The International Price System

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Abstract

I define and provide empirical evidence for an "International Price System" in global trade employing data for thirty-five developed and developing countries. This price system is characterized by two features. First, the overwhelming share of world trade is invoiced in very few currencies, with the dollar the dominant currency. Second, international prices, in their currency of invoicing, are not very sensitive to exchange rates at horizons of up to two years. In this system, a good proxy for a country's inflation sensitivity to exchange rate fluctuations is the fraction of its imports invoiced in a foreign currency. U.S. inflation is consequently more insulated from exchange rate shocks, while other countries are highly sensitive to it. Exchange rate depreciations (appreciations) make U.S. exports cheaper (expensive), while for other countries they mainly raise (lower) mark-ups and hence profits. U.S. monetary policy has spillover effects on inflation in other countries, while spillovers from other countries monetary policies on to U.S. inflation are more muted.

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1 Introduction

The relative price of a country's currency, that is its exchange rate, is the protagonist in debates on international spillovers of monetary policy and international trade competitiveness. Yet, the popular discourse on how exchange rate fluctuations impact inflation and trade is often quite simplistic. An exchange rate depreciation is perceived to be inflationary as the price of imported goods rise, and is perceived to improve a country's trade balance as it becomes more competitive. What appears to be absent is a systematic notion of why inflation in some countries may be more sensitive to exchange rate fluctuations than others.

I will argue that there are indeed systematic features of international prices that provide concrete predictions for the sensitivity of a country's inflation to exchange rate fluctuations. In addition there are important asymmetries across countries in the degree of sensitivity. Accordingly I define an 'International Price System' characterized by two key features: Firstly, the overwhelming share of world trade is priced/invoiced in a small set of currencies, with the dollar the dominant currency. Secondly, international prices *in their currency of invoicing*[1] are not very sensitive to exchange rates at horizons of up to two years. This implies that a good proxy for the sensitivity of a country's traded goods inflation to exchange rates is the fraction of its imports invoiced in a foreign currency (that is, not in its own currency). The higher this fraction the greater the sensitivity of traded goods inflation to exchange rate fluctuations and by extension to global shocks. I assemble data on prices and currency invoicing shares for thirty five developed and developing countries to establish these facts.

As an example take the case of three countries, the U.S., Japan and Turkey. As defined by the I.M.F. the U.S. and Japan are developed countries and Turkey is an emerging/developing country. Figure 1 plots the pass-through into the aggregate import price index[2] (and 2-standard-error bands) for each of the three countries, estimated using quarterly data over the sample period 1990-2014. The estimation details are provided in Section 2. In the case of Turkey (thick solid line),

[1] I will use the currency of invoice terminology to describe the currency in which prices are denominated. While the invoicing currency does not necessarily have to be the same as the currency of denomination, in practice they are, as documented in Friberg and Wilander (2008).

[2] Specifically for Japan and Turkey it is the import price index (unit value) from the International Financial Statistics database (IFS). For the U.S. it is the import price index excluding petroleum from the Bureau of Labor Statistics (BLS).

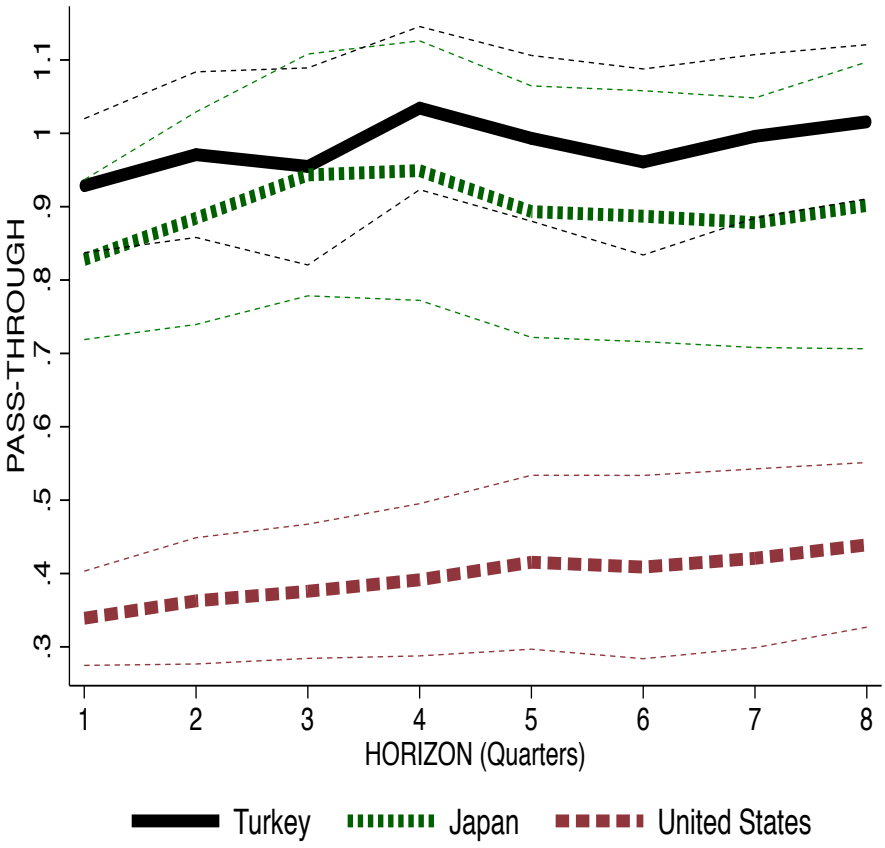


Figure 1: A Tale of Three Countries

a 10% depreciation of the Turkish Lira relative to its trading partners results in its import prices in Lira rising by 9.3% one quarter after the shock and by 10.0% eight quarters after the shock, a horizon referred to as the 'long-run'.[3] For Japan (thick short-dashed line) a 10% yen depreciation relative to its trading partners raises its prices by 8.3% after one quarter and cumulates to 9.0% after eight quarters, that is a ninety percent pass-through in the long-run. In the case of the U.S. (thick dashed line) the numbers are much lower at 3.4% and 4.4%, that is 44% pass-through in the long-run.[4]

There are two striking features of Figure 1. Firstly, while Japan and the U.S. are more similar in

[3]It is empirically a challenge to estimate the 'very' long-run impact that exceeds two years. As highlighted in Rogoff (1996) the "consensus view" for the average half-life of real exchange rate deviations for developed countries is 3-5 years, and the confidence bands surrounding these estimates are large as shown by Murray and Papell (2002) and Rossi (2005).

[4]This high degree of pass-through for Turkey and Japan is also estimated for sub-indices of import prices. For instance, the pass-through (standard error) into the manufacturing sub-sample of import prices for Turkey is 0.99 (0.06) in the short-run and 1.02 (0.08) in the long-run. In the case of Japan these numbers for manufacturing are 0.93 (0.11) in the short-run and 0.90 (0.21) in the long-run.

terms of income levels and the reserve currency status of their currencies, pass-through into Japan is both quantitatively and statistically similar to Turkey as compared to the U.S. Secondly, for each country there is little difference between its short-run and long-run pass-through as evident from the lack of any significant slope in the pass-through lines.

Both of these features can be accounted for by the definition of the International Price System. Both Turkey and Japan invoice a small fraction of their imports in their home currency, 3% and 24% respectively. Sixty percent of Turkey's imports are invoiced in dollars even though imports from the U.S. comprise on average 6% of its total imports. Similarly, 71% of Japanese imports are invoiced in dollars, while the U.S. trade share of its imports is only on average 13%. Unlike Japan and Turkey, 93% of U.S. imports are invoiced in its home currency, dollars. These facts are consistent with the first piece of the definition on dollar dominance in trade invoicing. When combined with the second piece of the definition that international prices in their currency of invoicing are not very sensitive to exchange rates at horizons of up to two years, the pass-throughs depicted in Figure 1 follow straightforwardly. Because 76% (97%) of Japan's (Turkey's) imports are invoiced in a currency not its own and that price has low sensitivity to the exchange rate, the pass-through into its own currency from exchange rate fluctuations will be high both in the short and long-run. Conversely, pass-through into U.S. import prices in dollars will be low both in the short and long-run.

As I demonstrate in the paper, this phenomenon that ties pass-through rates to currency invoicing and that keeps long-run pass-through rates close to short-run pass-through rates is a robust finding across many specifications. Firstly, evidence for Japan, Turkey and the U.S. extends to many other countries. Secondly, using detailed import price data for the U.S. I show that it holds even *within countries* and *within sectors* as detailed as 10-digit HS codes for goods invoiced in different currencies. That is, even for the U.S., the subset of its imports that are priced in foreign currency have the same high pass-through as what is observed for Turkey and Japan. Thirdly, it holds even when one conditions on price changes. That is goods invoiced in a foreign currency have higher pass-through into home currency prices as compared to goods invoiced in the home currency *even conditional on a price change*. Lastly, it holds for the sub-sample of trade transactions that are arms-length and not intra-firm.

The International Price System (IPS) has several implications for monetary policy and for the international spillovers of monetary policy. Firstly, it has positive implications for inflation stabilization. The IPS implies that inflation stabilization in response to exchange rate fluctuations (that arise from external shocks) is a smaller concern for the U.S. as compared to countries like Turkey. Using input-output tables to measure the import content of consumer goods expenditure[5] I estimate the direct impact of a 10% dollar depreciation to cumulatively raise U.S. CPI inflation over two years by 0.4-0.7 percentage points.[6] On the other hand a 10% depreciation of the Turkish Lira will raise cumulative inflation by 1.65-2.03 percentage points.

As the U.S. considers raising interest rates one concern often expressed is the consequence of the dollar appreciation on inflation. According to the IPS moderate dollar appreciations are unlikely to generate major disinflationary concerns for the U.S. but important inflationary concerns for a country like Turkey as its currency depreciates relative to the dollar.

On the flip side, dampening (raising) inflation to meet targets via contractionary (expansionary) monetary policy receives much less support from the exchange range channel for the U.S. than it does for Turkey.

Secondly, the IPS has implications for export competitiveness and trade balance adjustment following exchange rate fluctuations. An exchange rate depreciation (appreciation) is perceived to make a country's exports immediately cheaper (expensive) on world markets. However for the vast majority of countries whose exports are invoiced in a foreign currency this is unlikely to be the case. Consider Japan that has only 33% of its exports invoiced in its home currency. A yen depreciation will make only a small fraction of its exports cheaper, but instead will raise the mark-ups and hence profits of its exporting firms. This will be even more true for developing countries that typically have close to a 100% of their exports invoiced in a foreign currency. On the other hand, a dollar depreciation will make almost all of U.S. exports cheaper given that 97% of its exports are invoiced in dollars (home currency).

The first and second implications together imply that trade balance adjustments, through

[5]This includes both the direct import content measured as the fraction of consumption expenditure on imported consumer goods and the indirect import content that is the value of imported inputs used in the production of domestic consumer goods that enter the consumption bundle.

[6]To be clear there are no permanent effects on inflation, only that following the exchange rate shock consumer prices increase over two years by 0.4-0.7 percentage points.

relative price effects, are more likely to be driven by adjustments in exports in countries like the U.S., while being driven by adjustments in imports in countries like Turkey.

Thirdly, the IPS can generate asymmetries in monetary policy spillovers across countries. Consider the extreme of a world with 100% dollar invoicing. In this world consider a tightening of monetary policy in the U.S. This generates a stronger dollar and a weaker rest-of-the-world (ROW) currency. The high pass-through into import prices in the ROW then puts pressure on the ROW to tighten monetary policy as a consequence of the impact on inflation. On the other hand, a monetary tightening in the rest of the world has very low impact on U.S. inflation and consequently on U.S. monetary policy via the inflation channel.[7] In reality while the world is not 100% dollarized it is highly skewed towards dollar pricing and asymmetric monetary policy impacts via inflation can be important. This provides another argument for countries that have a large presence in world trade like China to internationalize their currency, as an increase in its use in world trade will have the added benefit of insulating domestic inflation from external shocks. Lastly, if firms were to price in SDRs, the IMF's unit of account, this could bring about greater symmetry. However for this to be optimal to adopt from an individual firm's perspective it should be simultaneously adopted by a large number of importers and exporters.

On going discussions of monetary policy spillovers focus on asset markets, with the prominence of the dollar in world asset trade flagging concerns about a global credit cycle driven by U.S. monetary policy, as in the important works of Rey (2013) and Bruno and Shin (2015). The IPS implies a similar asymmetry driven by the prominence of the dollar in world *goods* trade. The dollar is often described as enjoying an 'exorbitant privilege' owing to its reserve currency status in asset markets. One could argue that the dollar also enjoys a 'privileged insularity,' as regards inflation, owing to its invoicing currency status in world trade.

Finally I provide a theoretical discussion of how global value chains and global competition in product markets give rise to and sustain the IPS when it is costly to adjust prices. When prices are set flexibly currency invoicing is irrelevant. A Japanese firm selling to the U.S. should be indifferent between quoting a dollar price or quoting an equivalent yen price using the spot

[7]For a complete analysis of monetary policy spillovers one needs to consider the impact on other variables, besides inflation, such as the output gap. My statements are restricted to the inflation channel given this symposium's focus on inflation.

exchange rate. This is however no longer the case when there are costs to renegotiating prices and consequently prices are sticky in the invoicing currency. In this case when the firm chooses its price and the invoicing currency it takes into account the implications for its profits during the whole period when the chosen price will be in effect. Optimality implies that firms make their choices to mimic how much they would pass-through if they could choose prices flexibly. This so called 'desired' pass-through depends on the sensitivity of the firms' marginal costs and of its desired mark-up to exchange rate movements. Importantly, this sensitivity depends on the currency invoicing choices of other exporters.

For instance, consider a Japanese firm exporting to the U.S. If the dollar is the predominant currency of invoicing for other exporters, then the Japanese firm's imported inputs are priced in and (at least partially) sticky in dollars. This implies that its marginal costs in dollars are less sensitive to exchange rate movements, and consequently the Japanese firm has low desired pass-through into dollar prices and therefore will choose to price in dollars. A similar argument applies to the mark-up channel. If the Japanese firm faces competition in the U.S. market from other producers, both domestic and foreign, who set prices in dollars then profit maximization requires that the firm keep its price stable relative to its competitors so as not to lose market share. For this reason too its desired pass-through is low. During the period when the price is sticky this low desired pass-through can be attained by invoicing in dollars, so that yen-dollar exchange rate movements do not impact the dollar import price. Owing to these reasons, we should expect to find short-run pass-through to be close to long-run pass-through, as the latter approximates desired pass-through, which is what I find in the data. Importantly, if world trade markets are characterized by a predominance of dollar invoicing then through network effects this incentivizes any entrant exporter to also choose dollar invoicing.

The paper proceeds as follows. Section 2 defines the IPS and presents empirical evidence for it. Section 3 extends the analysis to consumer prices. Section 4 elaborates on the policy implications. Section 5 provides a theoretical discussion of determinants of pass-through into import prices and currency invoicing that rationalizes the existence of the IPS along with a survey of empirical evidence on currency invoicing patterns. Section 6 concludes.

2 Empirical evidence on the International Price System

In this section I define the IPS and present empirical evidence for it. The theoretical discussion of the link between pass-through and currency invoicing is provided in Section 5. I relegate details of the data used in the empirical analysis to the Appendix.

Definition 2.1. The International Price System is defined by:

1. **Dominance of dollar invoicing in world trade**
   (a) Relative stability of invoicing patterns over time.
2. **International prices, in their currency of invoicing, are not very sensitive to exchange rates at horizons of up to two years.**
   (a) Countries with high short-run pass-throughs have high long-run pass-through.
   (b) Countries with higher shares of imports invoiced in a foreign currency have higher short-run and long-run pass-through.
   (c) Conditional on a price change, prices in their currency of invoicing have low sensitivity to exchange rate shocks.

IPS Definition 1: Dominance of dollar invoicing in world trade

The volume of global merchandize trade now stands at 19.05 trillion dollars[8] having grown tremendously over the last several decades. As is well known, much of world trade is invoiced in very few currencies. Figure 2 provides evidence of this phenomenon using data from countries that report both trade flows disaggregated by counter-party country and by currency. I build on the empirical work of Goldberg (2011), Goldberg and Tille (2009a) and Ito and Chinn (2013) and include additional countries/years in the sample (details reported in Appendix D). Specifically I study 43 countries for imports and 44 countries for exports. The countries with information on both imports and exports are: Argentina, Australia, Austria, Belgium, Brazil, Canada, Colombia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary,

[8] This is defined as the average of world imports and exports.

Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, the Netherlands, Norway, Pakistan, Poland, Portugal, Romania, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, and the United Kingdom. In addition, Malta and Peru have imports data; and Algeria, Malaysia, and South Africa have exports data. These countries represent approximately 55% of world imports, and 57% of world exports.

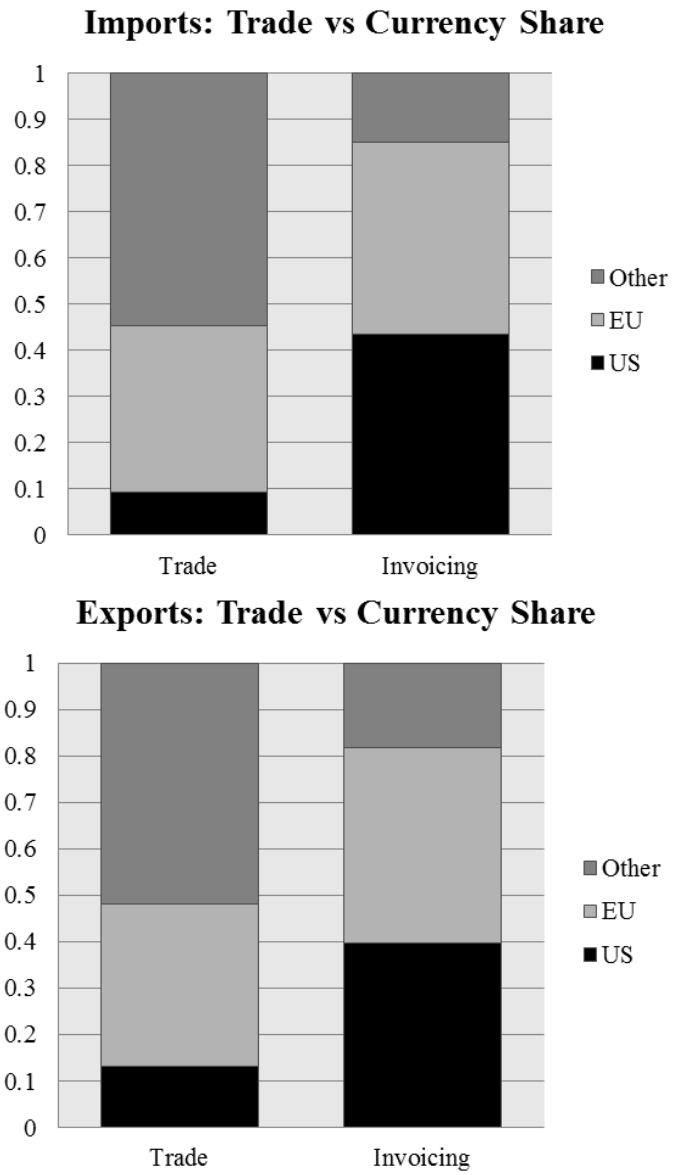


Figure 2: Dollar Dominance in World Trade: Aggregate

The top panel of Figure 2 represents the share of imports that are imported from the US, Eurozone, or the rest of the world; versus the share of imports that are invoiced in dollars, euros, or other currencies.[9] Specifically, for each country I calculate the share of imports from the U.S.,

[9]The trade shares data is the average of the quarterly data from 1999 - 2014 and the invoicing data is computed

from the Eurozone, and from all other sources as a share of its total imports.[10] I then calculate a weighted average of these shares across countries, weighted by the size of their imports, and this is reported in the column labeled "Trade". For the "Invoicing" column I construct the share of each countries imports that are invoiced in dollars, in euros and in other currencies and plot the weighted average. The lower panel performs the same calculation for exports.

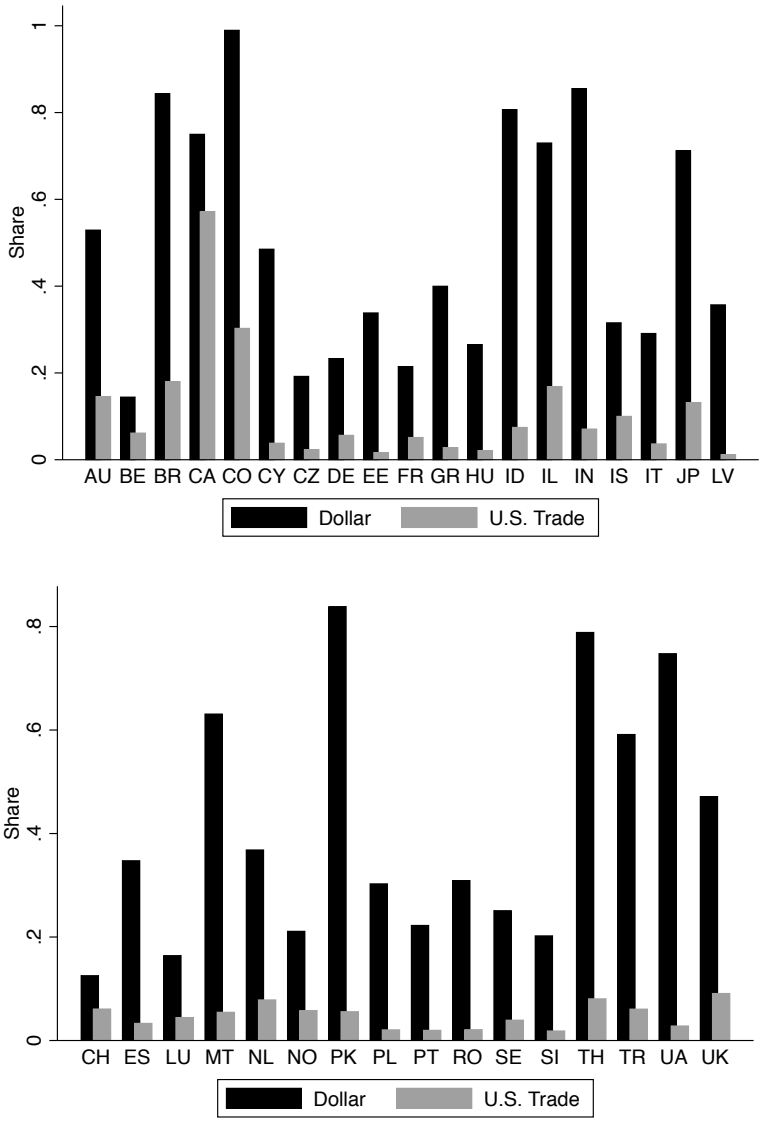


Figure 3: Dollar Dominance in World Trade: By Country

These invoicing shares are likely highly conservative for the dollar and euro - in reality, the dollar or euro shares are likely higher relative to the US or Eurozone trade. First, countries do

as the average of the post-1999 years for which we have data.

[10]We exclude the U.S. from the sample because of course there is no "US" trade counter-party, which would only serve to artificially increase the non-US trade and the dollar invoicing share.

not always report invoicing figures for 100% of their trade data. To be conservative, any residual was tallied as other currencies. For instance, Algeria only reported 49% of its trade in Euros. The residual 51% was ascribed to "Other", even though much of it is likely in dollars. More generally, currency invoicing information is scarcer for developing countries and they tend to overwhelmingly invoice in dollars (outside of the euro area).[11]

Despite this the dollars share as an invoicing currency is estimated to be around 4.7 (3.1) times its share in (my sample of) world imports (exports). The euro's share is more closely aligned at 1.2 times for imports and exports. Figure 3 plots the dollar's invoicing share in imports (black bar) next to the share of imports from the U.S. (grey bar) for each country, and the overwhelming use of the dollar in trade transactions is clearly evident. (Country names and ISO codes are listed in Table 10 in Appendix A.)

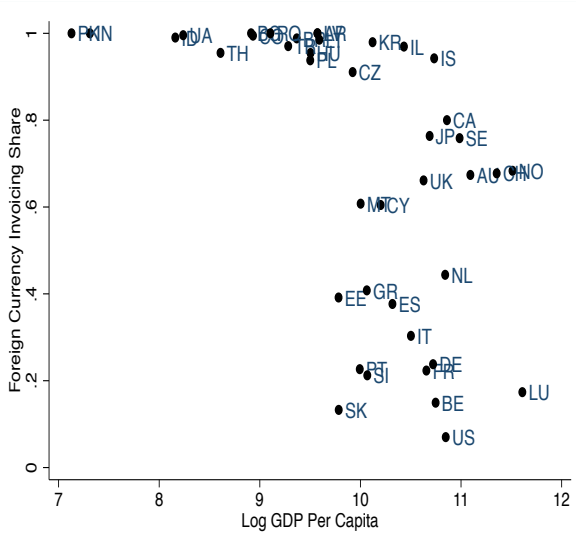
Figure 4 plots the foreign currency invoicing share for each country against its (log) per capita GDP. Figures 4(a) and 4(b) represent imports and exports respectively. Countries with higher GDP per capita rely less on foreign currency invoicing, however the relation is quite flat for a significant range of values of per capita GDP. Within the group of countries with high GDP per capita there is considerable variation in the foreign currency share, however this is mainly driven by euro area countries. Figures 4(c) and 4(d) re-create the graphs excluding euro area countries and as is evident, especially for imports, almost all countries except for the U.S. are bunched closer to the 100% line. This is to be expected given the dominance of the dollar in world trade.

IPS Definition 1a: Relative Stability of invoicing patterns over time

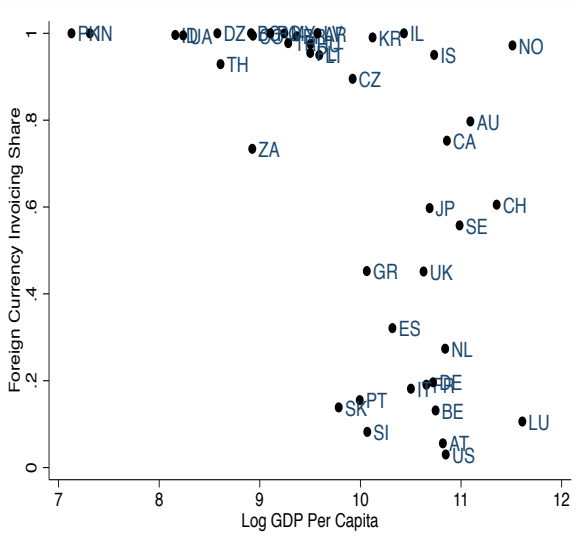
For the countries that have at least ten years of data I plot in Figure 5 the share of its imports invoiced in a foreign currency, that is in a currency not its own. These countries include Australia, Iceland, Indonesia, Japan, Norway, Thailand, Turkey, South Korea and the United States. The shares are quite stable over time. In the case of Japan the share of invoicing in yen increased during the nineteen eighties but has been very stable after that.

The exception to this would be countries in the eurozone after the adoption of the euro when

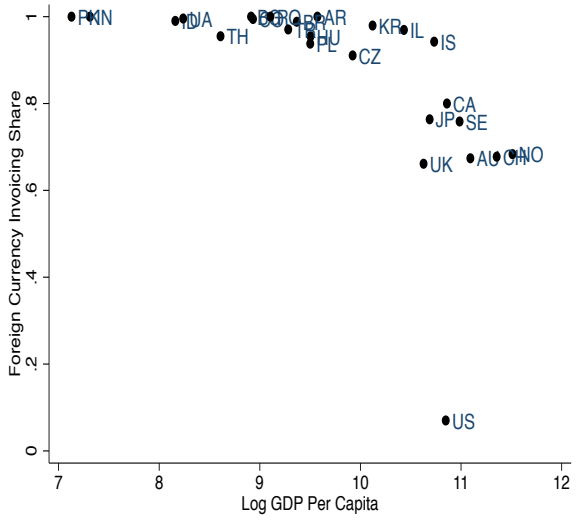
[11] I also exclude China from the sample because it has far too little data (7% of its invoicing data is in yuan, and the other 93% is unlabeled). Anecdotally, it is known that China's trade is predominantly in dollars and Euros, despite the fact that it trades substantial volumes with Asian countries too; and so inclusion of China will further increase dollar or euro prominence, relative to US or Eurozone trade.



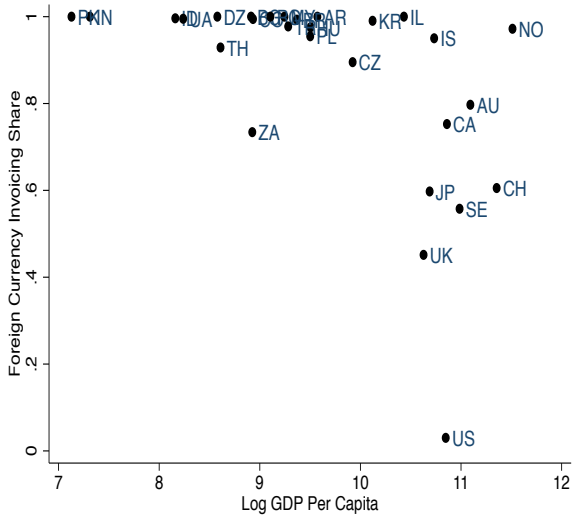
(a) Imports



(b) Exports



(c) Imports, Ex-Euro



(d) Exports, Ex-Euro

Figure 4: Invoicing Shares and GDP Per Capita

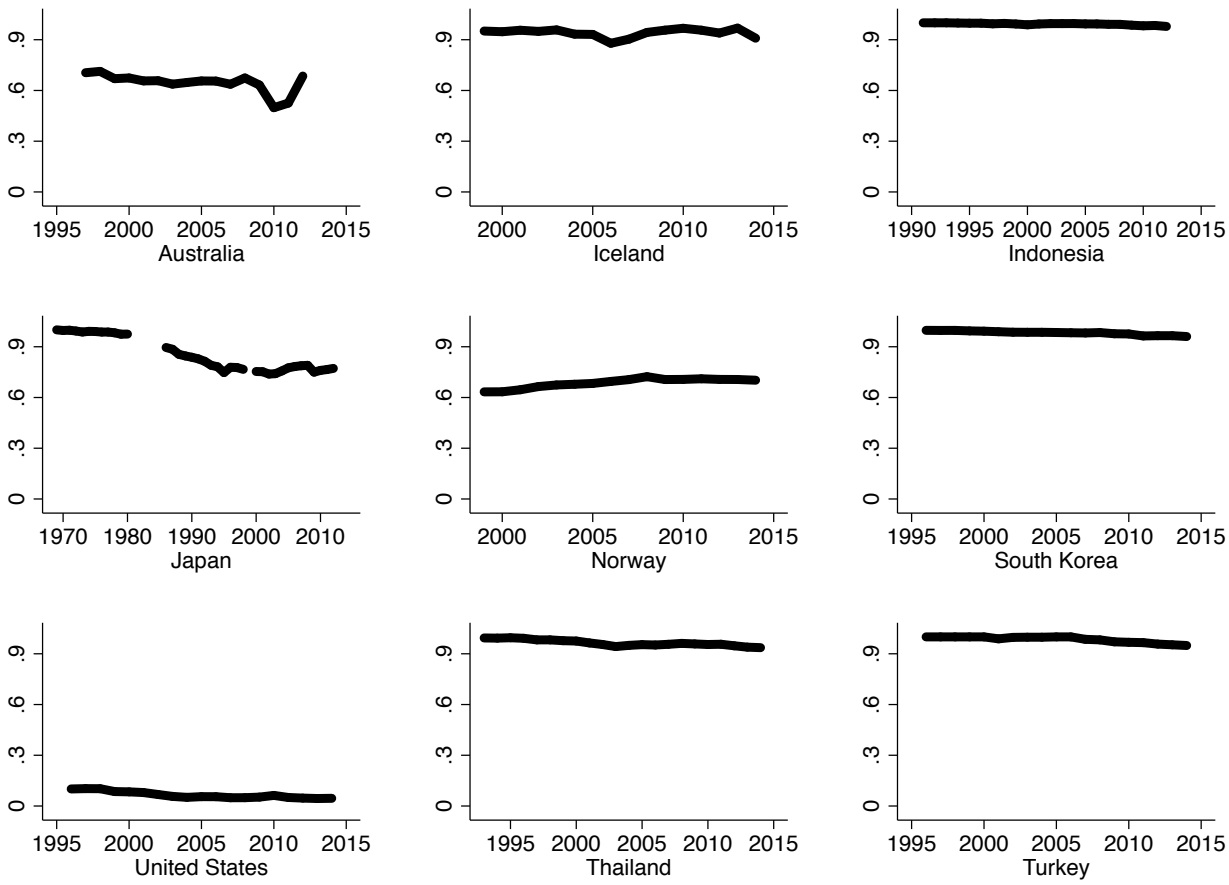


Figure 5: Fraction Priced in Foreign Currency

invoicing in home currency shares should have risen significantly. There is limited reliable currency invoicing information for the years prior to the euro.[12] However, what this highlights is that it takes a dramatic event such as the formation of a currency union to shift invoicing patterns.

***IPS* Definition 2: International prices, in their currency of invoicing, are not very sensitive to exchange rates at horizons of up to two years.**

I present evidence for this using aggregated and disaggregated price data. For all aggregate price indices I use quarterly data and the sample period is set to start at 1990 so as to exclude episodes of hyperinflation in some countries in our sample and also to focus on a time period when most countries are on floating exchange rates for at least the majority of the sample period.[13] Ideally the price indices should exclude commodity prices given that they are determined by

[12] Ito and Chinn (2013) present some evidence of increasing euro adoption in the European Union.
[13] We also restrict the sample to countries with at least thirty quarters of data.

demand and supply conditions in world markets and not the focus of this paper, which is about goods for which firms have some pricing power.[14] Such indices are however not readily available for many countries and accordingly for all countries I use the import price index for all commodities. The only exception is the U.S. for which I use the import price index excluding petroleum. The biases of not excluding commodity prices are particularly severe for the U.S. given the close co-movement between the dollar and commodity prices that are driven by global market conditions.[15]

IPS Definition 2a: Countries with high short-run passthroughs have high long-run pass-through.

Pass-through is an empirical concept that measures the sensitivity of a country's import price to fluctuations in its nominal exchange rate relative to that of its trading partners. The policy relevant question often is if a country's currency depreciates (appreciates) by a certain percent by what percent does that raise (lower) the home currency price of goods it imports.[16] The short-run pass-through measures the impact on prices over a short duration such as one quarter, while long-run pass-through measures the impact over a longer duration, typically two years.

In order to estimate pass-through I will employ a dynamic lag specification that is standard in the empirical literature, as in Campa and Goldberg (2005) and Burstein and Gopinath (2014). The regression takes the form below,

$$\Delta ipi_{n,t} = \alpha_n + \sum_{k=0}^{T} \beta_{n,k} \Delta e_{n,t-k} + \gamma_n X_{n,t} + \varepsilon_{n,t} \tag{1}$$

where $\Delta ipi_{n,t}$ represents the log change in the import price index in country n at time t, expressed in country n's currency. $\Delta e_{n,t-k}$ represents the log change in the trade weighted nominal exchange rate in country n at time $t-k$. $k > 0$ allows for lags in the pass-through of the trade weighted

[14] Please see Alquist et al. (2013) for an in-depth analysis of the relation between exchange rates and commodity prices.

[15] I verify this by using manufacturing sub-indices for some countries and find that unlike the case for the U.S. the estimates are very similar for the all-commodities and manufacturing only indices.

[16] The source of the nominal exchange rate fluctuation, such as whether it is a monetary shock or a financial shock, clearly will have implications for the estimated exchange rate pass-through via its impact on other components of a firms costs such as wages, if not appropriately controlled for. However, for horizons of two years and less, these other endogenous responses can be weak and consequently the estimates may not be very sensitive to the source of the shock. Importantly also, as I discuss in Section 5, the relevant pass-through estimate that ties pass-through to currency invoicing shares is the *unconditional* pass-through from exchange rates to prices. The standard omitted variable concerns that arise with pass-through regressions are therefore not an issue here.

exchange rate into prices. The nominal exchange rate is expressed as home currency per unit of foreign currency. Consequently a positive (negative) value for $\Delta e_{n,t-k}$ represents a nominal depreciation (appreciation) of the home currency. $X_{in,t}$ controls for the trade-weighted change in the cost of production of exporting countries. Specifically I use contemporaneous and eight lags of the change in the trade-weighted nominal exchange rate and trade weighted producer price index of exporting countries. The construction of trade weighted exchange rates and producer prices is described in Appendix C.

After estimating the $\beta_{n,k}$ coefficients I obtain cumulative pass-through rates $PT_{n,T} = \sum_{k=0}^{T} \beta_k$ at horizon T for each country. I define $PT_{n,1} = \sum_{k=0}^{1} \beta_{n,k}$ as short-run pass-through. By including the contemporaneous and one-lag effect on prices I allow for the possible difference in timing of when import prices are reported and exchange rates are measured in the data, which can bias estimates. According to *IPS Description 2a* countries with high $PT_{n,1}$ should have high cumulative pass-through at longer horizons. That is, a regression

$$PT_{n,T} = \gamma_T + \eta_T PT_{n,1} + \varepsilon_{n,T}, \qquad \text{for} \quad T > 1 \tag{2}$$

should generate in the case when the pass-throughs are identical $\gamma_T = 0$ and $\eta_T = 1$.

All	**Four Quarters** $PT_{n,4}$	**Eight Quarters** $PT_{n,8}$
$PT_{n,1}$	0.921***	0.871***
	(8.33)	(6.10)
Constant	0.053	0.102
	(0.70)	(1.06)
N	35	35
R^2	0.678	0.530
Developed		
$PT_{n,1}$	0.915***	0.928**
	(6.17)	(4.91)
Constant	0.073	0.109
	(0.79)	(0.94)
N	24	24
R^2	0.634	0.523

Table 1: Relation between Short-run and Long-run Pass-through

Table 1 reports the results of this regression for $T = 4$ and $T = 8$.[17] The bottom panel reports the results for the sub-sample of developed economies. Both in the full sample and in the developed country sample the point estimates for η_T are close to one and we cannot reject the null that they are significantly different from one.[18] η_4 is 0.923 (0.915) for the full (developed) sample. η_8 is 0.871 (0.928) for the full (developed) sample. In addition γ_T estimates are close to and insignificantly different from zero.

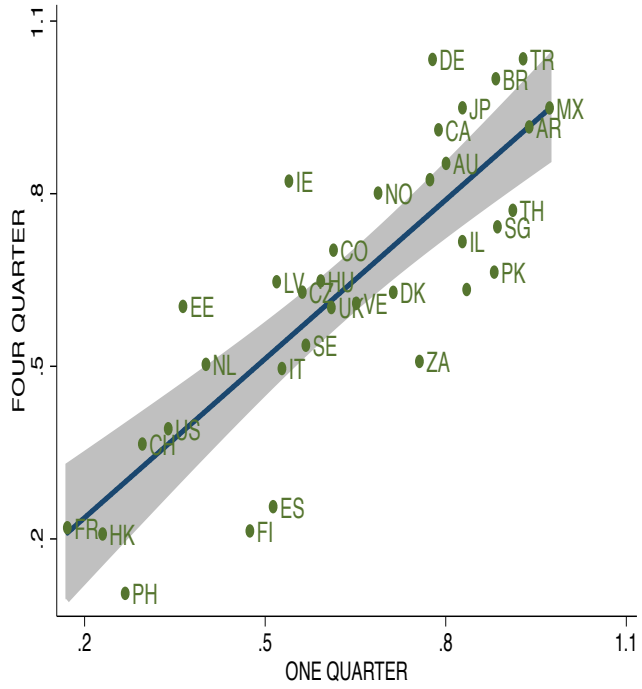


Figure 6: Four Vs. One Quarter Pass-through

The close relation between short-run and long-run pass-through is also evident in Figures 6 and 7 where I plot the relation between four quarter and one quarter and eight quarter and one quarter for all countries. Figures 8 and 9 graph the same for the developed country sub-sample.[19]

IPS Definition 2b: Countries with higher shares of imports invoiced in a foreign

[17] I exclude countries for which the pass-through estimates behave erratically, switching between positive and negative numbers. These include Austria, Belgium, Greece, India, Luxembourg, Poland and Portugal.

[18] I acknowledge that the standard errors need to be corrected for the generated regressor bias and the statistical tests needs to be interpreted with caution.

[19] In the case when IPIs, NERs, and producer prices are co-integrated, dynamic lag regressions are misspecified. To allow for cointegration a vector error correction model (VECM) should be estimated. However, as reported in Burstein and Gopinath (2014) the VECM specification generates estimates that are highly unstable depending on the sample period chosen and very imprecisely estimated. In addition for several countries we could not reject the null that the log import price index, the log of the NER and the log of foreign PPI are not cointegrated.

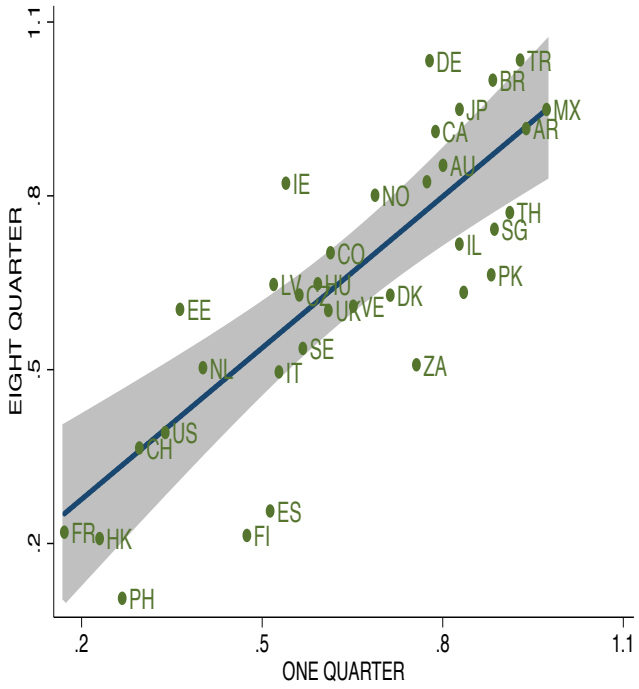


Figure 7: Eight Vs. One Quarter Pass-through

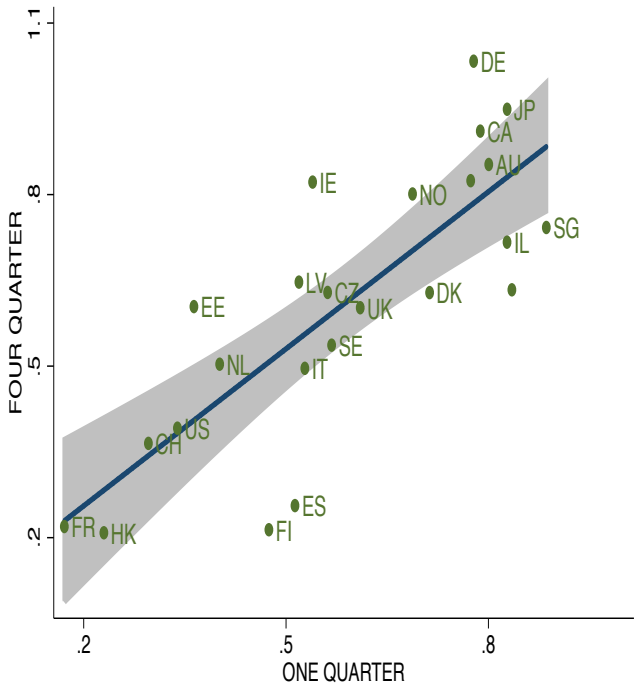


Figure 8: Four Vs. One Quarter Pass-through, Developed Countries

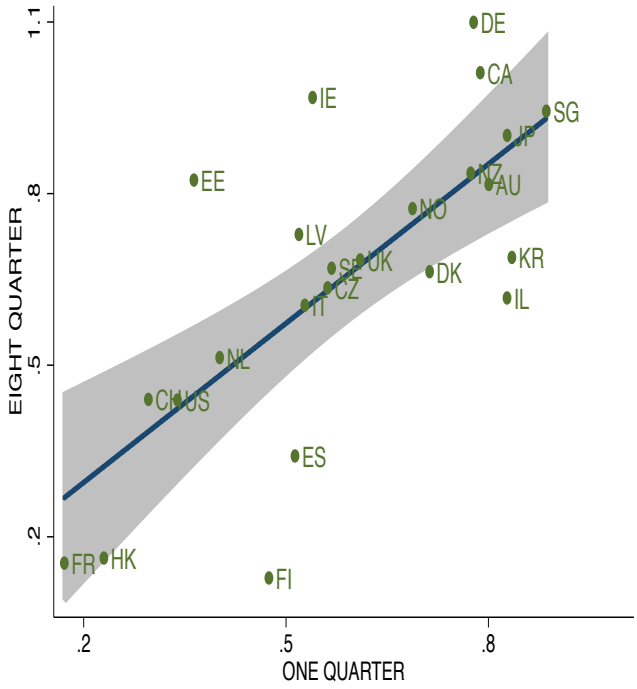


Figure 9: Eight Vs. One Quarter Pass-through, Developed countries

currency have higher short-run and long-run pass-through.

The second fact ties the pass-through rates to the currency invoicing patterns of each country's import bundle. Specifically I estimate the following regression:

$$PT_{n,T} = \theta_T + \phi FCS_n + \varepsilon_{n,T} \tag{3}$$

for $T = 1, 4, 8$. FCS_n is the share of the imports of country n that is not invoiced in the currency of country n. I use the average foreign currency share across time for each country.[20] The results are reported in Tables 2 and 3 and Figures 10 and 11.

The top panel of Table 2 reports the results for 24 countries for which we have both pass-through estimates and currency invoicing information. There is a positive relation between pass-through estimates and foreign currency invoicing shares at the one, four and eight quarter horizon. This is depicted in the figures.[21] As is evident Germany is an outlier. Excluding Germany the positive

[20]For some countries we only have partial invoicing information. If the missing information exceeds 20% of the countries imports I exclude this country from analysis. I renormalize the shares to ensure they add up to one.

[21]Figure 1 in Bacchetta and van Wincoop (2005) plots short-run pass-through against fraction invoiced in the *importers* currency for seven advanced economies and shows the relation to be negatively sloped, consistent with

All	One Quarters	Four Quarters	Eight Quarters
Foreign Invoicing	0.458***	0.361**	0.248
	(3.81)	(2.49)	(1.58)
Constant	0.314***	0.413***	0.510***
	(3.45)	(3.75)	(4.30)
N	24	24	24
R-sq	0.397	0.219	0.102
Excl. Germany			
Foreign Invoicing	0.553***	0.504***	0.389**
	(4.83)	(3.98)	(2.74)
Constant	0.230**	0.287***	0.386***
	(2.60)	(2.94)	(3.51)
N	23	23	23
R-sq	0.526	0.430	0.263

Table 2: Relation between Pass-through and Currency of Invoicing

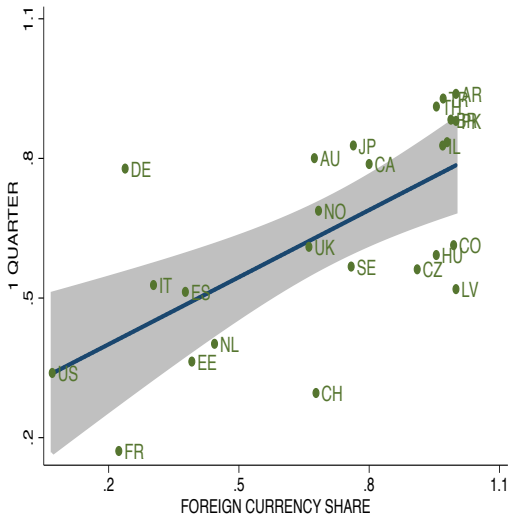
relation is tighter as reported in the figures and tables.

According to these estimates an increase in the share of foreign currency invoicing has a quantitatively significant effect on pass-through measures at short and long horizons. Based on lower panel estimates, one-quarter (four-quarter) pass-through increases from 23% (29%) to 78% (79%) as the foreign currency share rises from 0% to 100%. Similarly, the eight-quarter pass-through increases from 39% to 78% as the foreign currency share rises from 0% to 100%. The impact of currency invoicing on pass-through extends therefore beyond the short-run to horizons for which it is difficult to argue that price stickiness is still relevant.

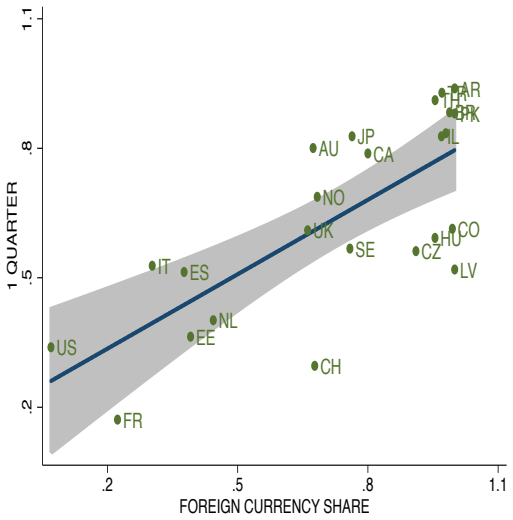
Burstein et al. (2005) study episodes of large devaluations and report that for Argentina, Brazil, Korea, Mexico and Thailand at-the-dock prices of imported goods rise almost one to one in home currency with the exchange rate devaluation. This is consistent with the IPS and demonstrates that even during crisis episodes countries whose imports are invoiced in a foreign currency, in this case the dollar, experience large pass-through into their import prices in home currency.

I would like to highlight some important caveats for the euro area countries. Firstly, the currency invoicing information corresponds to the post euro period while import pass-through is estimated including the pre-euro period, starting in 1990. This poses a problem when estimating

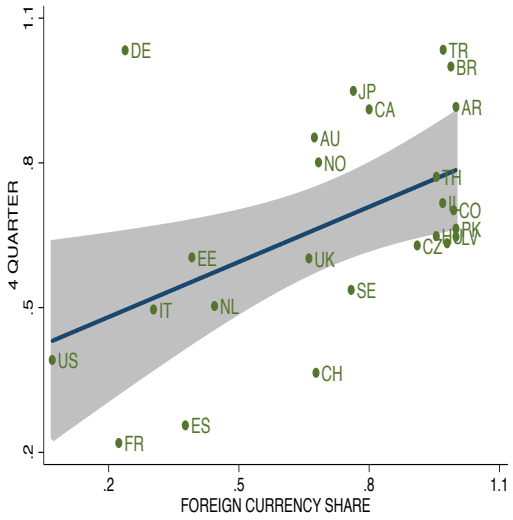
Figures 11(a) and 11(b) in this paper.



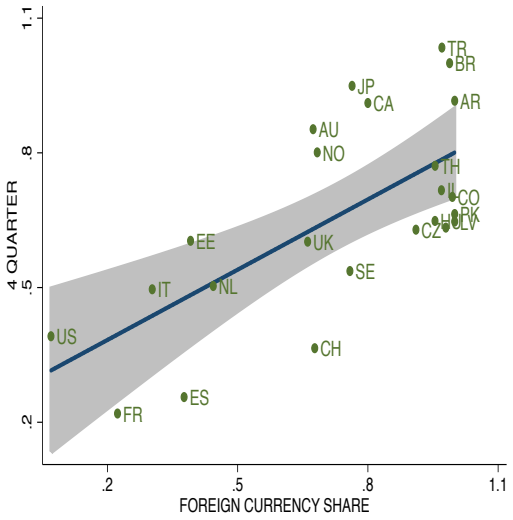
(a) All Countries



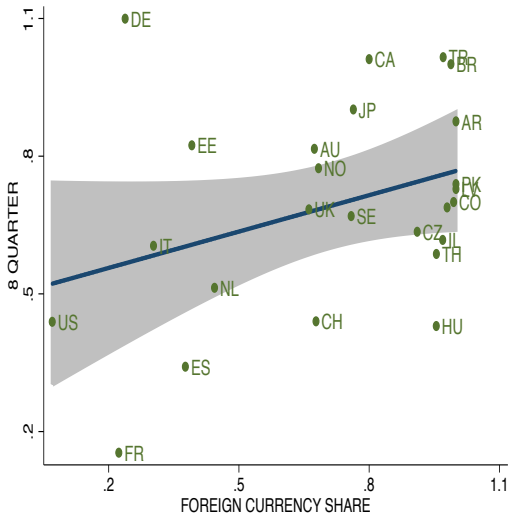
(b) All Countries, excl. Germany



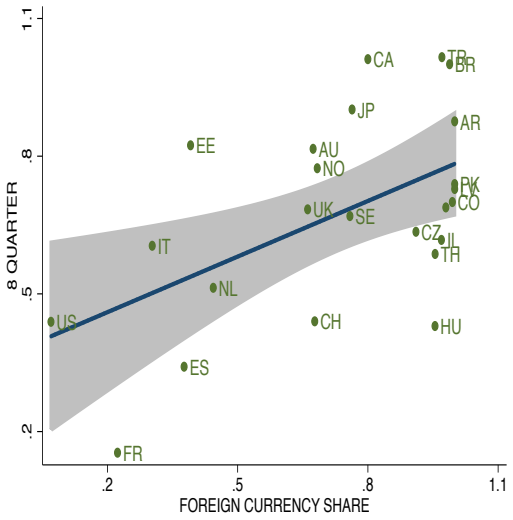
(c) All Countries



(d) All Countries, excl. Germany

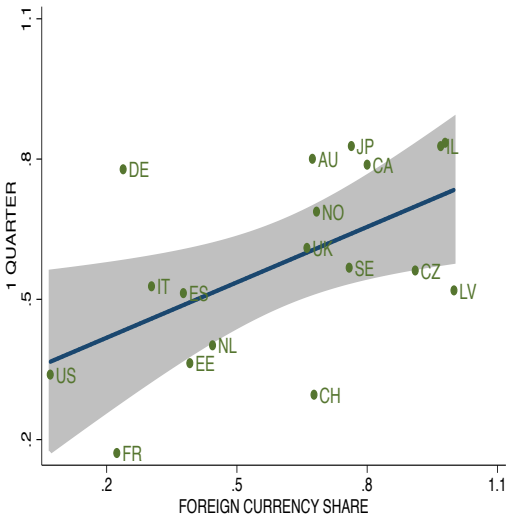


(e) All Countries

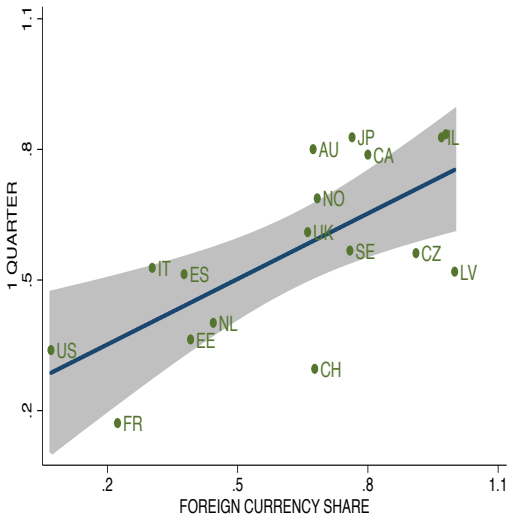


(f) All Countries, excl. Germany

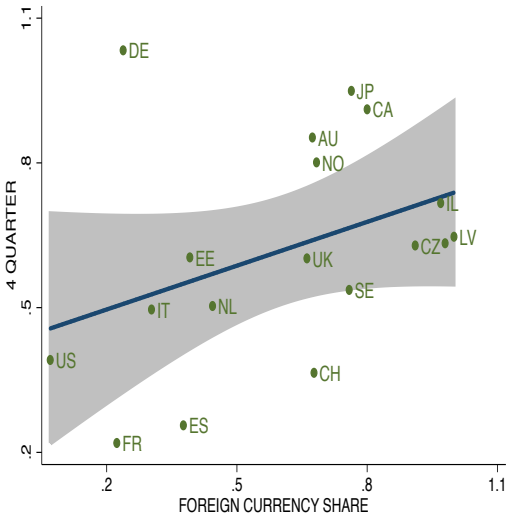
Figure 10: Pass-through and Currency Invoicing



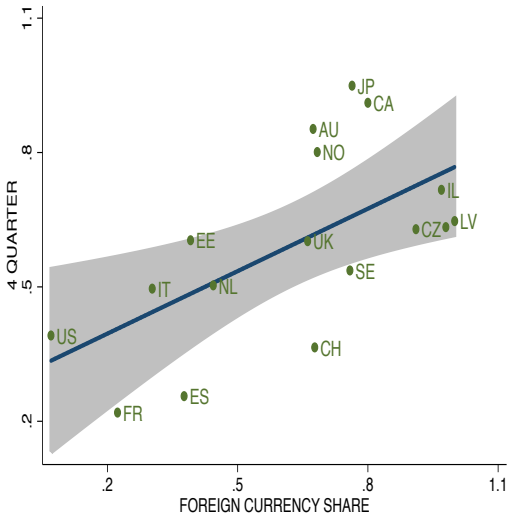
(a) All Countries



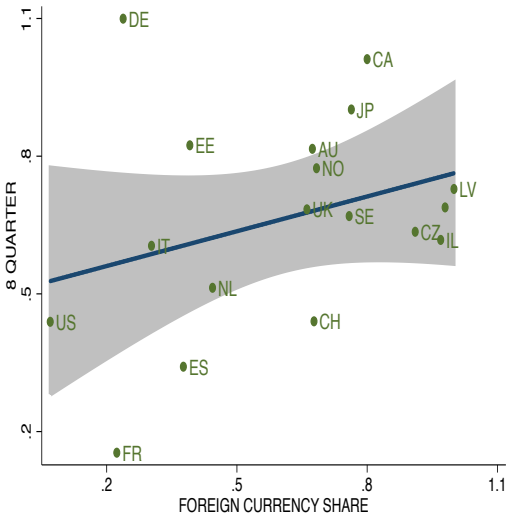
(b) All Countries, excl. Germany



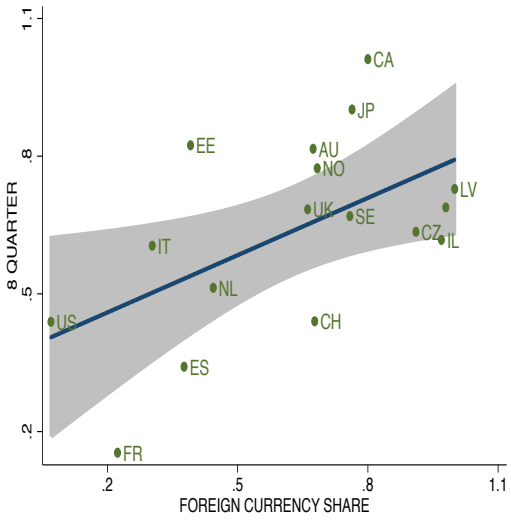
(c) All Countries



(d) All Countries, excl. Germany



(e) All Countries



(f) All Countries, excl. Germany

Figure 11: Pass-through and Currency Invoicing, Developed

Developed	**One Quarters**	**Four Quarters**	**Eight Quarters**
Foreign Invoicing	0.388**	0.299	0.251
	(2.64)	(1.64)	(1.33)
Constant	0.344***	0.439***	0.512***
	(3.50)	(3.60)	(4.06)
N	18	18	18
R-sq	0.304	0.144	0.099
Excl. Germany			
Foreign Invoicing	0.489***	0.453***	0.406**
	(3.58)	(2.99)	(2.53)
Constant	0.261**	0.312***	0.384***
	(2.79)	(3.00)	(3.50)
N	17	17	17
R-sq	0.461	0.373	0.300

Table 3: Relation between Pass-through and Currency of Invoicing: Developed

the link between pass-through and currency invoicing as the latter could have changed pre- and post- euro.[22] A second issue is that post-euro the variation in the right hand side variable in the pass-through regressions, i.e. the variation in the trade weighted nominal exchange rate is driven entirely by a country's trade outside the euro area. This complicates the link between pass-through estimates using aggregate import price indices and invoicing shares. For example if a country in the euro area has almost all of its ex-euro area trade denominated in dollars, and consistent with IPS, prices in their currency of invoicing are not sensitive to exchange rates, then the pass-through estimate using only the post-euro sample may be high, even if the majority of its trade is within the euro area and consequently it is reported as a low foreign currency invoicing share country.[23] Accordingly, I estimate equation 3 excluding euro countries. The coefficient (s.e) for ϕ is 0.51 (0.20) for one quarter pass-through, 0.41 (0.18) for four quarter pass-through and 0.29 (0.19) for eight quarter pass-through. The positive relation between pass-through and foreign invoicing share holds even excluding these countries though the standard errors are larger.

This leads into the discussion of more general concerns with using aggregate import price index data. Firstly, most of these indices are unit value indices that tend to be very noisy and generate

[22]Given the highly stable nature of currency invoicing shares this is a less likely concern for other countries that did not experience a dramatic change in their currency regimes such as from joining a monetary union.

[23]This may explain the high estimate for Germany.

imprecise pass-through estimates. A second concern is that they include prices of goods traded intra-firm and these transfer prices may be less allocative and consequently less interesting.[24] Thirdly, a few goods with long durations of price stickiness may bias the pass-through estimates even eight quarters out. Lastly, the evidence so far is cross-sectional, namely countries with a higher share of imports invoiced in their home currency have lower pass-through at all horizons. It is important to know if this holds even within country, that is, is it the case that within country there is greater pass-through into prices of goods invoiced in a foreign currency as compared to those invoiced in home currency. To address these concerns I turn to evidence from detailed micro price data from the U.S. Bureau of Labor Statistics in the next section.

2.1 Detailed Evidence from U.S. Imports

The Bureau of Labor Statistics surveys a representative sample of U.S. firms to collect detailed information on the prices of goods imported and exported. Alongside reporting the price of the good, firms report the currency of denomination of the transaction. I use monthly data for the twenty year period from 1994.M1-2014.M6 to examine the impact of currency denomination on pass-through into U.S. import prices. This evidence extends the findings in Gopinath et al. (2010) using ten years of additional data. This data while limited to the U.S. has several advantages over the aggregate indices. Firstly, it reports on whether the transaction is arms-length or intra-firm. For all of the analysis in this section I will restrict the sample to arms-length transactions. Secondly, one can estimate pass-through *conditional* on prices changing so this takes care of the problem of long duration sticky prices impacting estimates of aggregate pass-through over long horizons.[25]

Over 93% of all imports into the U.S. are invoiced in dollars. However there are a few countries like Germany for which this fraction is significantly lower. Table 2.1 reports the fraction of imports in the BLS sample invoiced in a currency that is not the dollar (non-dollar currency) by country of origin. For each country the non-dollar currency is their home currency, that is for Germany it

[24] Neiman (2010) contrasts the behavior of intra-firm and arms-length transaction prices for U.S. imports and documents that the former are characterized by less stickiness, less synchronization, and greater exchange rate passthrough.

[25] In addition because there is detailed information on the country of origin of the imported good, the appropriate bilateral exchange rate can be used unlike the case for the aggregate price index.

is euros starting 1999 and the deutsche mark before that. The countries are listed in a declining order of the fraction of imports invoiced in non-dollars. Germany and Switzerland have over 30% invoiced in non-dollars while the fraction for Italy, U.K. and Japan is around 20%.

Country	N	$Frac_{ND}$
Germany	2255	0.38
Switzerland	420	0.32
Italy	2310	0.21
UK	1365	0.21
Japan	4176	0.20
France	1143	0.18
Spain	540	0.16
Belgium	228	0.15
Netherlands	400	0.15
Sweden	333	0.09
Canada	4893	0.05
Austria	204	0.05

Table 4: Currency Composition

2.1.1 Pass-Through for Arms-Length Transactions

With the currency of invoicing information I construct for each country of origin three separate import price indices, all expressed in dollar values.[26] For example, for Germany I construct one index of the dollar value of all goods imported from Germany ("overall index"). Second I construct an index of the dollar value of all imports from Germany that are priced in dollars ("dollar index") and a third for those German goods that are priced in non-dollars ("non-dollar index"). I then estimate exchange rate pass-through in to each of these indices using the regression specification equation 1 in Gopinath et al. (2010).

$$\Delta p_{m,t} = \alpha_m + \sum_{k=0}^{T} \beta_k \Delta e_{m,t-k} + \sum_{k=0}^{T} \gamma_j \Delta \pi_{m,t-k} + \sum_{k=0}^{3} \delta_j \Delta y_{m,t-k} + \epsilon_{m,t} \tag{4}$$

where m indexes the country of origin of imports, Δp is the average monthly log price change

[26] The analysis in this section is restricted to the countries listed in Table 2.1.

in dollars, $\Delta e_{m,t-k}$ is the log change in the bilateral nominal exchange rate between country m and the U.S. (a positive value for $\Delta e_{m,t-k}$ implies a depreciation of the U.S. dollar relative to the currency of country m), π is the monthly foreign country inflation using the consumer price index, and Δy is average GDP growth in the U.S.; k is the number of lags which varies from 1 to 24. Since the data is monthly, I include up to 24 lags for the nominal exchange rate and foreign inflation and 3 lags for GDP growth.

This is very close to the specification in equation 1 with the only difference being that here I proxy the country of origin cost of production with consumer prices, as in Gopinath et al. (2010), instead of producer prices, and I include current and two lags of U.S. GDP growth.

I estimate equation 4 for the overall index, the dollar index and the non-dollar index. Figure 12 plots the impulse responses from an exchange rate shock into the three indices where we pool all the countries. The thick grey dashed line depicts the impulse response using the overall index. The pass-through is 22% in the short-run and then increases gradually to 35% by the 24 month horizon.

The thick solid black line and the thick dash-and-dots line plot the impulse response into the dollar index and non-dollar index respectively. The thin dashed lines plot the 95% confidence interval bands around the point estimates. In the short-run there is a large divergence in the pass-through for goods priced in dollars versus non-dollars. It is close to 0% for goods priced in dollars and 100% for good priced in non-dollars. This is to be expected when prices are sticky in their currency of denomination and when the selection effect of which firm changes prices is small. What is striking though is that the difference in the pass-through rates remains large even 24 months out. The pass-through into the dollar index increases from 0.3% to 20% at the 24 month horizon. The pass-through into the non-dollar index on the other hand starts at 100% and stays close to that value even 24 months out. This difference is also highly significant at all horizons. This confirms the hypothesis that the reason countries with a large import share denominated in foreign currency have high pass-through even two years out is because there is a large difference in pass-through between goods priced in home versus foreign currency at both short and long horizons. It is useful to compare Figure 12 with Figure 1 in the introduction. It highlights that even for the U.S., goods that it imports that are priced in a foreign currency have the same high

pass-through into U.S. dollar prices as what is observed for Turkey and Japan, which are countries that predominantly import in a foreign currency.

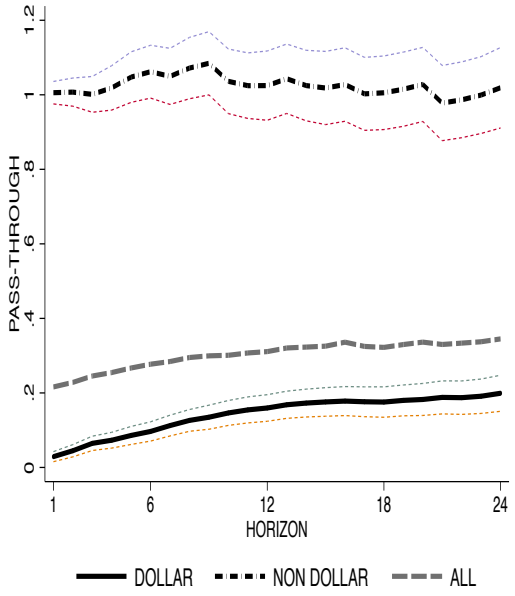


Figure 12: Aggregate ERPT by Currency

In Figure 13 I present the same impulse responses as in Figure 12 but by country of origin of imports. The same striking difference in pass-through between goods priced in dollars and in non-dollars is observed at the country level. Pass-through into dollar prices of goods imported from Germany that are dollar invoiced is 6% in the short-run and increases gradually up to 16% in the long-run. On the other hand goods invoiced in euros (deutsch mark pre-1999) have a pass-through of close to 100% at all horizons. In other words the same euro-dollar exchange rate movement is associated with very different pass-through rates into export prices from Germany. This difference is statistically significant for all countries with the exception of Canada where the estimates are noisy.[27]

2.2 Pass-through Conditional on a Price Change

IPS Definition 2c: Border prices, in whatever currency they are set in, respond partially to exchange rate shocks even conditional on a price change.

[27]This can arise because of the Canadian dollar being a commodity currency where by changes in commodity prices impact the value of the Canadian dollar.

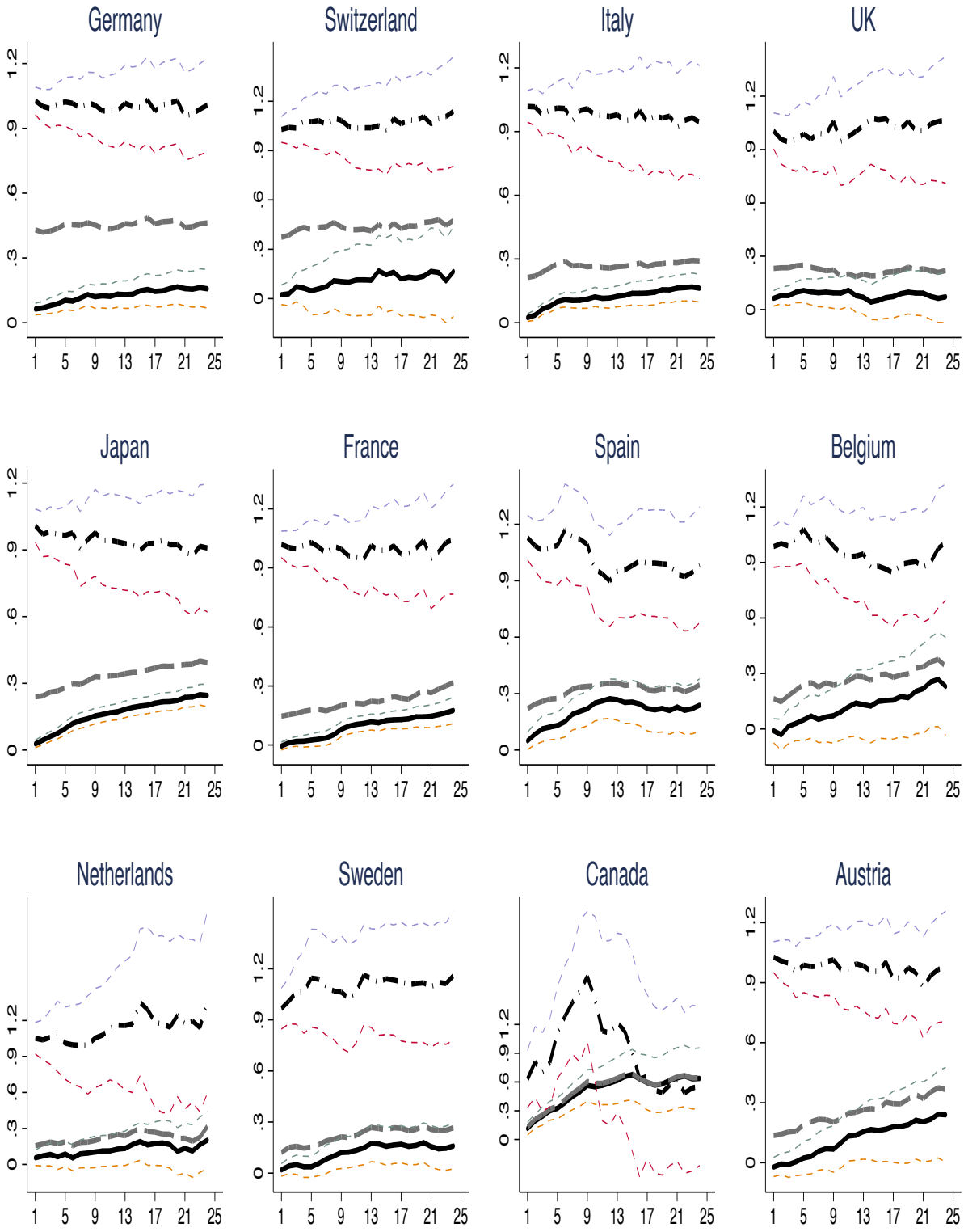


Figure 13: Aggregate ERPT by Currency by Country

The evidence presented in Section 2.1.1 includes constant price spells associated with price stickiness (in the currency of invoicing). In this section I condition the pass-through estimates on prices that actually change. Figure 14 taken from Gopinath and Itskhoki (2010b) plots a hypothetical path for the price of an imported good p_{it} and a path for the nominal exchange rate e_t against time. The points of time when prices adjust are also marked on the plot. Consider the price change in period t_{LL} by the amount $\Delta p = p_{t_{LL}} - p_{t_3}$. This price change responds to the cumulative change in the (log) exchange rate since the last time prices were adjusted. To measure the sensitivity of this response and how it differs across goods priced in dollar and non-dollars I estimate the following conditional pass-through regression.

$$\Delta p_{in,t} = \left[\beta_D \cdot D_i + \beta_{ND} \cdot (1 - D_i)\right] \Delta_c e_{in,t} + \gamma X_{in,t} + \varepsilon_{in,t}.$$

$\Delta p_{in,t}$ is the the change in the log price (in dollars) of the good imported in country n from country i, where the sample is restricted to those observations that have a non-zero price change in their currency of pricing. D_i is a dummy that takes the value of one if the good is priced in dollars and zero if priced in non-dollars. $\Delta_c e_{in,t}$ is the cumulative change in the bilateral nominal exchange rate over the duration for which the previous price was in effect. $X_{in,t}$ controls for the cumulative change in the (log) foreign consumer price level, the (log) U.S. consumer price level, the (log) of U.S. real GDP and includes fixed effects for every BLS defined primary strata (mostly 2-4 digit harmonized codes) and country pair (and standard errors are clustered at this level).

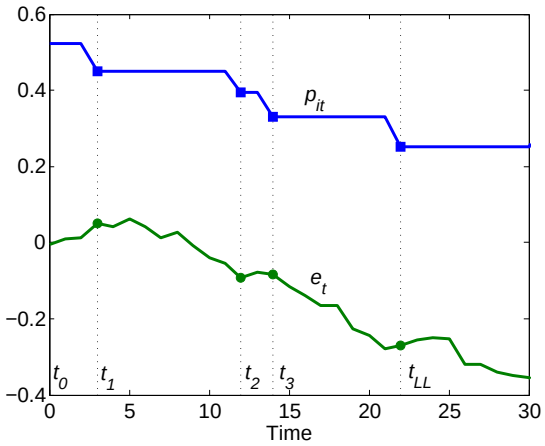


Figure 14: Hypothetical good-level price series and nominal exchange rate

I report in Table 5 estimates from the conditional pass-through regressions for U.S. import prices by country of origin of goods. Columns (1) and (3) report the pass-through conditional on a price change of dollar invoiced and non-dollar invoiced goods respectively. The difference between the estimates and the statistical significance of the difference (the t-statistic) are reported in columns (5) and (6) respectively. The difference in pass-throughs are large and highly significant. For all countries the pass-through is 26% for goods priced in dollars while it is 85% for goods priced in non-dollars. This pronounced difference is evident for imports from individual countries. In the case of Germany, the conditional pass-through is 32% for goods prices in dollars and 85% for goods priced in non-dollars. For ten of the twelve countries the difference is statistically significant at at least the 5% level.

This far I have not distinguished goods by sectoral characteristics. As I show below the stark contrast between pass-through of dollar and non-dollar invoiced goods persists even within sub-samples of narrowly defined sectors. First, Table 6 repeats the analysis in Table 5 for the sub-sample of differentiated goods as defined by Rauch (1999), goods for which firms have more pricing power. These are goods that are neither traded on an exchange nor have a reference price. Once again the differences are large. For all countries the conditional pass-through is 21% for goods priced in dollars and 93% for goods priced in non-dollars. For all countries conditional pass-through for non-dollar priced goods exceeds that for dollar priced goods and this difference is statistically significant for eleven out of the twelve countries.

In Table 7 for all twenty sectors that have a mix of dollar and non-dollar pricers, the pass-through of non-dollar priced goods exceeds that of dollar priced goods and this difference is significant at conventional levels for sixteen sectors.

	Dollar		Non-Dollar		Difference		N_{obs}	R^2
	β_D	s.e.(β_D)	β_{ND}	s.e.(β_{ND})	$\beta_{ND} - \beta_D$	t-stat		
All Countries	0.26	0.02	0.85	0.04	0.59	11.18	69,792	0.09
Canada	0.30	0.06	0.71	0.12	0.41	2.71	38,312	0.03
Sweden	0.15	0.09	0.87	0.09	0.72	5.85	881	0.14
United Kingdom	0.23	0.09	0.77	0.08	0.54	4.42	4,326	0.16
Netherlands	0.38	0.12	0.85	0.32	0.47	1.28	1,410	0.09
Belgium	0.06	0.08	1.37	0.31	1.31	4.11	854	0.35
France	0.19	0.04	0.72	0.16	0.53	3.28	2,634	0.17
Germany	0.32	0.06	0.85	0.11	0.53	4.38	5,542	0.16
Austria	-0.13	0.16	4.01	0.60	4.14	6.68	422	0.12
Switzerland	0.21	0.10	0.67	0.23	0.46	1.62	881	0.46
Spain	0.21	0.11	0.76	0.17	0.55	2.67	1,600	0.15
Italy	0.24	0.05	0.97	0.12	0.74	5.81	4,190	0.15
Japan	0.23	0.04	0.85	0.06	0.62	7.72	8,740	0.11

Table 5: ERPT Conditional on a Price Change: All Goods

	Dollar		Non-Dollar		Difference		N_{obs}	R^2
	β_D	s.e.(β_D)	β_{ND}	s.e.(β_{ND})	$\beta_{ND} - \beta_D$	t-stat		
All Countries	0.21	0.03	0.93	0.05	0.71	11.87	22,762	0.14
Canada	0.12	0.07	0.79	0.10	0.67	5.20	10,162	0.05
Sweden	0.29	0.15	1.08	0.06	0.79	5.22	393	0.36
United Kingdom	0.17	0.17	0.86	0.15	0.69	3.12	1,102	0.17
Netherlands	0.13	0.18	1.03	0.20	0.91	2.65	355	0.11
Belgium	0.10	0.08	1.45	0.47	1.35	2.83	160	0.54
France	0.19	0.09	1.00	0.12	0.81	5.59	711	0.18
Germany	0.40	0.08	0.96	0.12	0.55	3.88	2,830	0.20
Austria	-0.17	0.17	8.10	0.18	8.28	45.82	262	0.33
Switzerland	0.13	0.16	0.76	0.33	0.64	1.49	460	0.52
Spain	0.34	0.09	0.92	0.12	0.58	3.22	770	0.16
Italy	0.28	0.06	0.97	0.16	0.69	3.90	1,836	0.16
Japan	0.21	0.05	0.93	0.08	0.72	7.06	3,721	0.14

Table 6: ERPT Conditional on a Price Change: Differentiated Goods

Sector	Harm. Code	Dollar		Non-Dollar		Difference		N_{obs}	R^2
		β_D	s.e.(β_D)	β_{ND}	s.e.(β_{ND})	$\beta_{ND} - \beta_D$	t-stat		
Animal or vegetable fats and oils	15	0.43	0.21	0.61	0.01	0.18	0.84	584	0.20
Arms and ammunition	93	0.04	0.15	0.96	0.16	0.92	3.97	105	0.33
Articles of stone, plaster etc.	94-96	0.16	0.17	0.57	0.17	0.42	1.92	552	0.38
Base metals and articles of base metals	72-83	0.40	0.07	1.35	0.26	0.95	3.52	7097	0.21
Products of chemical and allied industries	28-38	0.25	0.08	0.47	0.21	0.22	0.96	3608	0.18
Footwear, headgear etc.	64-67	0.29	0.09	0.96	0.07	0.67	8.18	183	0.51
Live animals; animal products	01-05	0.23	0.06	0.80	0.14	0.57	3.84	3819	0.08
Machinery and mechanical appliances etc.	84-85	0.19	0.04	0.85	0.06	0.65	9.43	8873	0.25
Mineral products	25-27	0.58	0.11	0.65	0.09	0.07	0.84	13790	0.04
Miscellaneous manufactured articles	68-70	0.14	0.13	0.87	0.16	0.73	3.46	700	0.26

Table 7: ERPT Conditional on a Price Change: Within Sector (continued on the next page)

Sector	Harm. Code	Dollar		Non-Dollar		Difference		N_{obs}	R^2
		β_D	s.e.(β_D)	β_{ND}	s.e.(β_{ND})	$\beta_{ND} - \beta_D$	t-stat		
Optical, photographic etc.	90-92	0.23	0.06	0.90	0.14	0.67	4.24	1,254	0.35
Precious or semi precious stones etc.	71	0.46	0.12	1.68	0.32	1.21	4.07	3,509	0.13
Plastics and rubber articles	39-40	0.25	0.06	0.71	0.15	0.46	2.98	1,845	0.18
Prepared foodstuffs	16-24	0.22	0.04	0.63	0.28	0.41	1.45	3,272	0.11
Pulp of wood other fibrous cellulosic material	47-49	0.20	0.09	0.67	0.12	0.47	3.05	3741	0.17
Raw hides leather articles, furs etc.	41-43	0.17	0.13	0.97	0.10	0.80	5.17	248	0.45
Textile and textile articles	50-63	0.30	0.12	0.79	0.24	0.49	1.82	669	0.47
Vegetable products	06-14	0.17	0.12	1.23	0.31	1.07	3.24	2,998	0.10
Vehicles, aircraft etc.	86-89	0.10	0.06	0.88	0.10	0.79	7.03	3,587	0.11
Wood and articles of wood	44-46	0.25	0.06	1.24	0.20	0.99	4.16	9,358	0.03

Table 7: ERPT Conditional on a Price Change: Within Sector (continued from the previous page)

	Dollar		Non-Dollar		Difference		N_{obs}	R^2
	β_D	s.e.(β_D)	β_{ND}	s.e.(β_{ND})	$\beta_{ND} - \beta_D$	t-stat		
All Countries	0.47	0.07	1.01	0.09	0.54	5.67	10,337	0.32
Differentiated Goods	0.39	0.07	0.98	0.08	0.59	6.01	4,575	0.33

Table 8: ERPT Conditional on Multiple Price Changes

I next examine differential pass-through within those ten digit classification codes that have a mix of dollar and non-dollar invoiced goods. I find that dollar pricers have a pass-through of 27%, non-dollar of 88% and the difference is highly statistically significant (t-stat of 15.30).

Lastly, I take the conditional pass-through measure further by estimating pass-through after multiple rounds of price adjustment, specifically I regress the cumulative change in price over the life of a good in the BLS sample and regress that on the cumulative change in the exchange rate, in the foreign consumer price level, the U.S. consumer price level and U.S. GDP over the same period. The results are reported in Table 8 and there continues to be a quantitatively and statistically significant difference between pass-through of dollar and non-dollar goods.[28]

To summarize, there is strong evidence that currency invoicing patterns are good predictors for pass-through even conditional on a price change. This is the case even within highly disaggregated sectors.[29]

3 Consumer Price Inflation

The *IPS* focuses on import prices at-the-dock but has obvious implications for consumer prices. Consumer prices combine traded (commodities) and non-traded goods (services) and because non-traded goods prices are less sensitive to exchange rate fluctuations as compared to traded goods prices the pass-through into consumer prices is universally lower than pass-through into import prices for every country. This is elucidated in detail in Burstein et al. (2005), Goldberg and Campa (2010) and Burstein and Gopinath (2014), among other papers. Besides non-traded goods the consumer price bundle includes traded goods that are sold only domestically (local goods) and there is a distribution cost component (that includes retail mark-ups) that drives a wedge between at-the-dock prices and retail prices of imported goods. Importantly there is less sensitivity of local goods and distribution wedges to exchange rate changes as compared to import prices at-the-dock.

[28] Gopinath et al. (2011) use BLS data to document that even during the Great Trade Collapse of 2008-2009 most of the adjustment was in quantities and not in prices.

[29] As for price changes at the time of product substitutions Cavallo et al. (2014) provide evidence using a novel dataset of online prices of identical goods sold by four large global retailers in dozens of countries. They document that even at the time of product introduction there are large deviations in prices across countries that do not use the same currency. In other words not measuring price changes at the time of product introduction/substitution has little impact on the conclusions drawn from price changes during the life of the good.

Unlike empirical specifications for exchange rate pass-through into import prices, there is less of a common methodology for estimating pass-through into consumer prices. One approach is to use input-output tables to arrive at a measure of the import content of household consumption and combine that with estimates of import pass-through. This approach captures the impulse response of consumer prices to a change in import prices, while holding fixed any endogenous responses, including that of monetary policy to inflation.[30] I perform such a calculation for the countries in our sample, adopting the methodology in Burstein et al. (2005), the details of which are reported in Appendix F and the results are reported in Column (a) and (b) of Table 9. The direct import content measures the fraction of final consumption expenditure on imported goods. The total import content adds to the direct import content the value of imported inputs used in the production of final consumption goods.[31] Column (c) and (d) report estimates for short and long-run CPI pass-through respectively by multiplying total import content with import pass-through estimates from Section 2.

Pass-through into the CPI is expectedly lower than pass-through into the IPI given that import content is only a fraction of the consumption bundle. The import content share in the consumer bundle is on average 25% ranging from 10% to 41% with smaller economies having a larger import share. The correlation between long-run pass-through into the CPI and long-run pass-through into the IPI is 0.6, mainly indicating that variation in import content shares do not overturn the conclusion that countries with high import pass-throughs experience high pass-through into consumer prices. This is not surprising given that most small open economies (greater import content in consumption) predominantly adopt dollar invoicing.

According to these estimates a 10% depreciation of the dollar relative to its trading partners will raise cumulative CPI inflation two years out by 0.4-0.7 percentage points. On the other hand a 10% depreciation of the Turkish (Mexican) lira (peso) will raise cumulative CPI inflation two years out by 1.65-2.03 (1.38-1.59) percentage points. It is in this sense that U.S. inflation enjoys greater insulation from exchange rate shocks as compared to other countries whose imports are

[30] It also does not include any effects on prices of domestic producers that work through reducing or increasing desired mark-ups.

[31] Goldberg and Campa (2010) employ a more structural approach with specific demand, production and pricing assumptions along with data from input-output tables to estimate the impact of imported final and intermediate goods on consumer prices. Several of their estimates are comparable in magnitude to those reported in Table 9.

Country	**Direct**	**Total**	$\boldsymbol{SRPT_{CPI}}$		$\boldsymbol{LRPT_{CPI}}$	
			Est.	SE.	Est.	SE.
Argentina	0.043	0.096	0.090	(0.004)	0.084	(0.009)
Australia	0.096	0.184	0.147	(0.008)	0.150	(0.025)
Brazil	0.033	0.104	0.092	(0.006)	0.104	(0.005)
Canada	0.164	0.258	0.203	(0.014)	0.261	(0.033)
Czech Republic	0.181	0.384	0.216	(0.035)	0.244	(0.060)
Denmark	0.185	0.301	0.215	(0.048)	0.200	(0.072)
Estonia	0.227	0.413	0.150	(0.042)	0.341	(0.074)
Finland	0.136	0.268	0.127	(0.027)	0.034	(0.043)
France	0.120	0.227	0.039	(0.040)	0.035	(0.073)
Germany	0.105	0.224	0.174	(0.025)	0.246	(0.051)
Hungary	0.170	0.355	0.210	(0.048)	0.152	(0.127)
Ireland	0.176	0.373	0.201	(0.027)	0.361	(0.067)
Israel	0.146	0.293	0.242	(0.020)	0.181	(0.042)
Italy	0.081	0.212	0.112	(0.031)	0.128	(0.049)
Japan	0.048	0.115	0.095	(0.006)	0.104	(0.011)
Mexico	0.054	0.153	0.149	(0.003)	0.148	(0.005)
New Zealand	0.117	0.234	0.181	(0.025)	0.196	(0.034)
Norway	0.201	0.309	0.212	(0.037)	0.239	(0.088)
South Africa	0.095	0.206	0.156	(0.021)	0.103	(0.044)
South Korea	0.082	0.228	0.191	(0.013)	0.157	(0.043)
Spain	0.118	0.239	0.123	(0.039)	0.082	(0.067)
Sweden	0.135	0.279	0.158	(0.012)	0.187	(0.022)
Switzerland	0.114	0.220	0.065	(0.012)	0.097	(0.022)
Thailand	0.051	0.268	0.245	(0.023)	0.158	(0.052)
Turkey	0.060	0.181	0.168	(0.008)	0.184	(0.010)
United Kingdom	0.167	0.271	0.166	(0.010)	0.186	(0.012)
United States	0.060	0.119	0.040	(0.004)	0.052	(0.007)

Table 9: Import Content and CPI Pass-Through

invoiced in a foreign currency.

A more structural approach would be to estimate an open economy version of a New Keynesian Philips curve. There are however many challenges in doing this. Firstly, the appropriate specification relies heavily on assumptions related to the degree of international asset market completeness and the nature of wage and price stickiness, among others. Secondly, reliable data on inflation

expectations do not exist for most countries in the sample.

Lastly, the sensitivity of estimates to specification and sample periods is a major concern with this approach, as documented in the insightful and exhaustive analysis of Mavroeidis et al. (2014). Table 5 of Mavroeidis et al. (2014) reports that the median estimate for the impact of the output gap for quarterly U.S. inflation is 0.004, holding everything else constant including next period inflation expectations and lagged inflation. This implies that a 10 percentage point increase in the output gap raises the quarter on quarter inflation rate by 0.04 percentage points. The output gap coefficient ranges from -0.068 at the fifth percentile to 0.135 at the ninety-fifth percentile. I highlight these numbers to make the point that the sensitivity of CPI inflation to import prices that according to Table 9 is 0.12 for the U.S. is near the upper end of estimates for the sensitivity of inflation to the output gap. In addition, the volatility (standard deviation) of changes in the (log) import price index (excluding petroleum) for the U.S. over the period 1985-Q1 to 2014-Q4 is 1.1%, which is of a comparable magnitude to the volatility in the unemployment gap (often used as a measure of the output gap) of 1.43% over this same period. It is however lower than the volatility of the output gap measured using CBO estimates of potential GDP, which stands at 2.25%.

4 Policy Implications

In this section I elaborate on the policy implications of the International Price System.

1. **Inflation Stabilization:** A good rule of thumb for a countries inflation sensitivity to exchange rate fluctuations is the fraction of its imports invoiced in a foreign currency. The greater the fraction of a country's imports invoiced in a foreign currency the greater its inflation sensitivity to exchange rate fluctuations at both short and long horizons. The depreciation (appreciation) of a country's exchange rate from external shocks is not an inflationary (deflationary) concern for all countries. For the U.S. with 93% of its imports invoiced in dollars the consequences are far more muted than for a country like India that has 97% of its imports invoiced in foreign currency (mainly dollars). Conversely, monetary policy is less effective in lowering (raising) inflation via a stronger (weaker) currency in the

U.S. as compared to India. In addition, given that long-run pass-through into prices is not very different from short-run pass-through the direct impact of exchange rate fluctuations will be front-loaded.

2. **Export Competitiveness:** When a country's currency depreciates the expectation is that it will stimulate demand for the country's output as it lowers the relative price of its goods in world markets. The IPS implies that this is unlikely to be the case for many countries that rely on foreign currency invoicing for their exports. Consider the case of Japan discussed in Section 2.1. Around 80% of its exports to the U.S. are priced in dollars and the pass-through into dollar prices even conditional on a price change for these goods is 23%. Given the relative stability of the dollar price of U.S. imports from Japan even in the face of exchange rate changes we should not expect to see large quantity responses of Japanese exports. On the other hand it is more likely that exchange rate fluctuations show up in mark-up fluctuations such that Japanese exporters earn larger (smaller) profits following a yen depreciation (appreciation). A similar argument applies to exports from most developing countries that invoice their exports in dollars. Of course, higher profits following depreciations can feed into increased exports via new product entry (extensive margin) but this is different from the standard channel that arises from a country's terms of trade depreciating. In the case of the U.S. that has 97% of its exports priced in dollars the opposite is true. The relative stability of dollar export prices generates a high pass-through into the local currency price of the importing country.[32] Consequently the scope for expenditure switching via exports is greater, while mark-ups remain relatively stable.

3. **Trade Balance:** The previous two points imply that the reaction of the trade balance to exchange rate fluctuations for countries whose imports and exports are invoiced in their home currency (like the U.S.) is likely to be dominated by the export channel while for those that rely on foreign invoicing should be dominated by the import channel.

[32] Gopinath et al. (2010) document that for U.S. exports even conditional on a price change pass-through into local currency prices of goods that are priced in dollars is 84%, while pass-through for goods priced in the importing country's currency is 25%.

4. **Monetary Policy Spillovers:** The IPS has the potential to generate asymmetries in monetary policy spillovers. A monetary policy tightening in the U.S. that is associated with a dollar appreciation generates inflation in countries that import primarily in dollar invoiced prices and this may induce them to tighten monetary policy to address inflation concerns. On the other hand monetary tightening in the periphery has a smaller impact on U.S. inflation through import prices given the dollar dominance of invoicing in U.S. imports. While it has been discussed previously that dollar invoicing gives rise to such asymmetric effects[33] it was assumed to be relevant only for durations for when prices are sticky. The IPS implies that this is true for even longer horizons.

   What remains to be addressed are the implications of the IPS for *optimal* monetary policy, particularly for more open economies. There exists an important literature on optimal monetary policy under the assumptions of PCP and LCP. With PCP the optimal policy is to target producer prices (Clarida et al. (2002)) while with LCP there is an argument for targeting consumer prices (Engel (2011)). The world however looks closer to one of dollar pricing and particularly of the kind where one quarter pass-through rates are close to pass-through rates even two years out. Optimal policy in this case will differ across countries given the asymmetries in invoicing patterns.

5. **Internationalization of Currencies:** The low sensitivity of international prices in their currency of invoicing to exchange rate shocks suggests that countries can benefit from the use of their currency as an invoicing currency in terms of inflation stability. China's push to internationalize the yuan can have this added benefit. However given the large inertia in invoicing strategies this process can take a long time.

6. **Special Drawing Rights (SDR):** The relative stability of prices in their unit of account suggests that if firms were instead to price in the IMF's unit of account, SDRs, there would be greater symmetry in the impact of exchange rate shocks as compared to the current asymmetry. Because the value of the SDR is based on the market value of a basket of

[33] Such as in Corsetti and Pesenti (2005) and Goldberg and Tille (2009a).

major currencies, namely the U.S. dollar, euro, yen, and pound sterling, fluctuations in any individual major currency has a smaller impact on the value of the SDR and mutes spillovers across countries. If the yuan is added to this basket, a proposal that is being seriously considered, this has the potential to further mute the impact of any individual currency. However, as will follow from the discussion in the next section, for an individual firm to be tempted to price in SDRs it must be the case that a large number of other exporters and importers also do so.

5 Theoretical Discussion: Prices and Currency

The goal of this section is to explain how the forces of globalization including global value chains and global competition in product markets give rise to and sustain the IPS. To do so I first describe the theoretical determinants of pass-through into import prices distinguishing between flexible and sticky price environments. I then describe their implications for the choice of currency in which to price/invoice goods that in turn corroborates the definition of the IPS in Section 2. This section relies extensively on a large literature on pass-through and currency choice as surveyed in Burstein and Gopinath (2014).

To aid the discussion of determinants of pass-through I will use as a narrative tool the pricing decision of a Japanese firm exporting to the U.S. For now I assume that the Japanese exporter is risk-neutral. Suppose the yen depreciates relative to the U.S. dollar. It could be the outcome of a monetary expansion in Japan or a monetary contraction in the U.S. or a risk premia shock to foreign investors in Japanese bonds.

5.1 Flexible Prices

First consider the case where the Japanese firm sets prices flexibly and there are no lags between production, delivery of products and receipt of payments. This is an environment where currency serves a unit of account/invoicing role but is otherwise irrelevant. Because the problem is static the profit maximizing Japanese firm can quote a price in dollars or instead in yen using the

spot exchange rate.[34] This static problem is studied in the seminal works of Dornbusch (1987) and Krugman (1987) and is the framework for numerous papers in the literature as surveyed in Burstein and Gopinath (2014). I will assume without loss of generality that the invoicing currency is the dollar. Profit maximizing prices can be expressed generically as a mark-up over marginal costs. The pricing response of the Japanese firm then depends on two factors: the sensitivity of its marginal costs expressed in dollars to the exchange rate shock and the sensitivity of its desired mark-up to exchange rate shocks.

5.1.1 Marginal cost sensitivity

The marginal cost in dollars depends on prices of variable inputs that enter the production function such as labor, rental capital, and intermediate inputs when converted to dollars and on firm productivity.[35] In addition if production is subject to decreasing returns to scale then the level of production also impacts marginal costs. The sensitivity of the marginal cost to the exchange rate shock will generally depend on the source of the shock. Suppose the yen depreciation follows from a monetary expansion in Japan then it is possible that wages in yen rise alongside the yen depreciation and consequently the sensitivity of the wage bill in dollars is low. The empirical evidence however is more supportive of a disconnect between local currency (yen) wages and exchange rates especially at frequencies studied in the pass-through literature.[36] Accordingly, the yen depreciation is associated with an almost proportionate decline in wages denominated in dollars. The reduced sensitivity of the marginal cost to the exchange rate change can however arise from the use of imported intermediate inputs in production. If these imported inputs are priced in dollars and these dollar prices are insensitive to the exchange rate change then only the fraction of costs that rely on domestic inputs will react to the exchange rate shock. The incentive to lower dollar prices following the yen depreciation, and therefore the pass-through into dollar prices, then depends on the Japanese firms reliance on imported inputs in its production. The fact that most exporters are also importers is now well documented in the literature by Bernard et al. (2009), Kugler and Verhoogen (2009), Manova and Zhang (2009) among others. This is also reflected

[34] For the same reason the solution does not depend on whether the firm is maximizing yen profits or dollar profits.

[35] These prices can include wedges that arise from taxes or from financing frictions.

[36] See the literature following the seminal observation of Meese and Rogoff (1983).

in the fact that value added exports are significantly lower than gross exports, particularly for manufacturing, as documented in the works of Johnson (2014) Johnson and Noguera (2012). Amiti et al. (2014) employ data on Belgian firms to show that exporters that import more do indeed pass-through a smaller fraction of exchange rate shocks into their export prices (denominated in the destination currency).

Lastly, production can be subject to decreasing returns to scale because of the fixed nature of capital in the short-run and other forms of capacity constraints. In this case if the Japanese firm reduces the dollar price and consequently raises the demand it faces, as it produces more its marginal cost increases. This channel dampens the sensitivity of dollar marginal costs to exchange rate shocks thus reducing desired pass-through. This channel may be more important for firms in developing countries that face greater infrastructure constraints.

5.1.2 Mark-up Sensitivity

The mark-up a firm charges depends on the elasticity of the demand it faces and consequently the sensitivity of the mark-up to the exchange rate shock depends on the sensitivity of the elasticity of demand to the shock. A widely used demand form is the Dixit-Stigliz preferences which when combined with monopolistic competition gives rise to constant mark-ups. In this case pass-through is equal to the sensitivity of dollar marginal costs. If dollar marginal costs decline one to one in response to a yen depreciation then dollar prices are also reduced one to one and pass-through is a hundred percent. However, the importance of variable mark-ups in determining pass-through was recognized early on by Dornbusch (1987) and Krugman (1987) who studied oligopolies and monopolies. Atkeson and Burstein (2008) expand on this framework allowing for multiple industries and trade costs.

The Japanese firm selling to the U.S. market faces competition from U.S. producers and other exporters to the U.S. market. When firms are not infinitesimal the elasticity of demand they face varies with their market share. By lowering its dollar price the firm is able to gain market share but at the expense of lower mark-ups. A profit maximizing firm optimizes this trade-off. The extent to which it chooses to lower prices versus raising mark-ups depends on the extent of strategic complementarities in pricing. When complementarities are high firm profits are maximized when

the firm keeps its prices relative to its competitors prices stable. As Atkeson and Burstein (2008) show for a given cross-sector elasticity of demand the higher the elasticity of substitution across products within a sector the greater the absorption in mark-ups and consequently the lower is desired pass-through.[37]

The empirical evidence on variable mark-ups[38] dates back to Knetter (1989), Knetter (1993) and the survey article by Goldberg and Knetter (1997) who use aggregate export prices to multiple destinations from the same country to document that the law of one price fails across these destinations. The test design assumes that the costs of producing the good is independent of the destination to which it is sold. Consequently any evidence of the failure of the law of one price for goods originating in the same country must be evidence of variable mark-ups. Fitzgerald and Haller (2013) use Irish plant level data to provide evidence of pricing-to-market. Burstein and Jaimovich (2008) present evidence using data for the U.S. and Canada. Berman et al. (2012) present evidence of variable mark-ups tied to firm productivity using data for French firms.

To summarize, in the flexible price environment, pass-through into U.S. import prices of goods originating in Japan depends, firstly, on the sensitivity of Japanese firms marginal costs to the exchange rate shock, which in turn depends importantly on the reliance of its production structure on imported inputs and the sensitivity of those input costs (in dollar terms) to the exchange rate shock. Second, it depends on the impact of the shock on Japan's competitors, which include U.S. producers and exporters from other countries whose products compete with Japanese firms. In the presence of strategic complementarities in pricing Japanese firms would want to keep their prices relative to their competitors prices stable and this in turn lowers pass-through.

5.2 Sticky Prices

The existence of infrequent price adjustments has long been acknowledged in the literature. Terminology such as Producer Currency Pricing (PCP) to denote pricing in the exporters/origination currency and Local Currency Pricing (LCP) to denote pricing in the importers/destination cur-

[37] As the firm raises prices it lowers its market share and this raises the elasticity of demand it faces reducing desired mark-ups.

[38] I use variable mark-ups and pricing to market interchangeably. Technically to obtain pricing-to-market one requires not just a source for variable mark-ups but also some form of market segmentation such as trade costs (transportation costs, tariffs etc). Since it is safe to assume that such costs exist I treat the two terms as the same.

rency is standard in Keynesian open economy models. When prices are sticky the currency of denomination/invoicing has a large impact on pass-through.[39] If the Japanese firm sets prices that are sticky in U.S. dollars then for the duration when prices are unchanged pass-through in dollar prices is zero. On the other hand if prices are sticky in yen pass-through is a hundred percent. The duration of price stickiness and the currency of invoicing will therefore have a large impact on pass-through.[40]

When it is costly to adjust prices expectations of the future path of exchange rates enter pricing decisions. Because freely floating nominal exchange rates have been shown to behave like random walks in the time series firms should respond to these shocks as if they are permanent. However in reality it may be the case that firms expect exchange rate shocks to be transitory in which case their incentive to change prices in the currency of invoicing is limited as the exchange rate may revert during the time spell when the new price is in effect. This then generates differences in pass-through between LCP and PCP even conditional on prices having changed.

With the proliferation of micro datasets on prices there is now a large empirical literature surveyed in Klenow and Malin (2010) that documents considerable price stickiness especially for wholesale/producer prices. Gopinath and Rigobon (2008) and Gopinath and Itskhoki (2010a) present evidence of price stickiness of actual traded goods using import and export prices for the U.S. They document that the weighted median price duration in the currency of pricing for arms-length transactions is 10.6 (12.8) months for imports (exports). Fitzgerald and Haller (2013) report estimates of 6.25 months for Irish exports. Friberg and Wilander (2008) use survey data for Swedish firms and report estimates of one year for list prices. Sticky price concerns in international trade are therefore well founded.

[39] Prices in a specified currency are contracted for a period of time that may be deterministic (Taylor) or stochastic (Calvo, Menu-Cost).

[40] In theory the impact of price rigidity on aggregate pass-through depends on how firms get selected into changing prices. In a Calvo sticky price environment where firms are randomly assigned the option to change prices aggregate pass-through rates are closely tied to the degree of price stickiness. On the other hand, if firms optimally decide when to change prices, as in menu cost models, aggregate passthrough can be disconnected from price stickiness as originally elucidated by Caplin and Spulber (1987).

5.3 Currency of Invoicing

The vast majority of papers in the Keynesian open economy macro literature assumes exogenous currency invoicing, typically either PCP or LCP. Milton Friedman's advocacy for flexible exchange rates rests on the assumption that firms set prices in their own currency; that is, they practice PCP.[41] This exogeneity assumption arises to an important extent from the desire to maintain tractability in general equilibrium models. The incorporation of endogenous currency choice with price stickiness requires departures from more tractable demand and cost structures and typically involves multiple equilibria. However important progress has been made in connecting the sticky price environment and flexible price determinants in the works of Giovannini (1988), Donnenfeld and Zilcha (1991), Friberg (1998), Engel (2006), Devereux et al. (2004), Bacchetta and van Wincoop (2005), Gopinath et al. (2010), Goldberg and Tille (2008), Goldberg and Tille (2009b) among others. In this section I describe the implications of endogenous currency choice in a world with price stickiness. This then corroborates the description of the International Price System from a theoretical perspective.

When discussing currency choice I will use the currency of invoicing and currency of pricing terminology interchangeably. While the currency of invoice does not necessarily have to be the same as the currency of pricing, in practice they are. The best evidence is provided by Friberg and Wilander (2008) who use survey data for a sample of Swedish exporters and report that for the overwhelming share of exports the price, invoice and settlement are denominated in the same currency.

5.3.1 Desired Pass-Through

Initially I will continue to assume that there are no lags between production, delivery of products and receipt of payments and that the firm is risk-neutral. I will discuss the implications of relaxing these assumptions later in this section.

Consider the currency invoicing decision of the Japanese firm exporting to the U.S. market.

[41] The seminal contributions of Svensson and van Wijnbergen (1989) and Obstfeld and Rogoff (1995) embed this assumption as one of the foundations of the modern Keynesian open economy macro literature. However, the relative stability of local currency prices to exchange rate changes motivated important work using the alternative assumption of LCP, as in Devereux and Engel (2003).

The constraint here is the inability to adjust prices costlessly. When the firm chooses its price and the currency of pricing it takes into account the implications for its profits of its choices during the periods when the price will be in effect. If the firm chooses to price in dollars it will attain an *unconditional* pass-through of 0% into dollar prices for the duration when prices are unchanged. On the other hand if it chooses to price in yen the pass-through into dollar prices will be 100% during this period.

The choice of invoicing currency then depends on what its unconditional *desired* pass-through is, that is what its pass-through would have been if it could change prices flexibly. This choice therefore depends crucially on the flexible price determinants of pass-through.[42] Suppose its desired pass-through into dollars is low, say 10%, then dollar invoicing by implying a pass-through of 0% during the period of price rigidity helps the firm better mimic its desired pass-through, rather than yen invoicing that generates a pass-through of 100%. If on the other hand its desired pass-through into dollars is high, say 90% it will be optimal to choose yen invoicing.

Currency choice is then closely linked to the discussion in Section 5.1. It depends on the sensitivity of its marginal costs and desired mark-up to exchange rate movements. Importantly, in an environment with price stickiness, this sensitivity depends on the currency of invoicing choice of other exporters.

Consider the marginal cost sensitivity channel. If the dollar is the predominant currency of invoicing then the Japanese firms imported inputs are priced in dollars.[43] This implies that its marginal costs in dollars are less sensitive to exchange rate movements. Consequently the Japanese firm has low desired pass-through into dollar prices and therefore will choose to price in dollars. A similar argument applies to the mark-up channel. As described previously desired sensitivity of mark-ups depends on the extent of strategic complementarities in pricing. If the Japanese firm faces competition in the U.S. market from other producers, both domestic and foreign, who set prices in dollars then profit maximization requires the firm keep its price stable relative to its competitors. During the period when the price is sticky this can be attained by invoicing in dollars, so that yen-dollar exchange rate movements do not impact its relative price. More

[42] *Desired* pass-through is different from flexible price pass-through because it measures the extent of pass-through of a firm if it can change prices in an environment where other firms prices may be sticky.

[43] What really matters in the sensitivity of the dollar inputs costs to the exchange rate movements.

broadly if world trade markets are characterized by a predominance of dollar invoicing then that incentivizes any entrant exporter into also choosing dollar invoicing.

As is evident there is the possibility of multiple equilibria in currency invoicing. In the absence of a concerted effort by a significant fraction of exporters to switch the currency of invoicing the dollar dominance is reinforced with each additional entrant. The introduction of the euro is arguably one such coordinating shock to the currency of invoicing.

Now consider alternative explanations for currency of invoicing, some of which require relaxing the assumptions made at the start of this section.

5.3.2 Fixed costs in setting prices

International trade is dominated by large firms that export to multiple destinations. Destination specific pricing can be costly in terms of management hours, for instance in determining the elasticity of demand it faces in a particular market and the competitors it faces. If the destination market is large in the portfolio of the exporting firm it can be worthwhile incurring the cost. However if the destination market is small the firm may choose to offer the same price, in the same currency, as what it charges its larger customers. This can generate bunching in pricing and invoicing decisions across destinations.

5.3.3 Hedging

I emphasize that hedging (using forward contracts) does not make the currency invoicing decision in the presence of price stickiness irrelevant. The discussion in Section 5.3.1 from the perspective of a risk-neutral investor highlights that expected profits differ across currency invoicing regimes and accordingly hedging does not suffice to generate equivalence across regimes.

Risk averse exporters are however known to use currency hedging, such as forward currency contracts, to reduce volatility in profits arising from exchange rate uncertainty when pricing in a currency not their own. If the Japanese firm chooses to price in dollars and is risk-averse it can fully hedge its exchange rate exposure by selling forward the predetermined dollar revenue using the forward rate. If the forward equals the expected spot and the transaction is costless then this

is without loss of expected profits.[44] If the Japanese firm chooses to price in a third currency, hedging is less straightforward. This is because there is uncertainty in the revenue earned in the third currency and consequently there is uncertainty in the amount that is to be hedged.

In Section 5.3.1 the exporting firm chooses a price that is contracted for a length of time while quantity is left to be determined by the buyer given the price and is not contracted on. That is quantities can fluctuate in response to shocks during the duration when prices are sticky.[45] Often trade contracts take the form of pre-specified prices and quantities. In this case pricing in the exporters currency will eliminate profit risk to the exporter without the need to hedge. A similar argument applies for when there are lags between production and delivery and receipt of payment and hedging is costly.

5.3.4 Bargaining

In the preceding discussion I described the problem through the lens of exporters unilaterally choosing the optimal price and invoicing currency so as to maximize profits. In reality these decisions are the outcome of a negotiation process between the exporter and importer and the results are the outcome of a bargaining process. Goldberg and Tille (2013) explicitly consider such a bargaining process, specifically Nash bargaining, in an environment where there are risk-averse importers and exporters and lags between when contracts are written and actual transactions take place giving rise to the need to allocate exchange rate risk. A feature of the bargaining outcome Goldberg and Tille (2013) highlight is that when the importer is large there should be more invoicing in the importer's currency.

5.3.5 Financial market development

It is often suggested that currency invoicing choices in trade transactions are related to the depth of financial markets in currencies, particularly in the provision of trade credit. That is the dollar is used in trade transactions because of extremely liquid dollar financial markets and trade credit denominated in dollars. While this is plausible there is very little formal analysis of this linkage.

[44] See Friberg (1998) for a fuller discussion.

[45] Gopinath and Rigobon (2008) employ confidential BLS micro data to document that even when quantities are contracted on, some flexibility is allowed along side the price being completely rigid.

5.3.6 General Equilibrium

Most of the analysis on currency choice is carried out in partial equilibrium. Desired pass-through is the ratio of the covariance of the desired flexible price of the exporting firm (in the importers currency) with the exchange rate and the variance of the exchange rate. In general equilibrium both the covariance and variance depend on the fundamental shocks to the economy. Under specific assumptions Devereux et al. (2004) show that firms are less likely to invoice in the currency of a country with a volatile monetary policy that raises the variance of the exchange rate.

Summary: What does all of this imply for the sensitivity of a country's inflation to exchange rate shocks? Firstly, the close relation between desired pass-through and currency of invoicing implies that there should be a close link between short-run pass-through, when many goods prices are yet to change, and long-run pass-through into prices in any given currency. Consequently, countries with high (low) short-run sensitivity of their inflation to exchange rate shocks will have high (low) long-run sensitivity. Secondly, the invoicing patterns of a country's import bundle are good predictors of inflation sensitivity. Inflation sensitivity is greater the larger the fraction of a country's imports priced in a foreign currency, that is not in its own currency. Lastly, forces such as strategic complementarities in pricing and network effects through trade in intermediate inputs should give rise to the emergence of only a few currencies dominating invoicing in world trade and these invoicing patterns will change infrequently.[46] This is consistent with all the evidence reported in Section 2. This section also highlights that the relevant pass-through estimate (for currency choice) is an unconditional pass-through from exchange rates to prices. Because of this the standard omitted variable concerns that arise in pass-through regressions owing to the endogeneity of exchange rates do not apply here.

5.4 Evidence on factors influencing Currency Choice

The empirical evidence on what factors determine currency choice is rather limited for two reasons: Firstly, disaggregated firm level data on invoicing currency and prices for importers and exporters is hard to come by. Secondly, even with appropriate data it can be difficult to isolate the forces

[46] A complementary channel that gives rise to dominant currencies are transaction costs in exchanging currencies as in Rey (2001) and Devereux and Shi (2008).

described in Section 5.3 as there is no simple linear relation between variables such as strategic complementarity in pricing, marginal cost sensitivity, macroeconomic risk and currency choice. What is clear though is that given that international trade is dominated by at most two currencies, the dollar and the euro, the dominant explanatory factors have to be common across countries. That is, it cannot be about idiosyncratic features of transactions between individual importers and exporters.

Here I briefly summarize existing evidence. Several papers point to evidence of the strategic complementarity in pricing channel, that is when firms export goods that are close substitutes they are likely to invoice in a common currency. Gopinath et al. (2010) use BLS import price data to document that dollar pricing is more common in sectors classified as producing more homogenous goods as compared to differentiated goods (following the Rauch (1999) classification). For instance sectors such as 'Animal or Vegetable Fats and Oils', 'Wood and articles of Wood' and 'Mineral Products' are dominated by dollar pricers. On the other hand there is a greater share of non-dollar pricers in the 'Footwear', 'Textiles and textile articles', 'Machinery and mechanical appliances' sectors.[47] Goldberg and Tille (2008) find a similar result when they examine aggregate invoicing data for 24 countries, that is more homogenous goods are priced everywhere in a common currency, dollars, and this is less true for differentiated goods. Chung (2014) provides evidence for the imported intermediate inputs channel using UK trade transaction data with non-EU countries. She finds that a 1% decrease in the share of imported inputs priced in sterling decreases the probability that UK exporters invoice in sterling by about 18%. Goldberg and Tille (2009b) provide evidence to support a prediction of the bargaining model namely that the Canadian dollar is used more extensively for larger import transactions into Canada. This is also consistent with fixed costs in currency invoicing decisions.

Besides these sector and transaction level considerations it is documented that macroeconomic variables such as exchange rate volatility associated with volatile macroeconomic shocks impact currency invoicing. This more generally lines up with the fact that developing countries rely more heavily on third currency dollar invoicing as compared to developed countries as illustrated in Figure 4.

[47] Gopinath et al. (2010) also document that dollar prices change more frequently than non-dollar prices.

6 Conclusions

There is considerable variation in the sensitivity of a country's imported inflation to exchange rate shocks at horizons of up to two years. In this paper I demonstrate that one factor, the share of its imports invoiced in a foreign currency, plays a significant role in generating this variation. This has implications for a country's inflation insularity to exchange rate shocks and has predictions for the margins of adjustment of a country's trade balance to exchange rate fluctuations. It provides an additional argument for why countries can benefit from the internationalization of their currency, while at the same time highlighting the limits to its success given existing network effects.

There is clearly a lot more to be understood both on the empirical and theoretical front. Several of the policy implications spelt out in Section 4 need to be confronted with additional empirical evidence. This will require more systematic data collection efforts for import and export prices, quantities, and currency invoicing patterns by countries. Many countries simply lack usable import and export price index data. At present only a few programs like the International Price Program at the BLS in the U.S. construct actual price indices, while most countries rely on unit value indices. The pass-through estimates using aggregate unit value indices can be very noisy. On the theoretical front besides understanding the implications of the IPS for optimal monetary policy we also need a better understanding of the links between dollars prominence in asset markets and that in good markets. How does a country's reserve currency status benefit its invoicing status or the other way round?

Lastly, there can be important non-price methods of passing through exchange rate shocks that do not get captured in prices. For instance there can be lump-sum compensation for exchange rate changes despite reported prices being unchanged. The consequences of this for inflation and international trade need further investigation.

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Appendix

A Country Names and Codes

Country	Code	Country	Code
Algeria	DZ	Latvia	LV
Argentina	AR	Lithuania	LT
Australia	AU	Luxembourg	LU
Austria	AT	Malta	MT
Belgium	BE	Mexico	MX
Brazil	BR	Morocco	MA
Bulgaria	BG	Netherlands	NL
Canada	CA	New Zealand	NZ
China	CN	Norway	NO
Colombia	CO	Pakistan	PK
Cyprus	CY	Philippines	PH
Czech Republic	CZ	Poland	PL
Denmark	DK	Portugal	PT
Estonia	EE	Romania	RO
Finland	FI	Singapore	SG
France	FR	Slovakia	SK
Germany	DE	Slovenia	SI
Greece	GR	South Africa	ZA
Hong Kong	HK	South Korea	KR
Hungary	HU	Spain	ES
Iceland	IS	Sweden	SE
India	IN	Switzerland	CH
Indonesia	ID	Thailand	TH
Ireland	IE	Turkey	TR
Israel	IL	Ukraine	UA
Italy	IT	United Kingdom	UK
Japan	JP	United States	US
		Venezuela	VE

Table 10: ISO Country Codes

Consider the following passthrough equation:

$$\Delta p_{i,t} = \alpha_i + \sum_{k=0}^{T} \beta_{i,k} \Delta e_{i,t-k} + \gamma_i X_{i,t} + \epsilon_{i,t}$$

1. $\Delta p_{i,t}$ represents changes in a domestic price index or unit values series for country i
2. $\Delta e_{i,t}$ represents changes in country i's exchange rate
3. $X_{i,t}$ reflects other covariates, such as country i's producer price index, country i's unemployment rate, and country i's GDP

The data appendix will discuss the construction of each of these in turn.

B Domestic Prices

For any given source and country, $\Delta p_{i,t}$ is computed as log quarterly differences:

$$\Delta p_{i,t} = \log p_{i,t} - \log p_{i,t-1}$$

The series names and sources are given below, by country. Due to the differencing operation, almost all series start in the second quarter.

B.1 Argentina

series	start	end	source	concept	unit
CPI	2014q2	2014q4	IFS	Consumer Prices, all items	2010=100
IPI	1993q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.2 Australia

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q4	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.3 Austria

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1966q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Import Prices, all commodities	2010=100

B.4 Brazil

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q4	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.5 Canada

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1961q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.6 Colombia

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1999q1	2014q4	Bank of the Republic	Consumer Prices, excluding primary food, utilities, and fuel	2010=100
IPI	1970q2	2009q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.7 Czech Republic

series	start	end	source	concept	unit
CPI	1993q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1996q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1992q2	2013q3	OECD	Import Prices, total	2000=100

B.8 Denmark

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.9 Estonia

series	start	end	source	concept	unit
CPI	1992q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1998q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1998q2	2014q4	Statistics Estonia	Import Prices, total	Dec 1997=100

B.10 Finland

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1960q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.11 France

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1990q2	2009q1	IFS	Goods, Deflator/Unit Value Imports	local currency

B.12 Germany

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1962q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q3	IFS	Goods, Deflator/Unit Value Imports	local currency

B.13 Hong Kong

series	start	end	source	concept	unit
CPI	1981q1	2014q4	IFS	Consumer Prices, all items	2010=100
IPI	1969q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.14 Hungary

series	start	end	source	concept	unit
CPI	1976q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1990q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1979q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.15 Ireland

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.16 Israel

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1962q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.17 Italy

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1960q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.18 Japan

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.19 Latvia

series	start	end	source	concept	unit
CPI	1991q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1995q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1998q2	2014q4	Central Statistical Bureau of Latvia	Import Prices, unit value	2010=100

B.20 Luxembourg

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1967q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1989q2	2003q2	OECD	Import Prices, total, unit value	2000=100

B.21 Mexico

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1980q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1970q2	2014q4	Banco de Mexico	Import Prices, all items	local currency

B.22 Netherlands

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1960q3	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	

B.23 New Zealand

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1969q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.24 Norway

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.25 Pakistan

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1979q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1970q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.26 Philippines

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	2011q3	2014q4	Philippine Statistics Authority	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1996q2	2006q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.27 Portugal

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1988q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2010q4	IFS	Import Prices, all commodities	2010=100

B.28 Singapore

series	start	end	source	concept	unit
CPI	1961q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	2012q2	2014q4	Singapore department of Statistics	Consumer Prices, excluding accomodation and private road transport	2009=100
IPI	1974q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.29 South Africa

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	2002q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2006q1	IFS	Goods, Deflator/Unit Value Imports	local currency

B.30 South Korea

series	start	end	source	concept	unit
CPI	1970q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1990q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1963q2	2012q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.31 Spain

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.32 Sweden

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.33 Switzerland

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1963q2	2014q4	IFS	Import Prices, all commodities	2010=100

B.34 Thailand

series	start	end	source	concept	unit
CPI	1965q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	2007q1	2014q4	Thailand Ministry of Commerce	Consumer Prices, excluding raw food and energy	2011=100
IPI	1961q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.35 Turkey

series	start	end	source	concept	unit
CPI	1969q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1994q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1982q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.36 United Kingdom

series	start	end	source	concept	unit
CPI	1988q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1970q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

B.37 United States

series	start	end	source	concept	unit
CPI	1960q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1960q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1985q2	2014q4	BLS	Import Prices, no petroleum	2000=100

B.38 Venezuela

series	start	end	source	concept	unit
CPI	2008q2	2014q4	IFS	Consumer Prices, all items	2010=100
CPI	1976q2	2014q4	OECD	Consumer Prices, all items non-food, non-energy	2010=100
IPI	1960q2	2014q4	IFS	Goods, Deflator/Unit Value Imports	local currency

C Exchange Rates

Let Ω represent the set of all countries and Γ represent the set of all currencies, and define the mapping $f : \Omega \to \Gamma$ (e.g. f maps the UK to the pound). For any given source and country, $\Delta e_{i,t}$ is computed as weighted log quarterly differences in bilateral exchange rates for $f(i)$:

$$\Delta e_{i,t} = \sum_{j \in \Omega/\{i\}} w_{ij,t-1} \Delta e_{f(i)f(j),t} \quad \text{where} \quad \Delta e_{f(i)f(j),t} = \log e_{f(i)f(j),t} - \log e_{f(i)f(j),t-1}$$

This computation is implemented using bilateral exchange rates vis-a-vis the US dollar, such that:

$$\log e_{f(i)f(j),t} = \log e_{f(i)f(USA),t} - \log e_{f(j)f(USA),t}$$

This can be rewritten:

$$\begin{aligned} \Delta e_{i,t} = & \quad \textstyle\sum_{j \in \Omega/\{i\}} w_{ij,t-1} \left(\log e_{f(i)f(USA),t} - \log e_{f(j)f(USA),t} \right. \\ & \qquad \left. - \log e_{f(i)f(USA),t-1} + \log e_{f(j)f(USA),t-1} \right) \\ = & \quad \textstyle\sum_{j \in \Omega/\{i\}} w_{ij,t-1} \left(\log e_{f(i)f(USA),t} - \log e_{f(i)f(USA),t-1} \right) \\ & \qquad - \textstyle\sum_{j \in \Omega/\{i\}} w_{ij,t-1} \left(\log e_{f(j)f(USA),t} - \log e_{f(j)f(USA),t-1} \right) \end{aligned}$$

Since weights sum to one, the final expression is:

$$\Delta e_{i,t} = \Delta e_{f(i)f(USA),t} - \sum_{j \in \Omega/\{i\}} w_{ij,t-1} \Delta e_{f(j)f(USA),t}$$

Bilateral exchange rates vis-a-vis the United States are gathered from the IFS from 1955q1 - 2014q4, as the period average for national currency per US dollar. Ω is defined as a set of 192 countries. This paper makes use of three types of exchange rates: dollar exchange rates, trade-weighted exchange rates, and invoicing currency exchange rates. Each is computed by changing how $w_{ij,t}$ is constructed.

C.1 Dollar Exchange Rates

For dollar exchange rates, $w_{iUSA,t} = 1$ and $w_{ij,t} = 0 \; \forall \; j \neq \text{USA}$.

Since $\Delta e_{f(USA)f(USA),t} = 0$, this simplifies to:

$$\Delta e_{i,t} = \Delta e_{f(i)f(USA),t}$$

C.2 Trade-Weighted Exchange Rates

Under the trade-weighted exchange rate, two metrics are calculated: the import-weighted exchange rate and the export-weighted exchange rate. In both cases, data comes from the IMF's Direction of Trade Statistics on the value of imports and exports from 1960q1 - 2014q4. Define trade flows from country $j, j \in \Omega$ to country $i, i \in \Omega$ at time t as $F_{ji,t}$. Import weights are thus calculated as:

$$w_{ij,t} = \frac{F_{ji,t}}{\sum_{k \in \Omega/\{i\}} F_{ki,t}}$$

and export weights are analogously defined:

$$w_{ij,t} = \frac{F_{ij,t}}{\sum_{k \in \Omega/\{i\}} F_{ik,t}}$$

D Invoicing Shares

The sources, content, and timespan for each country with invoicing data are listed in the table below. The paper builds off a similar dataset compiled first by Kamps (2006), and later augmented by Chinn and Ito (2014), hereafter called the "CIK" dataset. The table below notes whether the CIK dataset was used, and which other sources were utilized. Special attention is given to the US dollar and Euro, since these are overwhelmingly the most popular currencies.

Computation

Start with both the CIK data and the supplemental data. Define $M_{ij,t}$ to be the the average imports for country i in currency $j, j \in \Gamma$ at time t, and $X_{ij,t}$ analogously. Where the supplemental data and the CIK data both contain a value for (i, j, t), we utilize the supplemental data — since the

supplemental data comes directly from official sources, possibly with revisions since previously gathered.
Second, we compute M_{ij} from $M_{ij,t}$, and X_{ij} from $X_{ij,t}$. Cross-sectional averages are important given the patchy coverage over time. Defined formally:

$$M_{ij} = \frac{1}{\sum_t I\{M_{ij,t} > 0\}} \sum_t M_{ij,t}$$

$$X_{ij} = \frac{1}{\sum_t I\{X_{ij,t} > 0\}} \sum_t X_{ij,t}$$

Third, we compute w_{ij} from M_{ij} and X_{ij} as described previously.

European Union
Data provided by the ECB presents a special case, as countries present invoicing data in only one of three tiers: import and export currencies for trade with the world, trade outside of the Eurozone, and trade outside of the European Union. The former format is ideal, and requires no modification above and beyond the approach described previously. The latter two formats are more difficult, as without modification, the results will be biased. For instance, Germany's trade with its Eurozone neighbors — largely conducted in Euros — will be excluded, while Germany's trade with the US — largely conducted in dollars — will be included, overstating the share of German trade in dollars.
To deal with this, we cite conversations with Annette Kamps and Arnaud Mehl at the ECB, who informally argue that most intra-Eurozone trade is conducted in Euros. Thus, for the latter two cases, we augment the dataset with intra-Eurozone trade flows and assume they are 100% Euros. For countries with ex-Eurozone data, this is a sufficient fix.
For countries with ex-European Union data, this too is only a partial fix: it combines interpolated intra-Eurozone data with actual ex-EU data, but misses the countries that are in the EU but not the Eurozone. Rather than making strong assumptions, we let these countries hold an unassigned residual. Thus, the invoicing currency exchange rates for these countries should be treated with more caution.
The list of countries and types of data are presented below.

Data Type	Country
Total	Cyprus
	Greece
	Portugal
	Slovenia
	Spain
	Sweden
Ex-Eurozone	Belgium
	France
	Germany
	Italy
	Luxembourg
	Netherlands
	Slovakia
Ex-European Union	Austria
	Finland
	Ireland

It is worth noting that not all EU countries are represented on the list. For instance, the UK provides its data separately. Separately, some EU countries (e.g. Sweden) provide invoicing data directly, which can be used to augment the estimates.

Country	USD	EUR	Local	Others	Years	CIK	Additional Sources
Algeria	×	×			2003-2004	×	
Argentina	×	×	×	BRL, CAD, GBP, JPY	2010-2014		INDEC
Australia	×	×	×	GBP, JPY, NZD	1999-2012	×	Australia Bureau of Statistics
Austria	×	×			2006-2012	×	ECB
Belgium	×	×			2000-2012		ECB
Brazil	×	×	×	AUS, CAD, CHF, DKK, GBP, JPY, NOK, SEK	2007-2011		Ministry of Development, Industry and Foreign Trade
Bulgaria	×	×			1999-2011	×	
Canada	×	×	×		2001-2009	×	Canadian Customs Administration
China			×		2009-2012	×	
Colombia	×	×	×	VEF	2007-2015		Casas
Cyprus	×	×			2003-2012	×	ECB
Czech Republic	×	×	×		1999-2011	×	
Denmark	×	×	×		1999-2012	×	
Estonia	×	×			2001-2011	×	
Finland	×	×			2006-2012	×	ECB
France	×	×			1999-2012		ECB
Germany	×	×			2002-2012	×	ECB
Greece	×	×			2001-2012		ECB
Hungary	×	×	×		1999-2012	×	
Iceland	×	×	×	CAD, DKK, GBP, JPY, NOK, SEK	1999-2014		Statistics Iceland
India	×	×		GBP, JPY	2005-2014	×	Reserve Bank of India
Indonesia	×	×	×		1999-2012	×	
Ireland	×	×			2006-2012		ECB

Country	USD	EUR	Local	Others	Years	CIK	Additional Sources
Israel	×	×	×	JPY	2000-2014	×	Israel Central Bureau of Statistics
Italy	×	×			2001-2012	×	ECB
Japan	×	×	×		2000-2012	×	MITI
Latvia	×	×			2000-2011	×	
Lithuania	×	×	×		1999-2012	×	
Luxembourg	×	×			2000-2012	×	ECB
Malaysia	×				2000-2000	×	
Malta	×	×			2000-2010	×	
Morocco		×			2003-2003	×	
Netherlands	×	×			1999-2012	×	ECB
Norway	×	×	×	DKK, GBP, JPY, SEK	1999-2014	×	Statistics Norway
Pakistan	×	×			2001-2003	×	
Peru	×				2012-2012		Cental Bank of Peru
Poland	×	×	×		1999-2009	×	
Portugal	×	×			2000-2012		ECB
Romania	×	×			1999-2011	×	
Slovakia	×	×			1999-2012	×	ECB
Slovenia	×	×			2000-2012	×	ECB
South Africa	×	×	×		2003-2003	×	
South Korea	×	×	×	JPY	1999-2014		The Bank of Korea
Spain	×	×			1999-2012	×	ECB
Sweden	×	×	×	CHF, CNY, DKK, GBP, JPY, NOK, PLN	2000-2012	×	Central Bank of Sweden, ECB
Switzerland	×	×	×		2013-2013		Swiss Federal Customs Authority
Thailand	×	×	×	GBP, JPY, SGD	1999-2014		Bank of Thailand

Country	USD	EUR	Local	Others	Years	CIK	Additional Sources
Turkey	×	×	×	CHF, GBP, JPY, NOK, SEK	1999-2014	×	Turkish Statistical Institute
Ukraine	×	×	×		2001-2007	×	
United Kingdom	×	×	×		1999-2012	×	
United States	×	×			2003-2003	×	Bureau of Labor Statistics

E Controls

This section details other covariates in the $X_{i,t}$ term.

E.1 Producer Prices

One covariate is the change in the trade-weighted producer price index, defined as:

$$\Delta p_{i,t}^{PPI} = \sum_{j \in \Omega} w_{ij,t-1} \Delta p_{j,t}$$

where $p_{j,t}$ represents the domestic PPI in country j and changes are defined as differences in logs. We gather domestic PPI data on 85 countries from the IFS, spanning 1960q2 - 2014q4. Weights are constructed from trade data; as before, trade data comes from the IMF's Direction of Trade Statistics from 1960q1 - 2014q4.

Unlike with exchange rates, PPI data is not widely available; although the largest countries are in the dataset. Let $\hat{\Omega}$ represent the set of 85 countries for which PPI data exists, $\hat{\Omega} \subset \Omega$, and again define trade flows from country $j, j \in \Omega$ to country $i, i \in \Omega$ at time t as $F_{ji,t}$. We compute a "completeness measure" m_i:

$$m_i = \frac{\sum_{j \in \hat{\Omega}/\{i\},t} F_{ji,t}}{\sum_{j \in \Omega/\{i\},t} F_{ji,t}}$$

For all but one country (Iran), $m_i > 0.8$; and for 55 countries, $m_i > 0.9$. So our PPI metric, while imperfect, should work for most countries. Thus, we compute the weights against country $j, j \in \hat{\Omega}$ as:

$$w_{ij,t} = \frac{F_{ji,t}}{\sum_{k \in \hat{\Omega}/\{i\}} F_{ki,t}}$$

E.2 GDP

The change in (real) GDP is another covariate, pulled from the IFS for all countries in the sample from 1950q2 - 2014q4, although the initial coverage is limited. The variable is defined as:

$$\Delta GDP_{i,t} = \log GDP_{i,t} - \log GDP_{i,t-1}$$

F Computing Import Content Using Input-output Tables

Two measures of import content of consumption are constructed in a similar way as in Burstein et al.(2005). The first measure, the direct import content, is defined as the fraction of imported final goods in total consumption. The second measure, the total import content, is defined as the sum of imported final goods and imported intermediate inputs used to produce final consumption goods as a fraction of total consumption. Data for computing import content are from OECD domestic input-output (i-o) tables. The following parts of an OECD i-o table are used for our calculation.

Define c as a 49×1 column vector consisting of data from row Ind1 to row Import under column Households Final Consumption. The direct import content is then given by

$$\frac{(0, \ldots, 1)c}{(1, \ldots, 1)c}.$$

	Intermediate				Final Demand
Industry	Ind 1	Ind 2	$\cdots$	Ind 48	Households Final Consumption
Ind 1					
Ind 2					
$\vdots$					
Ind 48					
Import					
Industry Output					

Note: Different from Burstein et al.(2005), we use a later version of oecd i-o tables, which have more detailed industry classification codes and report values in euro for euro zone countries.

To compute the total import content, we first construct matrix A, which expresses the domestic industry inputs and imported input as a fraction of each industry's output. The last column of matrix A consists of all 0's since no domestic industry inputs are used to produce imported goods. The total import content is obtained by

$$\frac{(0,\ldots,1)(I-A)^{-1}c}{(1,\ldots,1)c},$$

where is I is the identity matrix.