-1)}$  and demand for each individual input  $y_{n,k}$  as

$$q_{n,k} = y_k \left( \frac{P_{n,k}}{P_k} \right)^{-\rho} \quad (7)$$

Each producer faces a constant marginal costs  $\omega_n \tau_n c_{n,k}$  (which may include iceberg transportation costs) and maximizes profits subject to demand derived from (6) and (7). In addition to (6), the

only distinction from the standard Constant elasticity of substitution case of Dixit and Stiglitz (1977) is that firms do consider their effect on the demand for the sector, i.e. that their pricing decision has an influence on the.

$$P_{n,k} = \frac{\varepsilon(s_{n,k})}{\varepsilon(s_{n,k}) - \varepsilon(s_{n,k})} \omega_{n,k} \tau_{n,k} c_{n,k}$$

$$\varepsilon(s) = \left[ \frac{1}{\rho} (1 - s_{n,k}) + \frac{1}{\eta} s_{n,k} \right]^{-1}$$

Given that it is reasonable to assume that  $\rho > \eta$  (i.e. it is easier to substitute away from Reebok Shoes to Nike than to substitute away from shoes), a firm's perceived demand elasticity is decreasing in its market share and so its price is increasing.

Log-linearizing the firm's price yields

$$\widehat{P}_{n,k} = \Gamma(s_{n,k}) \widehat{s}_{n,k} + \widehat{w}_{n,k} \tag{8}$$

$$\widehat{s}_{n,k} = (\rho - 1) (\widehat{P}_k - \widehat{P}_{n,k})$$

where  $\Gamma(s_{n,k})$  measures the responsiveness of the markup to the market share, and is equal to  $\Gamma(s_{n,k}) = \frac{s_{n,k}(1/\eta - 1/\rho)}{1 - (1 - s_{n,k})/\rho - s_{n,k}/\eta} > 0$ .

## 5.2 Mapping Theory to our approach

We next map the above-described framework to our approach of identifying TPC and USD movements. In order to gauge precisely how market toughness matters, we would ideally have information on the sales of all single US producers and of all individual importing firms. Unfortunately, the BLS import price data does not include any information on quantities sold and also information on firm-specific sales by domestic firms is not available at the frequency we require.

In what follows below, we thus develop the main intuitions of our models for two easy cases, and we then gauge which underlying distribution of firms is the most likely one in the calibrations.

We thus use the information on aggregate bilateral imports and aggregate domestic production

in each sector to our dataset.

### 5.2.1 Assuming Equal-sized firms

The model is easiest to interpret when assuming that in the steady state, all firms are of equal size, so that  $\Gamma(s_{n,k}) = \frac{1/n(1/\eta-1/\rho)}{1-(1-1/n)/\rho-1/n\eta} \equiv \bar{\Gamma}/(1-\rho)$  is equal for all home and foreign firms. Given this symmetry assumption, the prices of all firms Denoting the fraction of firms from the US, a specific Trade Partner, and the ROW by  $n_{US}$ ,  $n_{TP}$ , and  $n_{ROW}$  respectively and the price change by firms originating from these nations by  $\hat{P}_{US}$ ,  $\hat{P}_{TP}$ , and  $\hat{P}_{ROW}$  respectively, the change in the sector's price index becomes

Log-linearizing  $\hat{P}_k$  yields

$$\hat{P}_k = n_{US}\hat{P}_{US} + n_{TP}\hat{P}_{TP} + n_{ROW}\hat{P}_{ROW}$$

$$\begin{aligned}\hat{P}_{n,k} &= \bar{\Gamma}\bar{s} + \hat{w}_{n,k} \\ \hat{s}_{n,k} &= (\rho - 1) \left( \hat{P}_k - \hat{P}_{n,k} \right)\end{aligned}\tag{9}$$

we can thus evaluate shocks to  $\hat{w}_{US}$ ,  $\hat{w}_{TP}$ , and  $\hat{w}_{ROW}$ .

$$\begin{aligned}\hat{P}_{US} &= -\frac{\bar{\Gamma} \left( n_{TP}\hat{P}_{TP} + n_{ROW}\hat{P}_{ROW} \right)}{(1 - \bar{\Gamma}(1 - n_{US}))} + \frac{\hat{w}_{USA}}{(1 - \bar{\Gamma}(1 - n_{US}))} \\ \hat{P}_{TP} &= -\frac{\bar{\Gamma} \left( n_{US}\hat{P}_{US} + n_{ROW}\hat{P}_{ROW} \right)}{(1 - \bar{\Gamma}(1 - n_{TP}))} + \frac{\hat{w}_{TP}}{(1 - \bar{\Gamma}(1 - n_{TP}))} \\ \hat{P}_{ROW} &= -\frac{\bar{\Gamma} \left( n_{US}\hat{P}_{US} + n_{TP}\hat{P}_{TP} \right)}{(1 - \bar{\Gamma}(1 - n_{ROW}))} + \frac{\hat{w}_{ROW}}{(1 - \bar{\Gamma}(1 - n_{ROW}))}\end{aligned}$$

Since all our prices are denominated in US Dollars and we only analyze cost shocks, we set  $\hat{w}_{US} = 0$ . Then, a widespread USD movement implies that  $\hat{w}_{ROW} = \hat{w}_{TP}$ .

$$\begin{aligned}\hat{P}_{TP} &= \frac{\bar{\Gamma}n_{US}}{(1-\bar{\Gamma}(1-n_{TP}))} \frac{\bar{\Gamma}(n_{TP}\hat{P}_{TP} + n_{ROW}\hat{P}_{ROW})}{(1-\bar{\Gamma}(1-n_{US}))} - \frac{\bar{\Gamma}n_{ROW}\hat{P}_{ROW}}{(1-\bar{\Gamma}(1-n_{TP}))} + \frac{\hat{w}_{TP}}{(1-\bar{\Gamma}(1-n_{TP}))} \\ \hat{P}_{ROW} &= \frac{\bar{\Gamma}n_{US}}{(1-\bar{\Gamma}(1-n_{ROW}))} \frac{\bar{\Gamma}(n_{TP}\hat{P}_{TP} + n_{ROW}\hat{P}_{ROW})}{(1-\bar{\Gamma}(1-n_{US}))} - \frac{\bar{\Gamma}n_{TP}\hat{P}_{TP}}{(1-\bar{\Gamma}(1-n_{ROW}))} + \frac{\hat{w}_{ROW}}{(1-\bar{\Gamma}(1-n_{ROW}))}\end{aligned}$$

$$\begin{aligned}\hat{P}_{TP} \left( (1-\bar{\Gamma}(1-n_{TP})) (1-\bar{\Gamma}(1-n_{US})) - \bar{\Gamma}^2 n_{US} n_{TP} \right) &= (\bar{\Gamma}-1) \bar{\Gamma} n_{ROW} \hat{P}_{ROW} + (1-\bar{\Gamma}(1-n_{US})) \hat{w}_{TP} \\ \hat{P}_{ROW} \left( (1-\bar{\Gamma}(1-n_{ROW})) (1-\bar{\Gamma}(1-n_{US})) - \bar{\Gamma}^2 n_{US} n_{ROW} \right) &= (\bar{\Gamma}-1) \bar{\Gamma} n_{TP} \hat{P}_{TP} + (1-\bar{\Gamma}(1-n_{US})) \hat{w}_{ROW}\end{aligned}$$

since  $(1-\bar{\Gamma}(1-n_{TP})) (1-\bar{\Gamma}(1-n_{US})) - \bar{\Gamma}^2 n_{US} n_{TP} = (1-\bar{\Gamma})(1-\bar{\Gamma}n_{ROW})$  and  $(1-\bar{\Gamma}(1-n_{ROW})) (1-\bar{\Gamma}(1-n_{US})) - \bar{\Gamma}^2 n_{US} n_{ROW} = (1-\bar{\Gamma})(1-\bar{\Gamma}n_{TP})$

$$\begin{aligned}\hat{P}_{TP} &= \frac{-\bar{\Gamma}n_{ROW}\hat{P}_{ROW}}{(1-\bar{\Gamma}n_{ROW})} + \frac{(1-\bar{\Gamma}(1-n_{US}))\hat{w}_{TP}}{(1-\bar{\Gamma})(1-\bar{\Gamma}n_{ROW})} \\ \hat{P}_{ROW} &= \frac{-\bar{\Gamma}n_{TP}\hat{P}_{TP}}{(1-\bar{\Gamma}n_{TP})} + \frac{(1-\bar{\Gamma}(1-n_{US}))\hat{w}_{ROW}}{(1-\bar{\Gamma})(1-\bar{\Gamma}n_{TP})}\end{aligned}$$

$$\hat{P}_{TP} = \underbrace{\frac{-\bar{\Gamma}}{(1-\bar{\Gamma})} n_{ROW} \hat{w}_{ROW}}_{\text{Effect of USD movements on } \hat{P}_k} + \underbrace{\frac{-\bar{\Gamma}}{(1-\bar{\Gamma})} n_{TP} \hat{w}_{TP}}_{\text{Effect of TP on } \hat{P}_k} + \underbrace{\frac{1}{(1-\bar{\Gamma})} \hat{w}_{TP}}_{\text{DirectCost Effect}}$$

To relate this to our empirical approach of identifying Cost-Pass through, we write  $\hat{w}'_{TP} \equiv \hat{w}_{TP} - \hat{w}_{ROW}$

$$\hat{P}_{TP} = \frac{1-(1-n_{US})\bar{\Gamma}}{1-\bar{\Gamma}} \hat{w}_{ROW} + \frac{1-\bar{\Gamma}n_{TP}}{1-\bar{\Gamma}} \hat{w}'_{TP}$$

We note that the following relations hold:

- $\frac{1-(1-n_{US})\bar{\Gamma}}{1-\bar{\Gamma}} > \frac{1-\bar{\Gamma}n_{TP}}{1-\bar{\Gamma}}$  if  $n_{Row} > 0$ , i.e. the PT following a widespread USD movement is

generally larger than following a TP movement.

- $\frac{\partial \frac{1-(1-n_{US})\bar{\Gamma}}{1-\bar{\Gamma}}}{\partial(1-n_{US})} > 0$ , i.e. PT following widespread USD movements is increasing in import penetration
- $\frac{\partial \left( \frac{1-\bar{\Gamma}n_{TP}}{1-\bar{\Gamma}} \right)}{\partial n_{TP}} > 0$ , i.e. PT following TPC movements is increasing in TP market share.

### 5.2.2 Allowing for firm Heterogeneity

Not only the mass of firms, but also the distribution of firm sizes matters for pass through. For example, for the same set of total exports, ERPT is large the less concentrated prices are. We thus also solve firm’s pricing decisions for two alternative scenarios.

1. All firms are equal-sized (variant: all importers are equal sized and all domestic firms are equal sized, but domestic firms are of different size than importers).
2. Each country admits one monopolist. That is, we assume that  $s_{n,k} = m_{c,k}$  where  $m_{c,k}$  is the country’s market share.
3. We infer the distribution of Firm sizes from prices. That is, we assume that within each NAICS industries, firm’s import shares are equal to  $s_{n,k} = (1 - m_{US,k}) \frac{p_{n,k}^{(\rho-1)}}{\sum_{n \in N_k} p_{n,k}^{(\rho-1)}}$  where  $m_{US,k}$  is the market share of US firms, for which we do not have individual prices, but aggregate quantities.

### 5.3 Calibration Results

We here present the results whether we can explain observed pass through rates, where we in principal want to explain three different sets of pass through rates:

1. Can we explain the variation of USD PT rates across industries?
2. Can we explain the variation in TPC PT rates across trade partner-sector pairs?
3. Can we explain the variation across average country-specific TPC pass through rates with the sectoral composition of each countries industry and the sectoral and trade partner -specific rate of pass through identified in 2?



## Results for case I Assuming Equal-Sized Firms

The scatterplot in Figure 1 compares the theoretically predicted to the empirically estimated Pass through rates for 24 3-digit NAICS industries with enough observations allowing us to estimate a pass through rate. On the horizontal axis, we report the empirically observed pass through rate following a USD movement estimated following (3). As is commonly found in the literature, there is a wide disparity in PT rates across sectors and a number of PT rates are below zero. The theoretically predicted PT rate is displayed on the vertical axis. Theoretically predicted PT rates can take values between 0 and 1, but most predicted rates are predicted rather high. (The outlier is industry NAICS XXX).

Overall, from this exercise, we conclude that we are able to qualitatively match pass through rates (estimated and predicted PT rates are positively correlated), but not quantitatively, as almost all observations would lie above the 45 degree line. There must be other factors determining incomplete pass-through.

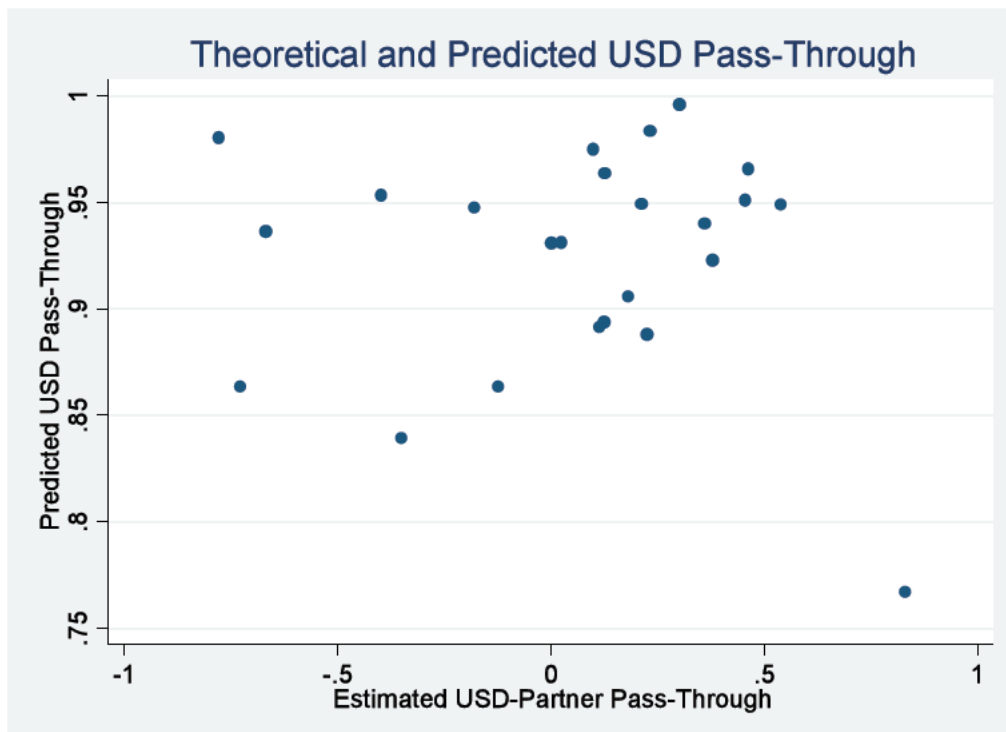


Figure 1:

Figure 2 documents the same relation between theory and data when we estimate trade partner-sector specific pass through rates following TPC movements. Here the number of observations is larger since there are roughly 175 trade-partner&3-digit Naics sectors-country combinations. Again, the empirically estimated PT rate is presented on the horizontal axis, while the vertical axis displays the predicted pass through rates.

While there again is a wide dispersion of estimated PT rates, there is a strong and significant positive relation between the two variables.

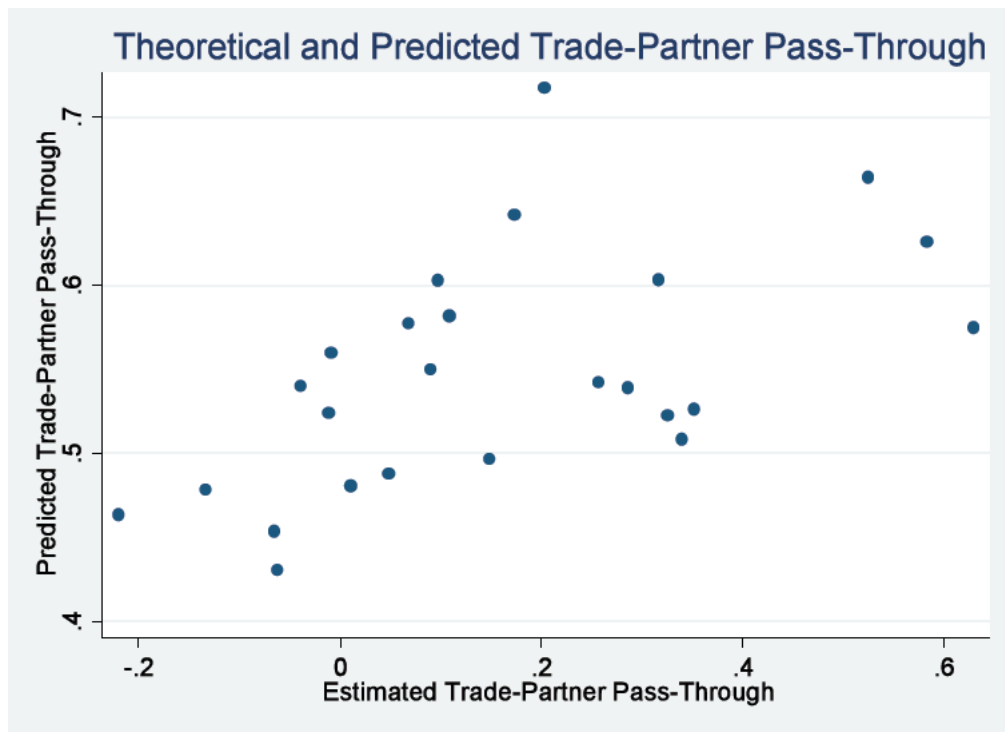


Figure 2:

@R Schönle: When redoing the graphs, we need to:

- add a regression line. Also report the slope of the regression line (it is a gauge of how far we are away from 1, the 45 degree line).

- Change title "Theoretical and Estimated PT Rates"

## 6 Conclusion

In this paper, we aim to understand whether the market structure and the way in which it affects pricing decisions of profit-maximizing firms is behind the incompleteness of long run exchange rate pass through (PT). Our analysis focuses on identifying how different exchange rate shocks affect the market environment differentially for different trade partners.

Our analysis proceeds in three steps. In the first step, we decompose bilateral exchange rate movements into US Dollar (USD) movements against the rest of the world on the one hand and trade-partner currency (TPC) movements against the rest of the world on the other hand. We show that USD movements are associated with a much higher PT rate than are TPC movements. Second, we document that TPC PT rate is increasing in the trade partner's sector specific market share and that the USD TP rate is decreasing in the market share of domestic producers.

Our findings are economically quite significant. For example, nearly two thirds of the average 2-year pass through rate in our sample is attributed to the fact that a trade partner market share is nonnegligible.

Last, we analyze whether a model of oligopolistic competition featuring variable markups can rationalize these patterns. In particular, we show that a model following Atkeson and Burstein (2008) can explain the empirically observed variation in pass through rates across sectors, trade partners, and sector-partner pairs when it is calibrated using our exchange rate decomposition and information on trade partner market shares.

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## 7 Tables



Table 1: Nominal vs USD or Trade Partner Pass Through Rates: Robustness Tests

Type of PT:	(1) Nominal	(2) USD	(3) Trade-Partner	(4) USD	(5) Trade-Partner	(6) Nominal	(7) USD	(8) Trade-Partner
Sample:	(1)-(3) All Observations, Single Estimation							
	(4)-(5) Full sample, joint estimation				(6)-(8) "High Volatility" Observations			
Horizon in Months	Nominal		USD		Nominal		USD	
1	0.075982	0.160401	0.056523	0.1598632	0.0577026	0.043515	0.150698	0.038827
	0.006579	0.014818	0.007343	0.0148161	0.00073438	0.009663	0.033611	0.011597
3	0.184533	0.315798	0.158452	0.3094034	0.1580078	0.165823	0.297983	0.177513
	0.009433	0.021877	0.010558	0.0218758	0.0105643	0.017621	0.051393	0.021272
6	0.249876	0.419579	0.220195	0.412164	0.2117234	0.19606	0.275609	0.204117
	0.013521	0.032416	0.015082	0.0325178	0.01511168	0.029078	0.084799	0.03263
12	0.311191	0.602546	0.26226	0.6335874	0.2561909	0.445255	0.494448	0.466066
	0.02189	0.061026	0.023494	0.0615382	0.023547	0.062459	0.194406	0.072063
18	0.318445	0.605754	0.28232	0.6842226	0.2797203	0.580702	1.769295	0.598237
	0.030958	0.092738	0.033015	0.0941571	0.0333118	0.099994	0.393909	0.113621
24	0.26383	0.738106	0.206856	0.883091	0.19632	0.662107	0.76073	0.790944
	0.043518	0.136451	0.04577	0.1388885	0.045985	0.208503	0.777754	0.219405

Table 2: Trade-Partner and USD Exchange Rate Pass-Through by Country

Country/Horizon	Trade-Partner	USD	Trade-Partner	USD
	6 months		12 months	
Canada	0.53	1.36	0.31	1.06
Mexico	0.01	0.48	0	0.46
Sweden	0.57	-0.63	0.96	1.1
Norway	0.15	0.34	0.09	0.74
Finland	0.23	0.45	0.51	1.06
Denmark	0	0.07	-0.05	0.28
UK	0.23	0.24	0.31	0.2
Ireland	0.29	0.47	0.42	-0.11
Netherlands	0.29	0.79	0.26	0.73
France	0.07	0.26	0.04	0.44
Germany	0.47	0.22	0.54	0.61
Austria	0.36	0.33	0.36	0.22
Czech Republic	0.07	0.2	-0.07	-0.52
Hungary	-0.13	0.6	-0.7	1.57
Switzerland	0.5	0.15	0.61	-0.17
China	0.81	-0.31	1	0.32
Portugal	0.37	0.43	0.21	0.12
Italy	0.26	0.25	0.21	-0.07
Greece	0.09	0.45	0.53	0.96
Singapore	-0.59	0.68	0.22	0.23
South Korea	0.1	0.32	0.14	0.55
Japan	0.32	0.24	0.37	0.8
Australia	0.44	0.88	0.8	1.18
New Zealand	0.21	0.55	0.1	0.53
Mean	0.24	0.37	0.30	0.51
Median	0.25	0.34	0.29	0.50

Table 3: The Impact of Unit Labor Cost Changes on the Exchange Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quarterly Ch. ULC	Baseline	Lags	More Lags	Lags, AR	non Euro	Euro	all	Euro
	0.4487	0.3572	0.2814	0.249	0.5568	0.1415	0.2814	0.3485
	[0.0513]**	[0.0493]**	[0.0535]**	[0.0536]**	[0.0631]**	[0.0611]*	[0.0535]**	[0.0793]**
Lag 1 Quarterly Ch. ULC		0.1566	0.1065	0.0811			0.1065	0.1782
		[0.0509]**	[0.0577]	[0.0555]			[0.0577]	[0.0794]*
Lag 2 Quarterly Ch. ULC		0.0406	-0.0449	-0.0454			-0.0449	-0.0478
		[0.0460]	[0.0518]	[0.0512]			[0.0518]	[0.0761]
Lag 3 Quarterly Ch. ULC		0.0811	-0.0228	-0.0403			-0.0228	0.0407
		[0.0435]	[0.0483]	[0.0475]			[0.0483]	[0.0680]
Lag 4 Quarterly Ch. ULC			0.035	0.0153			0.035	-0.0591
			[0.0494]	[0.0487]			[0.0494]	[0.0694]
Lag 5 Quarterly Ch. ULC			0.0962	0.0698			0.0962	0.0512
			[0.0490]*	[0.0483]			[0.0490]*	[0.0645]
Lag 6 Quarterly Ch. ULC			0.1585	0.1275			0.1585	0.1261
			[0.0480]**	[0.0469]**			[0.0480]**	[0.0637]*
Lag 7 Quarterly Ch. ULC			0.1749	0.1488			0.1749	0.2055
			[0.0558]**	[0.0538]**			[0.0558]**	[0.0745]**
Autoregressive Terms								
Lag 1 of the Exchange Rate				0.1142				
				[0.0360]**				
Lag 1 of the Exchange Rate				-0.0506				
				[0.0250]*				
Lag 1 of the Exchange Rate				0.0814				
				[0.0245]**				
Lag 1 of the Exchange Rate				-0.0267				
				[0.0259]				
Lag 1 of the Exchange Rate				0.0328				
				[0.0222]				
Lag 1 of the Exchange Rate				0.079				
				[0.0242]**				
Lag 1 of the Exchange Rate				-0.0072				
				[0.0250]				
Observations (Quarter *Country)	2337	2238	2106	2106	1257	1080	2106	1131
No. Countries	33	33	33	33	18	15	33	18

Dependent Variable is the Quarterly Change in the Bilateral Exchange Rate against the USD  
Robust standard errors in brackets, \* significant at 5%; \*\* significant at 1%

Table 4: Monthly Fractions of Price Changes under High Volatility

	Fraction All	Fraction Up	Fraction Down	Fraction Small
Baseline	15.75% (0.05%)	7.98% (0.04%)	7.78% (0.03%)	28.52% (1.01%)
High Nominal Volatility	20.90% (0.17%)	10.65% (0.13%)	10.25% (0.13%)	31.55% (2.56%)
High USD Volatility	21.36% (0.16%)	11.05% (0.13%)	10.31% (0.12%)	32.12% (2.64%)
High Trade-Partner Volatility	21.84% (0.17%)	11.37% (0.13%)	10.47% (0.13%)	31.80% (2.47%)
High Risk 1 Volatility	6.28% (0.05%)	3.17% (0.04%)	3.11% (0.04%)	35.82% (2.88%)
High Risk 2 Volatility	6.28% (0.05%)	2.98% (0.04%)	3.30% (0.04%)	31.67% (2.96%)
High Risk 3 Volatility	8.45% (0.06%)	4.53% (0.04%)	3.93% (0.04%)	30.10% (2.82%)
High Risk 4 Volatility	15.54% (0.09%)	7.86% (0.06%)	7.69% (0.06%)	33.13% (2.30%)

Table 5: Size of Price Changes

	$\Delta p$	$ \Delta p $	$\Delta p > 0$	$\Delta p < 0$
Baseline	0.02% (0.08%)	7.37% (0.07%)	7.29% (0.10%)	-7.44% (0.11%)
High Nominal Volatility	-0.25% (0.19%)	7.41% (0.18%)	7.02% (0.25%)	-7.80% (0.25%)
High USD Volatility	-0.67% (0.19%)	7.88% (0.17%)	6.97% (0.21%)	-8.86% (0.28%)
High Trade-Partner Volatility	0.01% (0.18%)	7.17% (0.16%)	6.89% (0.21%)	-7.47% (0.26%)
High Risk 1 Volatility	-0.98% (0.20%)	7.71% (0.19%)	6.66% (0.25%)	-8.78% (0.27%)
High Risk 2 Volatility	-1.62% (0.18%)	7.80% (0.16%)	6.53% (0.19%)	-8.96% (0.26%)
High Risk 3 Volatility	-0.45% (0.12%)	6.96% (0.11%)	6.08% (0.13%)	-7.98% (0.20%)
High Risk 4 Volatility	-0.09% (0.12%)	6.48% (0.11%)	6.32% (0.15%)	-6.64% (0.16%)

# 8 Graphs

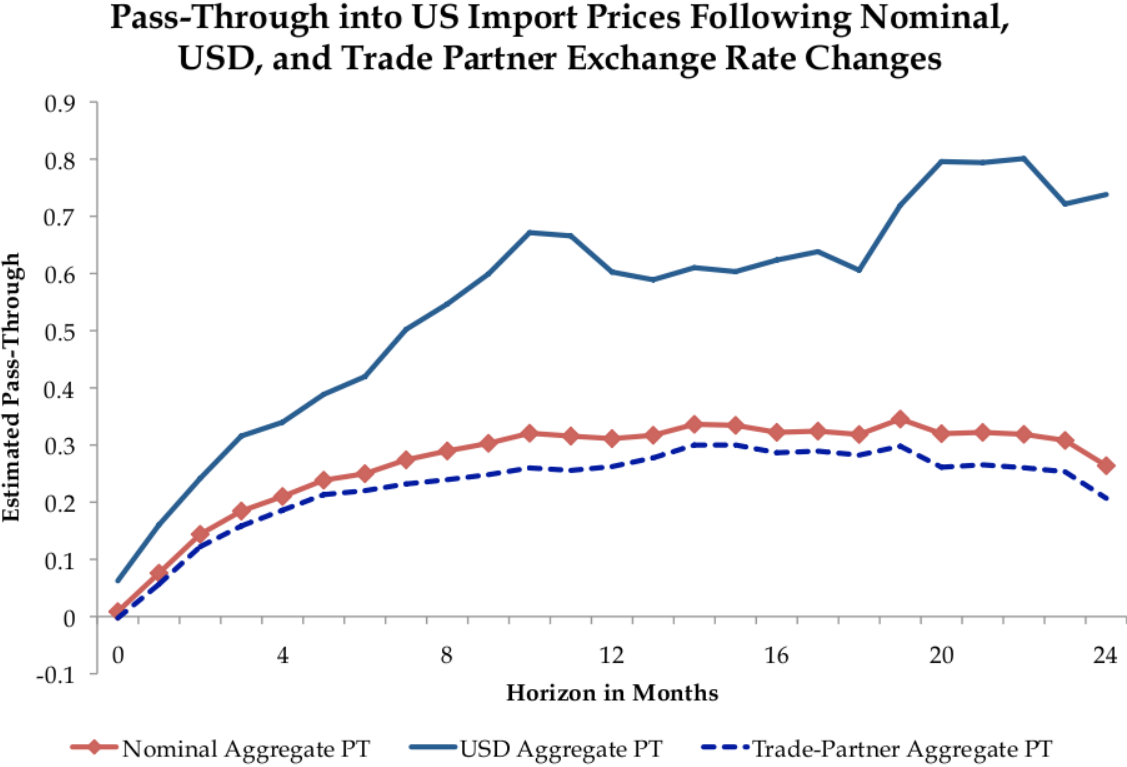


Figure 3: Pass-Through of Different Exchange Measures into US Import Prices

### Pass-Through under Joint Estimation (With 95% C.I.)

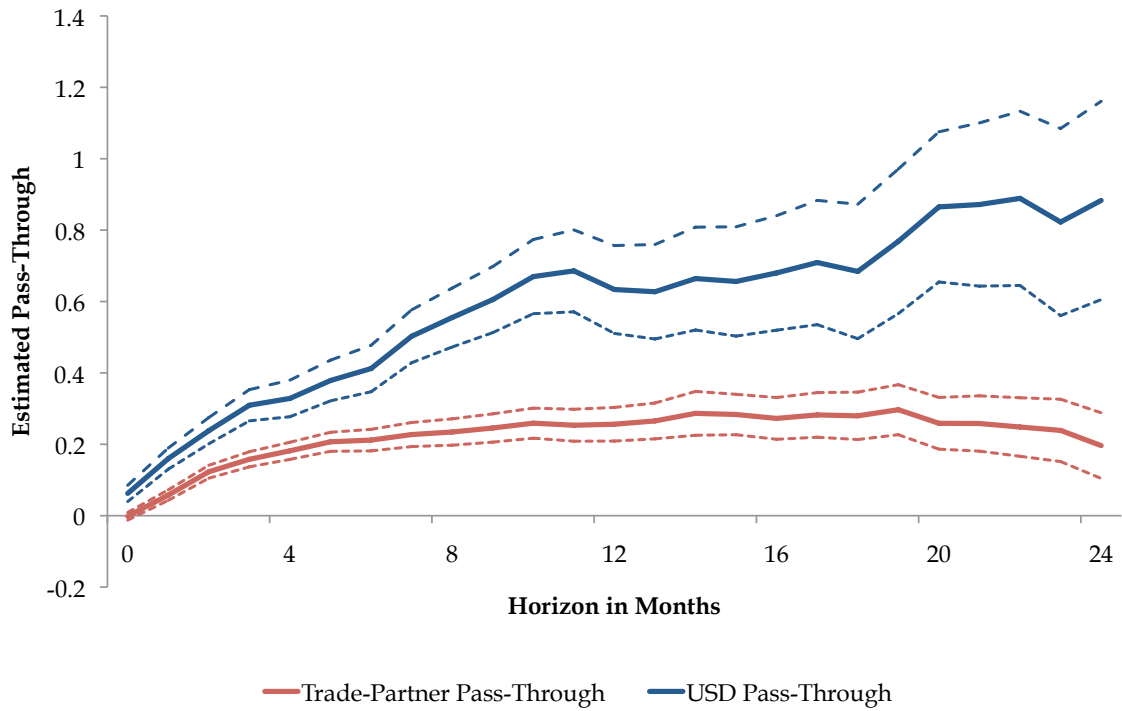


Figure 4: Jointly Estimated Pass-Through of USD and Trade-Partner Exchange Rate Changes into US Import Prices

### Pass-Through for TP and USD Movements for Two Selected Industries

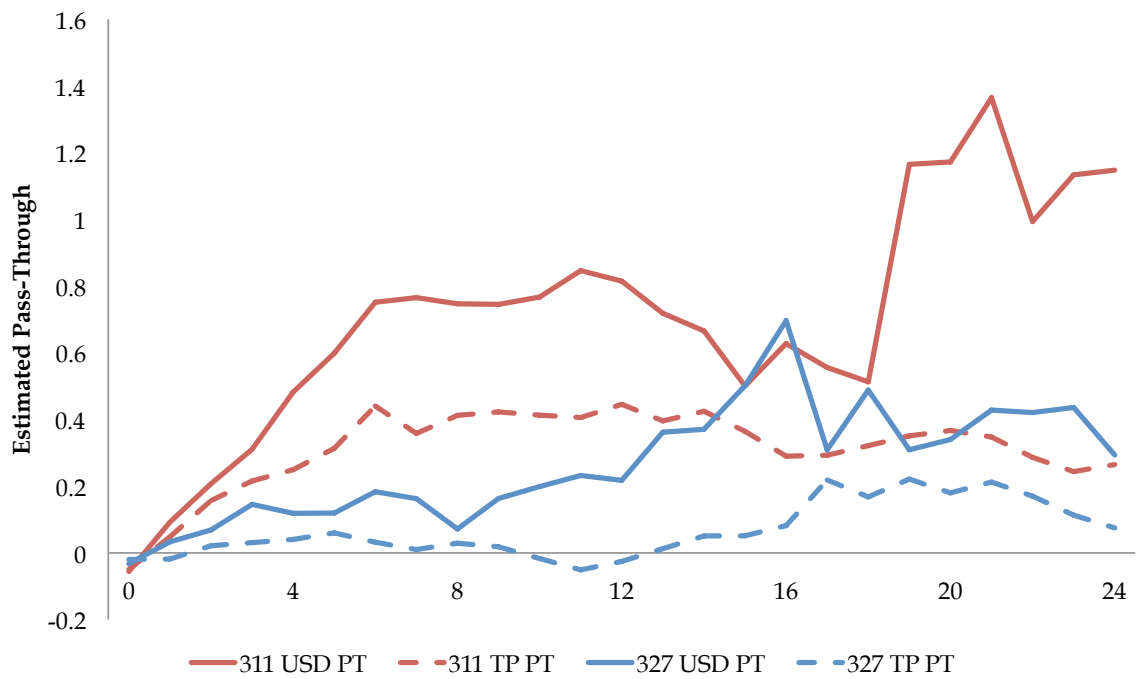


Figure 5: Pass-Through for TP and USD Movements for NAICS Industries 311 and 327

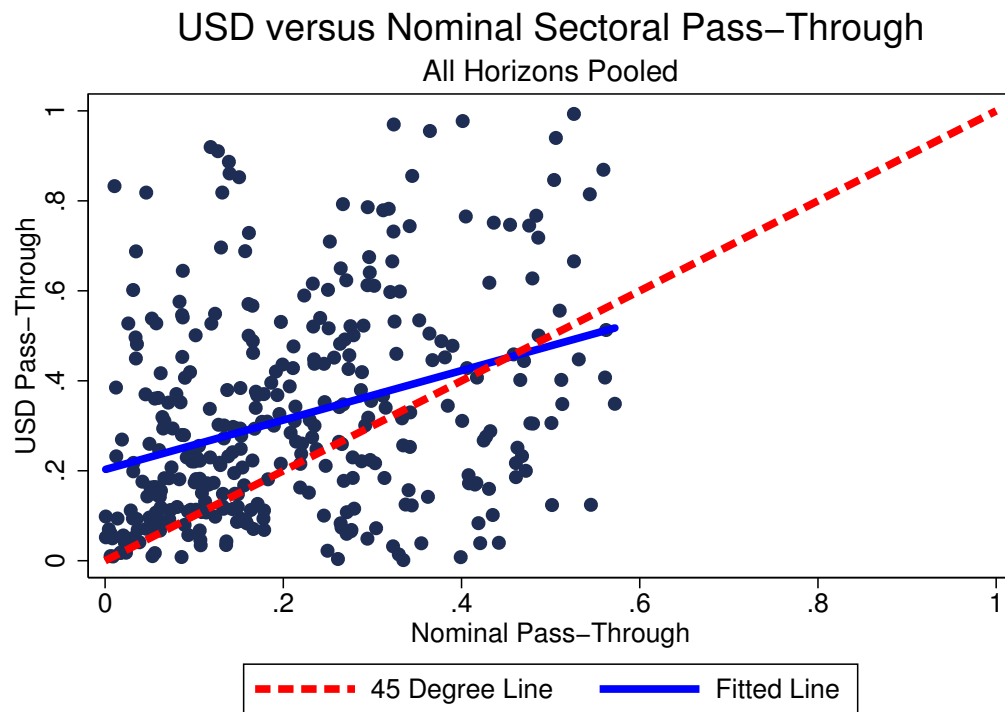


Figure 6: USD and Nominal Exchange Rate Pass-Through into US Import Prices



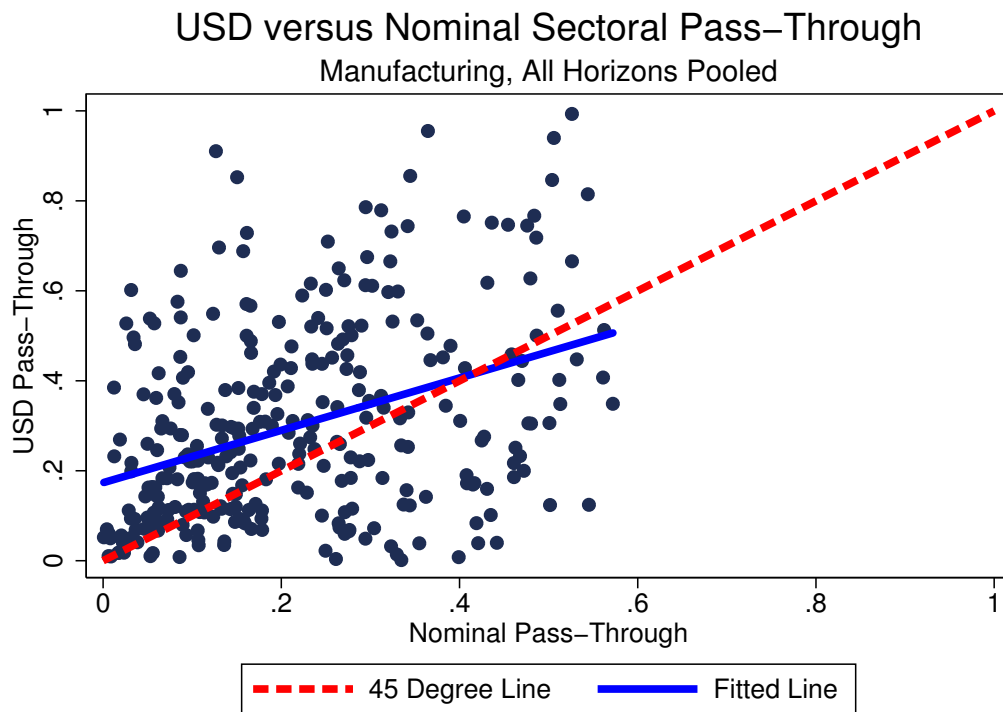


Figure 7: USD and Nominal Exchange Rate Pass-Through into US Import Prices, Manufacturing

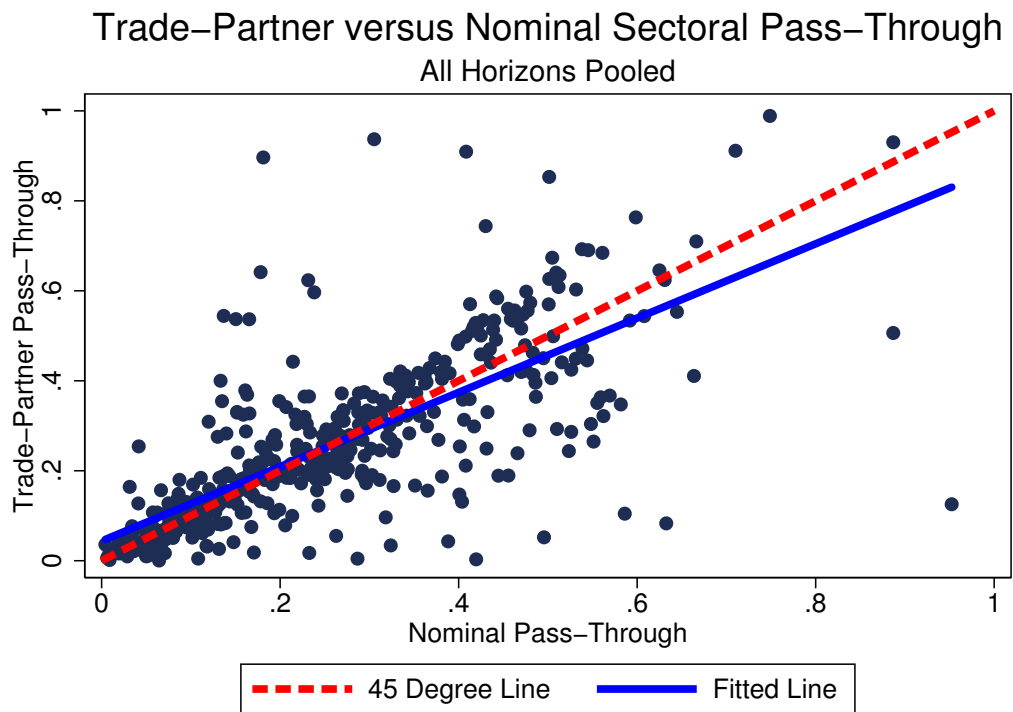


Figure 8: Trade-Partner and Nominal Exchange Rate Pass-Through into US Import Prices

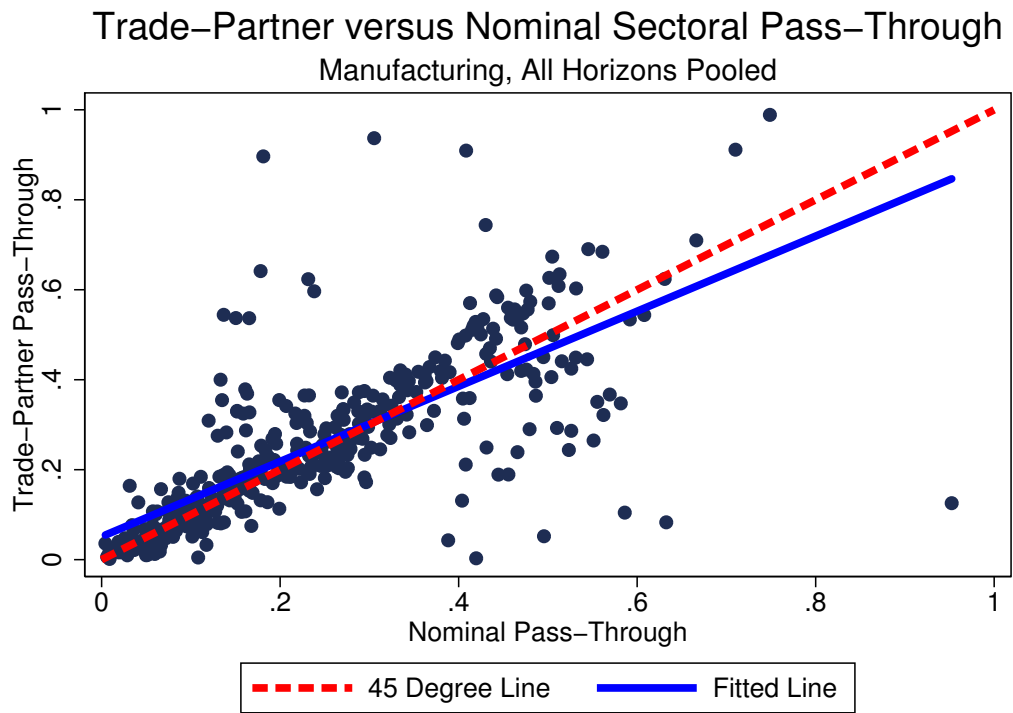


Figure 9: Trade-Partner and Nominal Exchange Rate Pass-Through into US Import Prices, Manufacturing

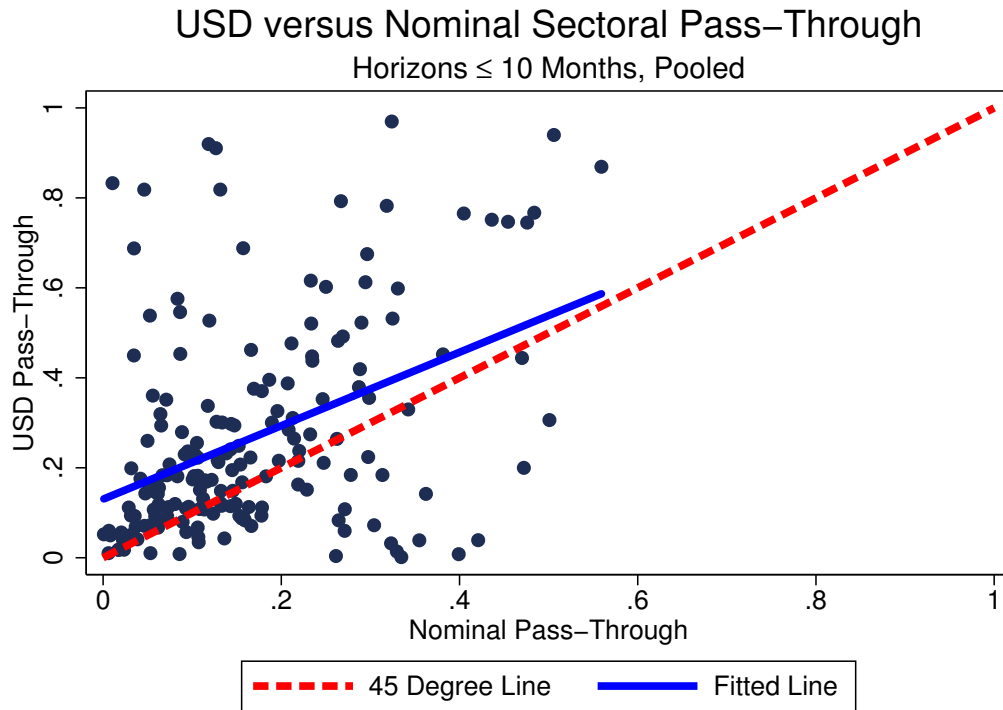


Figure 10: USD and Nominal Exchange Rate Pass-Through into US Import Prices, 0-10 Months Horizon

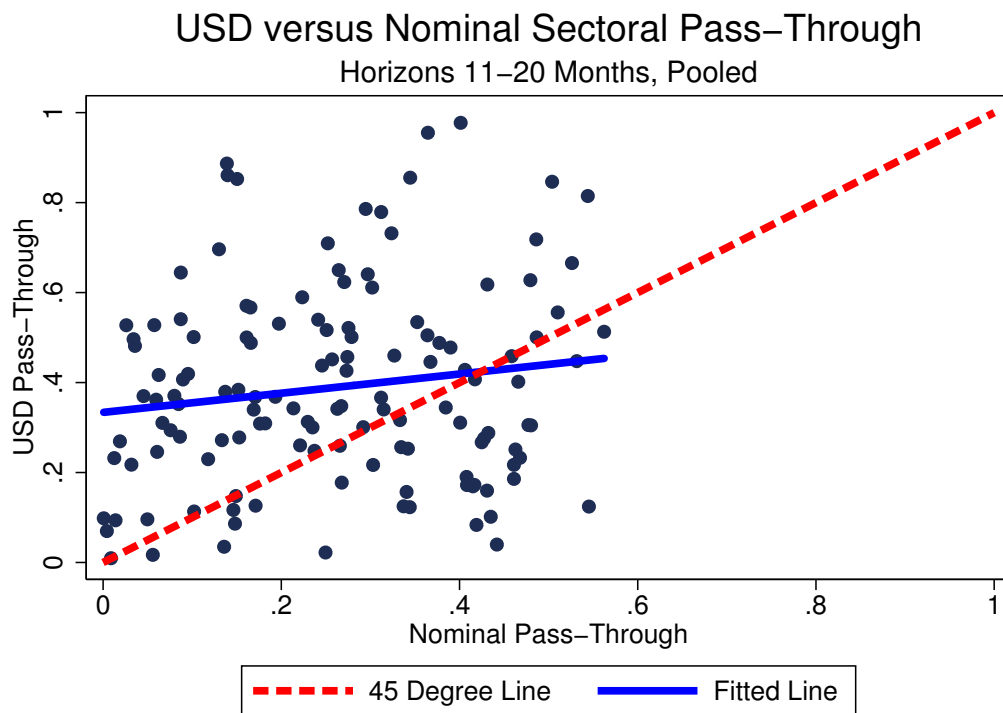


Figure 11: USD and Nominal Exchange Rate Pass-Through into US Import Prices, 11-20 Months Horizon

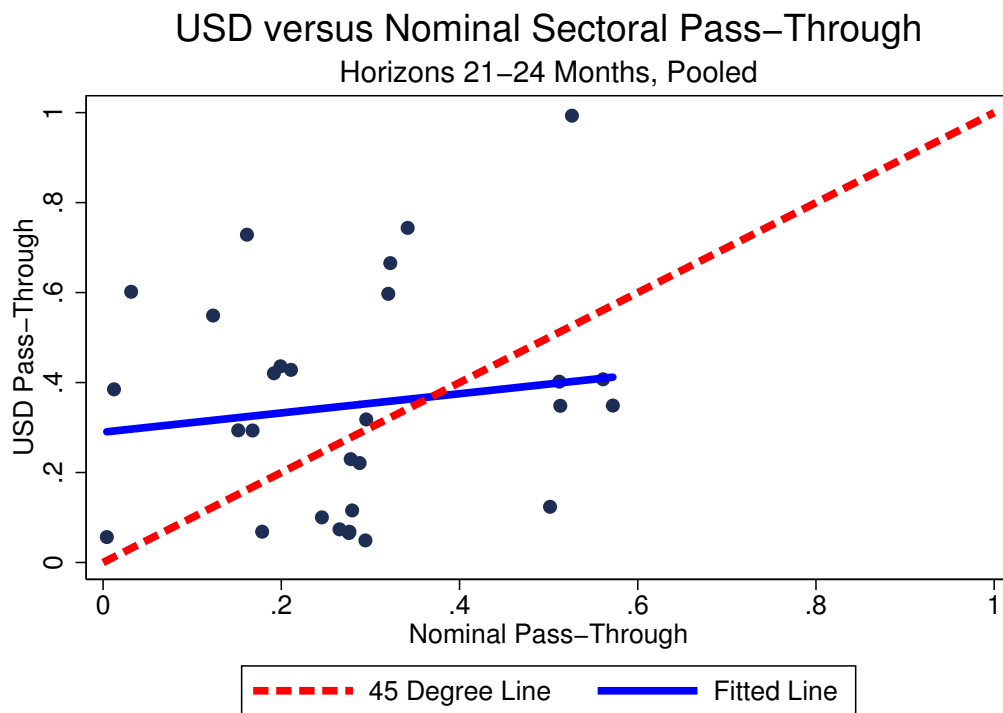


Figure 12: USD and Nominal Exchange Rate Pass-Through into US Import Prices, 21-25 Months Horizon

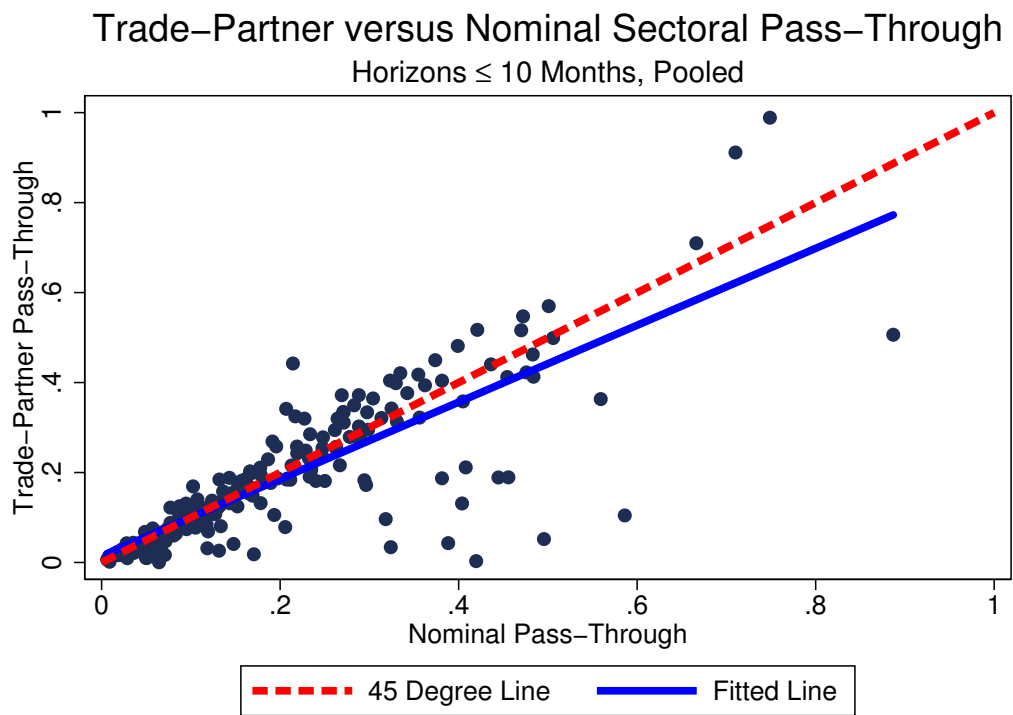


Figure 13: Trade-Partner and Nominal Exchange Rate Pass-Through into US Import Prices, 0-10 Months Horizon

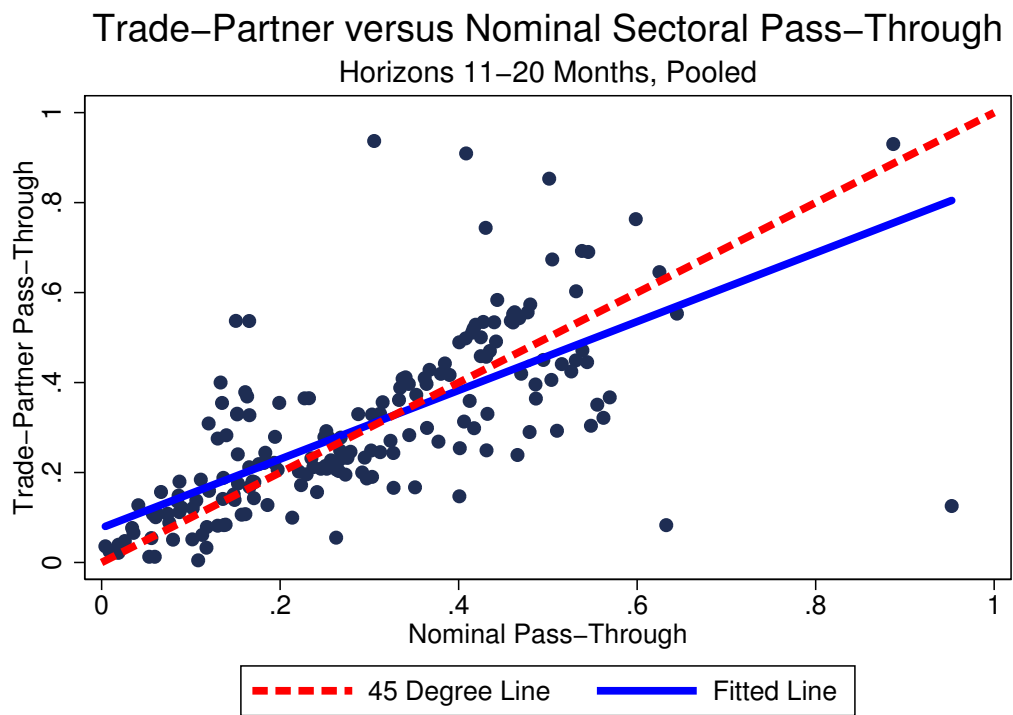


Figure 14: Trade-Partner and Nominal Exchange Rate Pass-Through into US Import Prices, 11-20 Months Horizon



Trade-Partner versus Nominal Sectoral Pass-Through  
Horizons 21-25 Months, Pooled

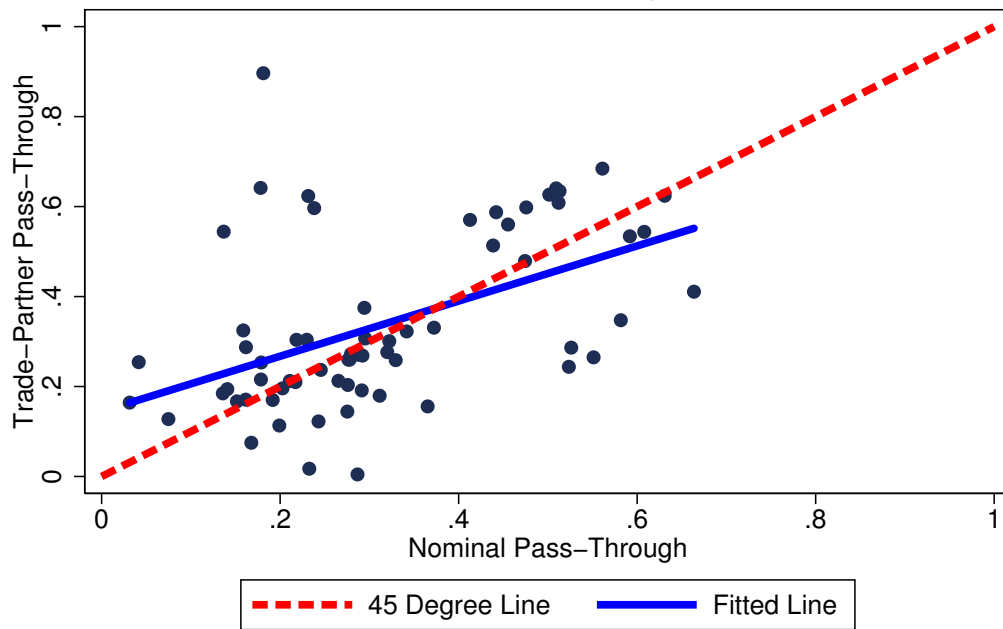


Figure 15: Trade-Partner and Nominal Exchange Rate Pass-Through into US Import Prices, 21-25 Months Horizon