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What can Big Data tell us about the passthrough of big exchange rate changes?

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Abstract

Using a large data set of import volumes and values for goods imports from around 50 trading partners, and 3,000 goods type, this paper finds that the micro level, passthrough is non-linear in the exchange rate. The passthrough of larger bilateral exchange rate movements (ie more than 5%) is around four times larger than that of smaller changes. However, regressions on aggregate data indicate that passthrough at the macro level is close to full. The resolution to this apparent puzzle lies in the fact that larger bilateral movements account for the vast majority of variation in the exchange rate index, and hence the non-linearity at the micro level largely disappears at the macro level.

Key words: Exchange rate passthrough, Big Data, non-linearity.

JEL classification: E31, F14, F41.

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1 Introduction

In an open economy, the extent to which exchange rate changes are passed through into import prices is a key channel by which the external environment can feed through to domestic prices. The bulk of the existing literature tends to focus either on aggregate behaviour- i.e. the response of aggregate import prices to a change in some exchange rate index; or looks at more micro level responses- by individual firms or across product classes. But making inferences about one, based on emprical evidence for the other may be complicated by the problem of aggregation. More specifically, if the marginal passthrough differs across cross-sectional units, and if bilateral exchange rate changes are not homogenous for all partner currencies, then the estimated "micro" passthrough coefficient may not match up with that obtained from macro data.

This is a potentially important issue in bringing microfounded theory to the data. Since most standard open economy models consist of two countries, they abstract from any compositional effects of the exchange rate, since the bilateral rate against the foreign economy is the same thing as the exchange rate index, and so the passthrough coefficients of bilateral exchange rates are the same as those for the exchange rate index. Introducing more than one trading partner breaks down this equivalence.

Accordingly, this paper explores the consequences of non-linear passthrough at the micro level for aggregate import price dynamics.

The passthrough of exchange rate changes can have both real and nominal determinants. On the nominal side, the literature has focussed around the currency in which the rigidity exists. Under local currency pricing, prices are set in the currency of importing currency, and hence for the duration of the price rigidity, passthrough is zero. By contrast, under producer pricing, the price rigidity is in the exporting country's currency, and hence passthrough to import prices is full. But starting from Obstfeld and Rogoff (2000), a sizeable body of work has argued that attributing lower measured passthrough purely to nominal rigidities is not consistent with the stylised fact that exchange rate depreciations tend to lead to deteriorations in the terms of trade. Moreover, since price rigidities are an inherently short run phenomenon, they cannot account for incomplete long run passthrough, or for the stylised fact that incomplete passthrough lasts on average longer than period for which prices are sticky (Giovannini, 1988; Marston, 1990; Campa and Goldberg, 2005). Accordingly, a subsequent literature has emerged which invokes real as well as nominal causes for apparent stickiness in import prices. Corsetti, Dedola and Leduc (2008) develop of a model of imperfect competition, in which long-run passthrough is incomplete even under perfectly flexible prices because the the presence of a domestic distribution sector.

This paper explores how passthrough may differ depending on the size of the bilateral exchange rate change. It utilises a dataset on import volumes and values for around 3000 goods types, from 45 trading partners from the EU's comext database. Having both a trading partner and a goods type dimension affords the obvious advantage of expanding the number of observations available, but also permits the exploration of how goods prices respond to bilateral exchange rate changes.

The disaggregated data reveal a distinct non-linearity in passthrough at the micro level. For "small" moves in the bilateral exchange rate (less than 5% year-on-year in either direction), only about 16% of the change is passed on to import price- i.e passthrough is 0.16- but for larger changes, passthrough is around 0.75. The overall effect on aggregate import prices therefore depends on the distribution of changes in the bilateral rates that make up the overall exchange rate index. Running equivalent regressions on aggregate data, yields the result that exchange rate passthrough is close to full. This result doesn't stem from the same aggregation bias as Imbs et al (2005), rather it relates to the fact that contributions of each currency to the *change* in the ERI, may not be the same as the weight of each currency in constructing the index in levels.

And in practice, movements in the exchange rate index (ERI) are typically not characterised as a uniform change in all bilateral exchange rates. Decomposing the ERI into the contributions of "large" and "small" bilateral changes, we find that the former make up the overwhelming majority of aggregate ERI moves. As a result, aggregation effects do matter.

Failure to account for these aggregation effects yields an emprical puzzle-passthrough estimates using macro level data yield a much higher estimate aroundthan what the micro data would suggest. But allowing for these aggregation effects, one can resolve the puzzle. Decomposing the movement in the ERI into the contributions of large and small bilateral changes, we find that the former account for the vast majority of movements in the ERI. And hence, the bulk of movements in the ERI stem from changes where passthrough is high, aggregate passthrough appears very high.

This result has parallels with the literature on the relationship between micro price stickiness and the response of aggregate prices to monetary shocks. Several authors have shown that sluggish responses at the micro level need not imply corresponding stickiness at the macro level (Caplin and Spulber, 1987; Cabellero and Engel, 1991; Bils and Klenov, 2004; Golosov and Lucas, 2007; Gerlter and Leahy, 2008; Cabellero and Engel, 2007).

One stream of work has foccused primarily on micro data has found that the passthrough of bilateral exchange rate changes may not be homogenous. For example, Gopinath et al (2010), have shown that the invoicing currency matters for passthrough, will dollar priced goods having a much lower passthrough than those priced in nondollars. Auer and Schoenle (2012) and Gopinath and Itskhoki (2010) both find that broad movements in the USD against all partner currencies are subject to higher passthrough than bilateral movements which reflect factors idiosynchratic to a particular trading partner. Another related stream, focussing on the macro side, has explored the possibility of non-linear or asymmetric responses of aggregate import prices to changes in the exchange rate index. In cross country work, Bussiere (2013) finds that the overall response of import prices can vary with the size and sign of the exchange rate change; and Pollard and Coughlin (2003) find evidence for the US that passthrough is fuller, the larger is the bilateral exchange rate change. For the UK, Herzberg et al (2003) find no evidence of asymmetric passthorugh at the macro level.

This paper contributes to literature in several dimensions. First, it marries together micro and macro evidence from micro data, and to resolve the apparent puzzle in differential passthrough. The results here demonstrate that whilst there is a non-linearity at the micro level, this does not manifest itself at the macro level because the overwhelming majority of movements in the ERI are accounted for by larger bilateral changes. Second, the bulk of the literature on the micro side tends to use US data. But given the US dollar's role as an international currency, and its consequent attractiveness as an invoicing currency for exporters, results for the US may not generalise to other countries. Accordingly it provides evidence on micro passthrough for a smaller, more open economy.

This remainder of this paper is organised as follows: Section 2 outlines the dataset used, section 3 presents the micro level evidence, section 4 the macro evidence and section 5 presents a decomposition of the exchange rate index which can reconcile the two pieces of evidence. Section 6 concludes.

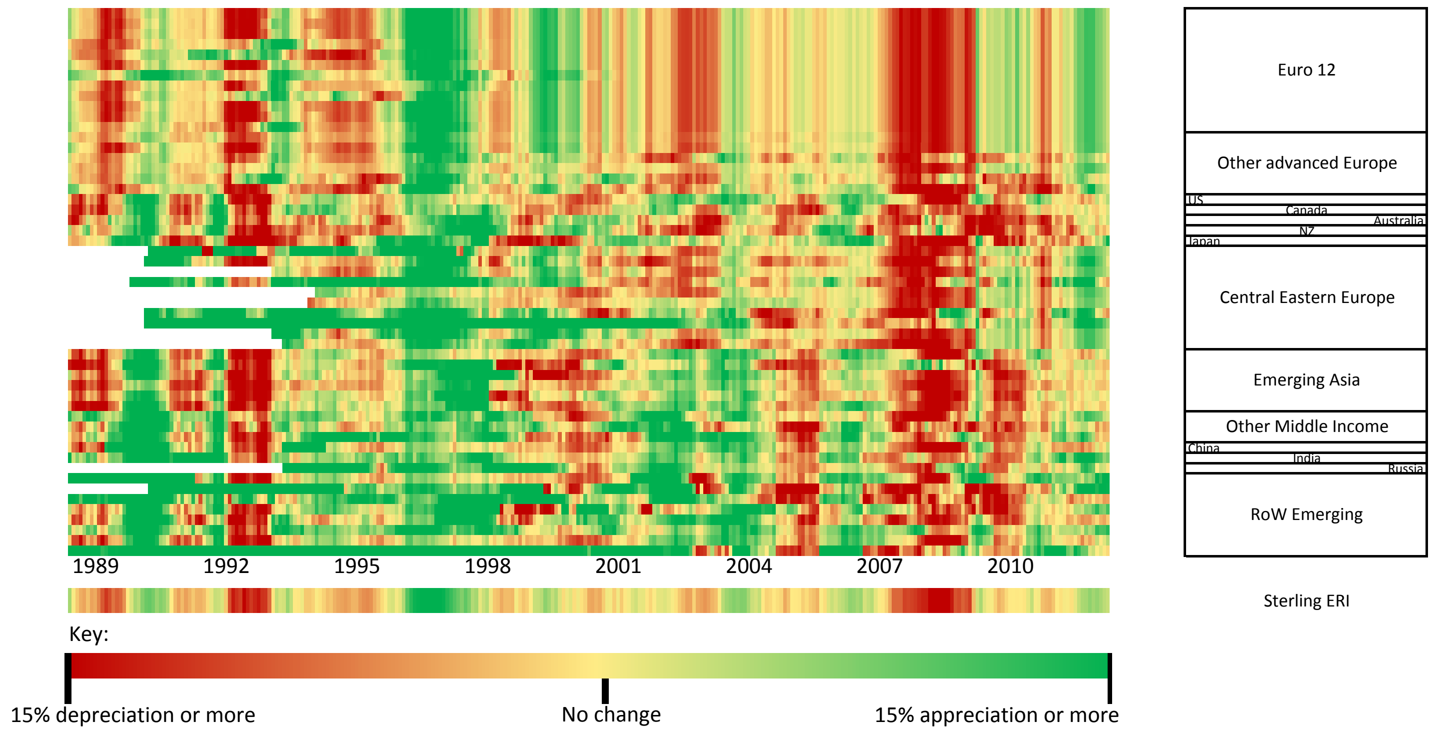
2 Data

To gauge the impact of changes in bilateral exchange rates on import prices, we utilise data from the EU's comext database. This provides statistics on merchandise trade, based on data provided by national statistical agencies. The data is classified according to 8 digit subdivision of the Harmonised System, and its most dissaggregate contains the volumes and values of goods imports across around 3000 goods categories and by trading partners, at the monthly frequency. To keep the dataset manageable, 45 countries countries were selected, corresponding to the same 45 countries which appear in the Bank of England's exchange rate index.[1]

Not every country exports every good in each period, and so there are many zero observations in the dataset, but nevertheless this yields in excess 3 million datapoints. We proxy import prices by taking a unit value measure obtained by dividing the value of imports from country i of good j at time t, is divided by the corresponding volume , which is then log-differenced to generate the dependent variable. We then combine this with bilateral exchange rate data from datastream, and export price inflation indices for each of the trading partners.

[1] These are:the other 26 EU members, plus Norway, Switzerland, Russia, Turkey, Argentina, Brazil, Colombia, Chile, Mexico, Canada, US, China, Hong Kong, Indonesia, India, Israel, Japan, Malaysia, Pakistan, Phillipines, Saudi Arabia, Singapore, South Korea, Taiwan, Thailand, Australia, New Zealand and South Africa

Figure 1: Bilateral exchange rates



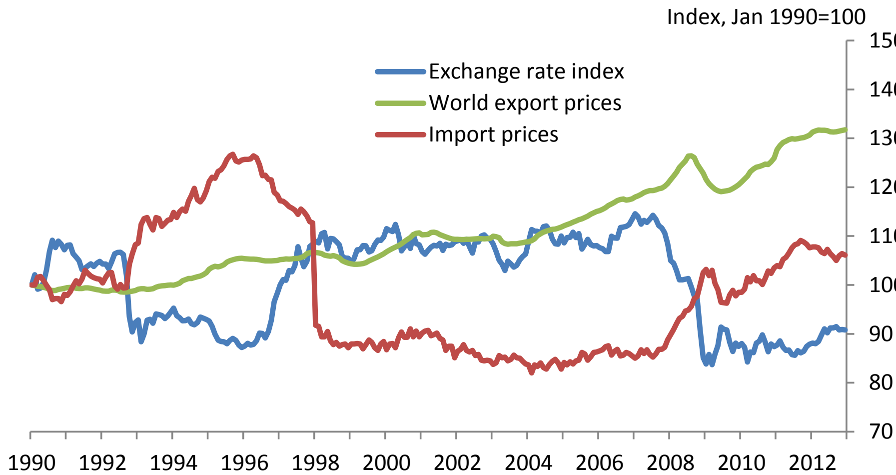
Looking at this exchange rate data, it is apparent that the aggregate ERI masks quite different movements in invidual bilateral exchange rates. Figure 5 shows the year-on-year bilateral change in sterling against each of the 45 countries over the period 1989-2013. Yellow denotes no change, whilst progressively darker shades of green and red denote stronger appreciations and depreciations respectively. Whilst there are periods of generalised appreciation (1996-7) and depreciation (2007-9) against almost all currencies, at other times sterling moves in different directions and by different magnitudes against the partner currencies.

To clean up the data and mitigate the risk of any outliers, we drop any unit value inflation observation which is larger than +100% or smaller than -50%, month on month. Similarly, to avoid the sample being unduly influenced by countries undergoing very large depreciations against sterling, we drop any observations where the annual depreciation against sterling exceeds 20%.

For the macro level regressions, data are taken from different sources. To construct the dependent variable we use aggregate import price data is taken from the UK's Office for National statistics. For the exchange rate, we use the Bank of England's nominal trade weighted exchange rate index. To measure world export price inflation, we use a weighted average of national export price inflation rates, weighted together using the same weights as the exchange rate index. These are shown in figure 2

World export prices, measured here in the exporting country's domestic currency, have trended upwards over the time period. For the most part import prices have moved inversely with the exchange rate index, as one would expect.

Figure 2: Exchange rates, export prices and UK import prices



3 Passthrough at the micro level

To gauge the passthrough at the micro level, we estimate a standard passthrough regression using the specification of Campa and Goldberg (2005) and others.

$$\Delta p_{ijt} = \alpha + \sum_{k=0}^{12} \beta_k \Delta e_{j,t-k} + \sum_{k=0}^{12} \gamma_k \pi_{j,t-k} + \sum_{k=0}^{12} \phi_k \Delta y_{t-k} + \mu_{ij} + \epsilon_{ijt} \qquad (1)$$

where i indexes the industry, j the trading partner, and t the time period. Δp is the unit value measure of import price inflation, e_j the bilateral nominal exchange rate, π is the log difference of foreign export price inflation and Δy is real GDP growth in the UK[2]. Fixed effects are included across the country-industry pair. The primary object of interest is the passthrough coefficients, given by β_k, the sum of which from 0 to k will give the cumulative passthrough at k months.

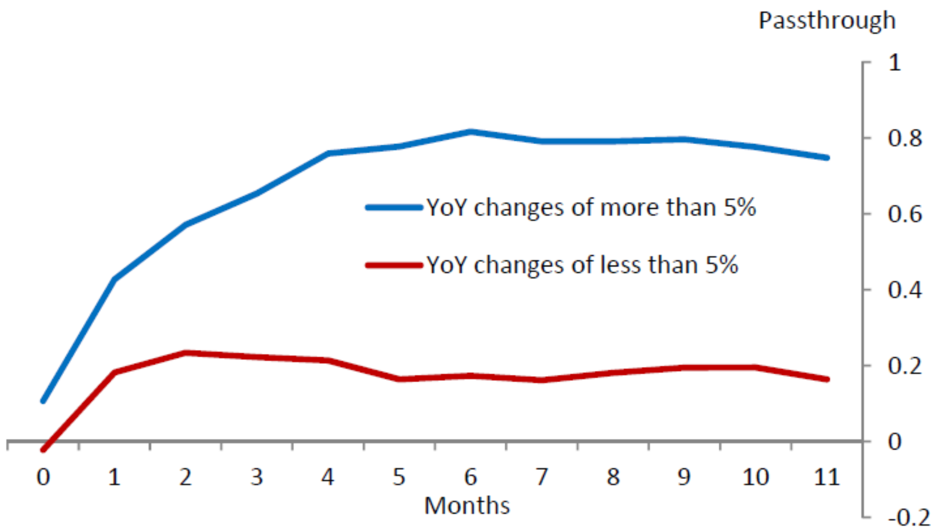
[2] Since the regression is expressed in monthly terms, interpolation is used to generate a quarterly GDP series

Estimates of exchange passthrough could be biased if either exporters costs or domestic demand is correlated with the exchange rate but excluded from the regression equation. This was point was discussed informally by Campa and Goldberg, but was given a macroeconomic justification by Corsetti, Dedola and Leduc (2008), who presented simulation results from a two-country open economy model with a distribution sector, which showed that reduced form estimations of exchange rate passthrough can differ quite substantially from the true structural parameters of the model. They showed that the inclusion of foreign wages and domestic GDP as control variables can substantially lower the bias in reduced form estimates.

To capture the former, we therefore include the GDP term, which proxies variations in domestic demand. This may be an imperfect proxy for demand for a particular product because the income elasticity of demand for each product may differ and hence fluctuations in UK GDP may not a lead to common scalar expansion/contraction in demand for all product. In addition, there may be industry specific demand shocks orthogonal to the exchange rate. But to the extent that these factors are affecting demand for (and hence the price of) a particular product idiosynchratically, they will not bias the aggregate coefficients. The inclusion of the aggregate GDP term thefore proxies the aggregate shock which might be systematically correlated across the cross secotional dimension and generate a bias in the estimated coefficient.

One unusual feature of the dataset is that at the cross sectional level (i.e. across country, industry pairs), there is a large variation in the value of goods types in each month . Given that we have unit value data, which is only a proxy for underlying pricing, one might expect measurement error to be lower across good X than good Y simply because X is aggregating over a much larger volume of trade, and hence X to provide a better estimate of the underlying passthrough parameter. Moreover, the larger the value of a given industry-country pair, the greater proportion of total imports they account for in a period,

Figure 3: Passthrough at the micro level



and hence the greater their influence on overall import price passthrough. For that reason, the our micro equation is estimated using weighted least squares, where the weighting variable used is the share of that country-industry pair in total imports in each period.

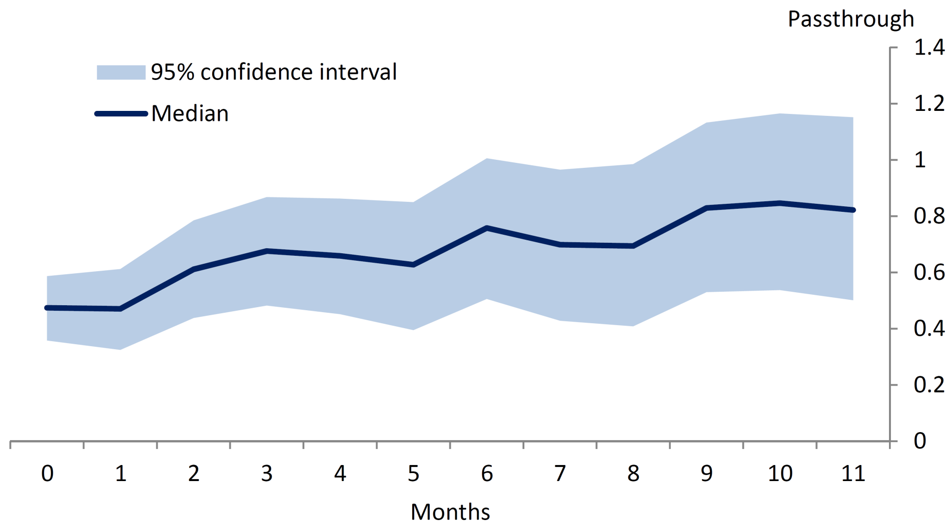
To test for non-linearities, we run the regressions over two sub samples - appreciations of more than 5% and depreciations of more than 5%; versus bilateral changes of less than 5%. This yields three samples with roughly the same number of observations in each. The results are shown in figure 3.

This reveals a pronounced non-linearity in passthrough. Smaller bilateral changes are subject to a much lower passthrough (around 0.16 over 12 months), than larger bilateral changes (0.75 over 12 months).

4 Passthrough at the macro level

For the aggregate, we estimate the equivalent regression at the macro level:

Figure 4: Passthrough at the macro level



$$\Delta\overline{p}_t = \alpha + \sum_{k=0}^{12}\beta_k \Delta ERI_{t-k} + \sum_{k=0}^{12}\gamma_k \overline{\pi}_{t-k} + \sum_{k=0}^{12}\phi_k \Delta y_{t-k} + \epsilon_t \quad (2)$$

This time, the dependent variable is the log difference of aggregate goods import prices, $\Delta\overline{p}$, measured by the ONS' imported goods price index. In the absence of a country or goods dimension, the exchange rate is now simply captured by the Bank of England's trade-weighted exchange rate index, and foreign inflation by trade-weighted world export price inflation. As with the micro case, the graphs below plot the sum of the coefficients out to 12 months. The shaded areas depict a 90% confidence band derived using a Monte Carlo method. Specifically, given the variance covariance matrix for the parameter estimates, one can take a draw from the estimated joint distribution of parameters and compute the rolling sum of $\widehat{\beta}_k$ out to 12 months. Discarding the top and bottom 5% of outturns in each month gives the 90% confidence interval shown.

Although the confidence intervals are not particularly narrow, the point estimate is 0.82. This estimate is very close to that obtained for the passthrough of large bilateral exchange rate movements in the micro data. This creates something of a puzzle, as the micro level evidence appears to point to non-linear, and on average lower, passthrough than the corresponding aggregate data. The resolution to this lies is in looking at the relative contributions of large and small bilateral changes to movements in the ERI. It is to this point that we now turn.

5 Reconciling macro and micro evidence

To see the importance of the distribution in the change of the bilateral exchange rates, consider the following decomposition. To avoid excessive notational clutter, we abstract from the goods dimension[3], and suppress the non-exchange rate terms. The effect on aggregate import prices can therefore be written as:

$$\Delta MP = \sum_{j=0}^{J} w_j \Delta p_{jt} = \sum_{j=0}^{J}\sum_{k=0}^{12} w_j \beta_{jk,} \Delta e_{j,t-k} \tag{3}$$

The aggregate response of import prices to the exchange rate is generally a function of the individual bilateral exchange rate movements and the marginal passthrough coefficients. There will not be a simple relationship between aggregate passthrough and the micro coefficients, except under two specific cases. The first such case, is where all the marginal coefficients are homogenous across trading partners- i.e. $\beta_{jk} = \widetilde{\beta}_k \; \forall j$. In that case, the expression simplifies to:

$$\sum_{j=0}^{J}\sum_{k=0}^{12} \widetilde{\beta}_k w_{j,t-k} \Delta e_{j,t-k} = \sum_{k=0}^{12} \widetilde{\beta}_k \Delta ERI_{t-k} \tag{4}$$

where the $NEER$ is defined as the change in the trade-weighted nominal exchange rate index. In that case, there is a perfect mapping between the

[3]through when a goods dimension is included. Since $\beta_{ijk} = \beta_{jk} \; \forall i$, it follows that any weighted average of β_{ijk} across the industry dimension will collapse to β_{jk}

micro coefficients and their macro counterparts. However, the preceding results demonstrate clearly that this assumption is violated in practice- exchange rate passthrough is not constant across all trade partners.

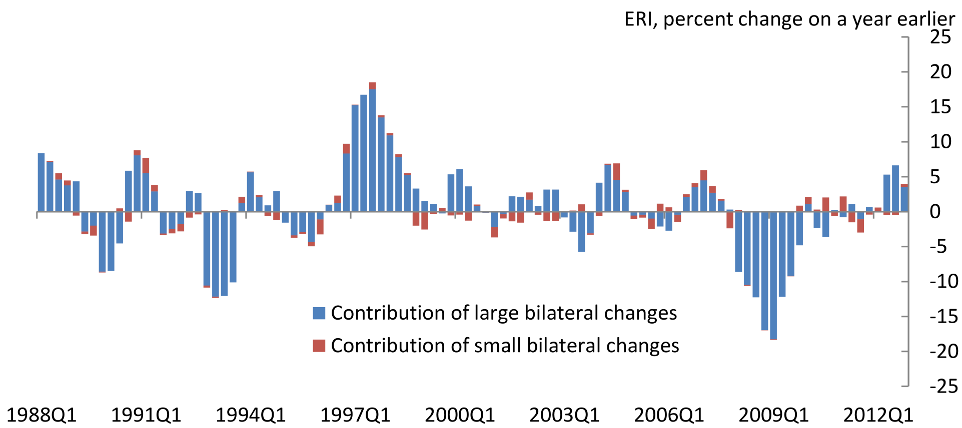
The second such case is where all bilateral exchange rates are homogenous across all trading partners, i.e. $\Delta e_{jt} = \Delta ERI_t \; \forall j$. In this case, the expression simplifies to:

$$\sum_{j=0}^{J}\sum_{k=0}^{12}\widetilde{\beta}_k w_{j,t-k}\Delta e_{j,t-k} = \sum_{j=0}^{J}\sum_{k=0}^{12} w_j \beta_{jk,} \Delta ERI_{t-k} \tag{5}$$

In this case, aggregate passthrough is a function of the exchange rate index, where the aggregate coefficient is simply a trade-weighted average of the country passthrough coefficients. In pratice, however, this assumption is unlikely to hold- bilateral exchange rates can and do move differently to one another. In reality since neither condition holds, the relationship between micro and macro coefficients will not merely be a function of the NEER, but some consideration of the distribution of bilateral changes will be required.

Given the non-linearity uncovered above, macro level passthrough will depend on the relative contributions of large and small changes to the exchange rate index. To see this intuitively, consider the following example where there are just two trading partners of equal weight- the euro area and the US. Suppose that sterling appreciates by 4% against both currencies. This yields an ERI index appreciation of 4%, but since both bilateral movements are below the 5% threshold, both bilateral changes are passed through at 0.16, and hence aggregate exchange rate passthrough is 0.16. Now imagine an alternative scenario- sterling appreciates by 8% against the euro, but is unchanged against the dollar. Given equal weights, this too yields an ERI appreciation of 4%. But unlike the preceding case, all of the change in the ERI is coming through a bilateral movement above the 5% threshold and hence is passed through at 0.75 As a result, the two equally sized ERI appreciations have very different passthroughs. This

Figure 5: Passthrough at the micro level



implies both that passthrough can vary over time as the relative contributions of big and small bilateral changes vary, but also that the relative contributions to changes in the ERI need not be the same as the the trade weights. In the latter example, the euro accounts for only 50% of the ERI basket, but changes in the euro account for 100% of the changes in the ERI.

To see how this effect pans out in practice, one can decompose movements in the ERI into the contributions of large and small changes. At any point in time, one can divide partner currencies up into those with large (L) and those with small (S) bilateral changes. Formally speaking we have:

$$ERI_t - ERI_{t-12} = \sum_j^J w_j(e_{jt} - e_{jt-12}) = \sum_j^{j \subset S} w_j(e_{jt} - e_{jt-12}) + \sum_j^{j \subset L} w_j(e_{jt} - e_{jt-12}) \tag{6}$$

Figure 5, below plots the this decomposition for the UK. The yellow diamonds show the total year on year change in the log of the ERI, the red bars represent the first term in the equation above- i.e the contribution of small bilateral changes; and the blue bars the contribution of larger bilateral changes.

The striking feature about figure 5 is that almost all of the change in the ERI is accounted for by large bilateral movements. And this holds for virtually all time periods, and even in the fairly frequent case where the overall movement in the ERI is less than 5% year on year. Over the sample period, large bilateral changes account for 93% of the variation in the ERI, and small changes for 7%. Given our 12-month passthrough estimates of 0.75 and 0.16, for each group from the micro data, this implies that aggregate passthrough over the sample period should be 0.93*0.75+0.07*0.16=0.71 This is close to the 0.82 estimate obtained from the regressions on the aggregate data.

6 Conclusions

This paper analyses the passthrough of exchange rate changes into import prices at the macro and micro level, using UK data from the period 1990-2012. At the micro level, we use a large dataset of imports from 45 countries for over 3000 goods types to estimate the reaction of import prices to changes in bilateral exchange rate. There is a pronounced non-linearity: for small bilateral changes passthrough is incomplete (around 0.16), but for larger bilateral changes, passthrough is close to full (around 0.75). But this non-linearity is not present at the aggregate level, where passthrough from the exchange rate index into aggregate import prices appears quite close to full (0.82). How the non-linearity at the micro levels maps through to the macro level depends on the distribution of the change in bilateral exchange rates. Splitting up the exchange rate index into the contributions of large and small bilateral changes reveals that the overwhelming majority of movements in the ERI are accounted for by larger bilateral changes. As a result, the passthrough of import prices at the aggregate level is almost exclusively driven by larger changes in bilateral rates which are passed through almost fully and hence aggregate passthrough is close to unity.

This aggregation problem has important consequences for generalising the results of two country micro-founded models into a real life setting where there is more than one foreign economy. If passthrough is non-linear at the micro level, then there is the simple one-to-one correspondence between micro and macro passthrough coefficients breaks down. For the UK case, we show that a pronounced non-linearity in passthrough of bilateral exchange rates does not manifest itself in a similar non-linearity at the aggregate level.

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