Revisiting exchange rate puzzles

Charles Engel and Feng Zhu[1]

Abstract

Engel and Zhu (2017) revisit a number of major exchange rate puzzles and conduct empirical tests to compare the behaviour of real exchange rates among pairs of economies that have rigidly fixed nominal exchange rates with their behaviour among pairs of economies under floating rates. They find that some of these puzzles become less puzzling for countries within the euro area, and regions in China and Canada, than for the non-euro-area OECD economies. Their results may have implications for exchange rate modelling.

Keywords: consumption correlation puzzle; excess volatility, exchange rate disconnect, exchange rate regime, real exchange rate, purchasing power parity, uncovered interest rate parity.

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1. Introduction

The literature has named several exchange rate puzzles and has offered many potential explanations for these puzzles.[2] This paper summarises our recent work (Engel and Zhu (2017)), which focuses on six major exchange rate puzzles and investigates whether the nature of these puzzles differs under fixed and under free-floating exchange rate regimes. These puzzles include the excess volatility of real exchange rates; their excess reaction to the real interest rate differentials; the uncovered interest rate parity (UIP) puzzle; the excess persistence of real exchange rates; the exchange rate disconnect puzzle; and the consumption correlation puzzle.

We study which of the puzzles may be significantly different under rigidly fixed exchange rates versus floating exchange rates. We compare the degree to which the puzzles hold among pairs of economies with floating exchange rates (eg among the pairs of OECD member countries that are not in the euro area) with pairs of economies which have rigidly fixed exchange rates (such as Hong Kong SAR vis-à-vis the United States and country pairs within the euro area). We also extend the analysis to intra-national data, such as for US states and Canadian and Chinese provinces, and examine at least some of these propositions, depending on data availability. Within the national borders, nominal exchange rates are irrevocably fixed, providing the best example of fixed exchange rates.

Engel and Zhu (2017) suggest that, under a rigidly fixed nominal exchange rate regime, the excess volatility puzzle of real exchange rates practically disappears or becomes minor for the vast majority of the fixed-rate economies; there is less evidence for an excess reaction of the real exchange rate to the real interest rate differential; there is less disconnect between the real exchange rate and the economic fundamentals; and uncovered interest rate parity appears to hold more frequently in these economies. However, real exchange rates are as persistent in these economies as in the floating-rate economies, and the evidence for risk-sharing shows little difference among countries with fixed versus floating nominal exchange rates. This evidence may provide clues to the types of model that are useful for resolving the puzzles – and therefore, the types of model that are most useful for open-economy macroeconomic analysis.

The rest of this summary is organised as follows. Section II describes the six major exchange rate puzzles and our tests. In Section III, we present the empirical results. Section IV concludes.

2. Six exchange rate puzzles

A vast literature exists on each of the six exchange rate puzzles we examine. A key focus of Engel and Zhu (2017) is the behaviour of such puzzles under a rigidly fixed nominal exchange rate regime. There are many open-economy macroeconomic models in which there is stickiness in nominal prices or wages of varying degrees. In these models, the behaviour of the nominal exchange rate does matter for the real

2 Obstfeld and Rogoff (2001) list six challenging puzzles in international macroeconomics, namely the home-bias-in-trade puzzle, the Feldstein-Horioka (1980) puzzle, the home-bias portfolio puzzle, the consumption correlations puzzle, the purchasing-power-parity puzzle, and the exchange-rate disconnect puzzle. They suggest that trade costs could help resolve the core quantity puzzles.

exchange rates, and the real exchange rate behaves very differently under fixed than it does under floating nominal exchange rates.

Engel and Zhu (2017) study six major exchange rate puzzles under different nominal exchange rate regimes. Define the real exchange rate Q_t as

$$Q_t \equiv \frac{S_t P_t^*}{P_t}$$

where S_t is the nominal exchange rate (the price of the foreign currency in home currency or the amount of the home currency that can be bought with one unit of foreign currency), P_t is the consumer price level in the home country, and P_t^* is the consumer price level in the foreign country. The real exchange rate is the price of the consumer basket in the foreign country relative to the price in the home country. Using lower case letters to denote the logs of variables written in upper case letters, we have

$$q_t = s_t + p_t^* - p_t \qquad (1)$$

A rise in q_t then indicates a real depreciation of the home currency. Note that under a rigidly fixed nominal exchange rate regime, the real exchange rate becomes the relative foreign-to-home price, ie $q_t = p_t^* - p_t$.

One of the main puzzles of real exchange rate behaviour is the "excess volatility" of real exchange rates (see, for example, Rogoff (1996) and Evans (2011)). We define real exchange rate volatility as $\mathrm{var}(q_t)$ or $\mathrm{var}(q_t - q_{t-1})$, ie the variance of the log of the real exchange rate and the variance of the change in the log of the real exchange rate, respectively. Write:

$$p_t = \alpha_N p_{N,t} + (1-\alpha_N) p_{T,t}$$

where $p_{N,t}$ and $p_{T,t}$ are the log of the prices of non-traded and traded goods in the home country, respectively, and α_N is the weight of traded goods in the consumption basket. Then,

$$q_t = s_{T,t} + p_{T,t}^* - p_{T,t} + \alpha_N \left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right) \qquad (2)$$

Under the assumption of no home bias in consumption and no pricing-to-market for traded goods, since $\alpha_N < 1$, we must have

$$\mathrm{var}(q_t) < \mathrm{var}\left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right), \text{ and}$$

$$\mathrm{var}(\Delta q_t) < \mathrm{var}\,\Delta\left[\left(p_{N,t}^* - p_{T,t}^* - \left(p_{N,t} - p_{T,t} \right) \right) \right] \qquad (3)$$

Besides (3), Engel and Zhu (2017) propose three alternative tests of excess volatility, one of which is derived based on a simple version of the Harrod-Balassa-Samuelson model.

The second puzzle that Engel and Zhu (2017) examine is the excess reaction of the real exchange rate to the real interest rate differential. Engel (2016) notes that, under uncovered interest parity (UIP), the covariance of the real interest rate differential with the real exchange rate should be equal to that with the real exchange rate consistent with the UIP assumption. Yet for many floating-rate economies, there tends to be excess co-movement between the real exchange rate and the real interest rate differential. We compare these two covariances by estimating the UIP-consistent real exchange rates from VAR models, in terms of both levels and first differences.

The third, uncovered interest rate parity puzzle can be illustrated in the well known Fama (1984) regression:

$$s_{t+1} - s_t = \alpha_0 + \beta_0 \left(i_t - i_t^* \right) + u_{0,t+1} \quad (4)$$

where i_t and i_t^* are nominal interest rates in the home and foreign countries. The UIP relationship postulates that

$$i_t^* + E_t s_{t+1} - s_t = i_t \quad (5)$$

Under UIP, the null hypothesis is that $\alpha_0 = 0$ and $\beta_0 = 1$. Yet, in practice, for many pairs of economies under a floating exchange rate regime, the empirics actually suggest that $\beta_0 < 1$ and frequently $\beta_0 < 0$, hence the UIP puzzle.

Engel (2014, 2016) points out that most models offered as explanations for the UIP puzzle, particularly those based on foreign exchange risk premiums, actually account for the co-movement of the excess return with the real interest rate differential. In practice, the existing models present theories constructed on real exchange rates in order to explain the UIP puzzle based on returns expressed in nominal terms. But under a fixed nominal exchange rate, the only source of variation in the real exchange rate resides in inflation movements.

Recognising that the countries that have fixed nominal exchange rates do not fit the paradigm of the literature which assumes that each bond pays off a riskless return in units of the bond-issuing country's consumption basket, we modify the UIP regression. Given the fixed nominal exchange rates, the change in the real exchange rate is simply the different between foreign and home inflation rates, that is

$$\pi_{t+1}^* - \pi_{t+1} = \alpha_1 + \beta_1 \left(i_t - E_t \pi_{t+1} - \left(i_t^* - E_t \pi_{t+1}^* \right) \right) + u_{1,t+1} \quad (6)$$

For country pairs with rigidly fixed nominal exchange rates, the risk characteristics of the two bonds should be identical. Even for risk-averse investors, the two bonds should have equal expected real rates of return. This implies that UIP should hold ex ante. That is, we should find $\alpha_1 = 0$ and $\beta_1 = 1$. We test the null hypothesis of $\beta_1 = 1$.

The fourth puzzle we study relates to the excess persistence of real exchange rates, or the purchasing power parity (PPP) puzzle. Rogoff (1996) defines the puzzle as "how can one reconcile the enormous short-term volatility of real exchange rates with the extremely slow rate at which shocks appear to damp out?" He argues that the high volatility of real exchange rates might be explained in a monetary model with sticky prices, implying that the real exchange rate's persistence is determined by the speed of adjustment of nominal prices. Rogoff (1996) notes that consensus estimates suggest half-lives for shocks to real exchange rates to be of approximately three to five years for floating-rate countries, "seemingly far too long to be explained by nominal rigidities". Indeed, measures of price stickiness suggest that the half-life of nominal price levels is closer to nine months.

For economies under a rigidly fixed nominal exchange rate regime, one direct test of excess persistence is to examine whether the half-life of real exchange rates is closer to nine months. Alternatively, we compare the half-life of real exchange rates to that of the difference between foreign and domestic relative prices of non-tradable to tradable goods.

The fifth, the exchange rate disconnect puzzle relates to the seemingly rather weak relationship between the exchange rate and any economic fundamentals. Engel and Zhu (2017) consider two different expressions for the fundamentals. The first approach, based on a simple Harrod-Balassa-Samuelson model, is to study the short-run and long-run relationship between real exchange rates and relative non-traded-to-traded productivity, by estimating an error correction model.

Alternatively, we examine the correlation between the real exchange rate q_t and q_t^{IP}, the rate that is consistent with UIP, which captures the effect of measurable economic fundamentals on the real exchange rate. That is, factors such as monetary policy, fiscal policy, productivity changes, or indeed anything that affects the real exchange rate through the real interest rate channel rather than through the deviations from UIP.

The sixth, the consumption correlation puzzle relates to the earlier literature on whether financial markets deliver risk-sharing across countries. In the presence of financial integration and some capital mobility, one would expect some degree of consumption-smoothing across countries, implying higher correlation in the growth in real consumption than that in output growth. Yet Backus et al (1992) find lower consumption growth correlation relative to output growth correlation. Engel and Zhu (2017) instead examine the correlation of the income available for consumption, ie total income minus investment and government spending in the home country, with that in the foreign country. These variables represent income made available for private consumption in the home and foreign countries, if they were closed.

But even with complete financial markets, we might not see high consumption correlation across countries, because financial assets are denominated in currencies, not in units of aggregate consumption. Assuming a constant relative risk-aversion utility function, if PPP does not hold, then relative consumption growth rates should be perfectly positively correlated with the growth rate of the real exchange rate. However, a fairly large empirical literature, including Backus and Smith (1993), has found that, among pairs of countries with floating nominal exchange rates, the correlation is actually low and negative, hence the consumption correlation puzzle or consumption-real-exchange-rate anomaly.

In reality, PPP does not hold. Assuming a logarithmic utility function, then growth rates of nominal consumption that are expressed in a common currency should be perfectly correlated if markets are incomplete. The traditional test of the consumption correlation puzzle becomes one of comparing the correlation of nominal domestic and foreign consumption with that of nominal and foreign domestic income available for consumption.

3. Empirical results

We summarise our results on the exchange rate volatility puzzle in Table 1, based on the variance bound tests (3). For the economies under a fixed nominal exchange rate arrangement, including 19 euro area countries, the variance bound (3) in levels are satisfied in 154 out of 172 cases, but only 42 out of 423 cases for the non-euro area OECD economies with floating rates.[3] The difference in terms of the changes in the real exchange rate is even more striking. Clearly, excess real exchange rate volatility is much less an issue for the economies under a rigidly fixed nominal exchange rate regime, but it remains a puzzle in those economies with floating exchange rates. The same analysis on intra-national data for 10 provinces in Canada, 31 provinces in China and 27 metropolitan areas in the United States further strengthen the outcome we obtained from the international comparisons.

The results for the alternative variance bounds are similarly striking and suggest a broadly similar picture to the patterns we observe in Table 1. The excess volatility puzzle of real exchange rates practically disappears or becomes minor for the vast majority of the economies which have adopted a rigidly fixed nominal exchange rate arrangement. The puzzle remains for most of the countries with floating nominal exchange rates such as the non-euro area OECD economies.

Excess volatility of real exchange rates: variance bounds (3)[1]

Table 1

	Pairs of economies with rigidly fixed exchange rates					
	In levels			In changes		
	Both fixed[2]	Both floating[3]	Fixed vs floating[4]	Both fixed[2]	Both floating[3]	Fixed vs floating[4]
Within the bound	154	3	39	172	0	31
Above the bound	18	116	265	0	119	273
Total of pairs	172	119	304	172	119	304
	Regions in Canada, China and the United States[5]					
	In levels			In changes		
	Canada[6]	China[7]	US[8]	Canada[6]	China[7]	US[8]
Within the bound	41	411	293	45	454	351
Above the bound	4	54	58	0	11	0
Total of pairs	45	465	351	45	465	351

[1] Variance of real exchange rates relative to the variance of relative prices. [2] For the 19 euro area countries, there are a total of (19 * 19 – 19)/2 = 171 pairs. In addition, we have the US-HK pair. [3] Four of the 19 non-euro area OECD countries (Australia, Israel, Korea and New Zealand) have incomplete data. Hence, we have (15 * 15 – 15)/2 = 105 pairs. Plus 14 pairs with HK. [4] With data for 19 euro area countries and 14 non-euro area OECD countries, there are a total of 19 * 15 = 285 pairs. Plus 19 pairs with HK. [5] Based on regional data for Canada, China and the United States. [6] For the 10 Canadian provinces, there are a total of (10 * 10 – 10)/2 = 45 pairs. [7] For the 31 Chinese provinces, there are a total of (31 * 31 – 31)/2 = 465 pairs. [8] For the 27 Metropolitan area pairs, there are a total of (27 * 27 – 27)/2 = 351 pairs.

Sources: Eurostat; OECD; authors' calculations.

Empirical results are similar for the puzzle of excess reaction to the real interest rate differential. Both in levels and changes, our covariance bound is satisfied for the

[3] In the latter calculation, we group together the "both floating" and the "fixed vs floating" countries, since in fact the exchange rate floats between all country pairs in both groups.

vast majority of country pairs within the euro area for which we have data, but for only a small fraction of floating exchange rate pairs. This implies that there is an excess reaction of the real exchange rate for most floating-rate pairs, while the puzzle largely dissipates for the economies with rigidly fixed nominal exchange rates.

To analyse the UIP puzzle, Engel and Zhu (2017) estimate the coefficients α_1 and β_1 in regression (6). Table 2 summarises the test results for the null hypothesis of $\beta_1 = 1$. For the 12 euro area economies with fixed exchange rates, the null can be rejected in 27 out of 66 cases at the 1% significance level and in 31 cases at the 10% significance level. Even though the estimated coefficients are close to one, the standard errors of the coefficient estimates tend to be very small for the countries with fixed exchange rates, leading to rejection of the null at the 10% level in nearly half the country pairs. The null can be rejected in 186 out 312 country pairs at a 1% significance level and in 267 cases at the 10% significance level among the floating rate pairs.

Uncovered interest rate parity puzzle, null H0: $\beta_1 = 1$

Table 2

	Both fixed[1]			Both floating[1]			Fixed vs floating[3]		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
Do not reject H0: $\beta_1 = 1$	35	37	39	18	31	55	27	39	71
Reject H0: $\beta_1 = 1$	31	29	27	102	89	65	165	153	121
Total	66			120			192		

Note: the numbers indicate the counts of observations for which the *p*-values are greater than 0.10, 0.05 and 0.01, respectively.

[1] For the 12 euro area countries, there are a total of (12 * 12 – 12)/2 = 66 pairs. [2] Three of the 19 non-euro zone OECD countries (Iceland, Israel and Korea) have incomplete data. Therefore, we have (16 * 16 – 16)/2 = 120 pairs. [3] With data for the 12 euro area countries and 16 non-euro zone OECD countries, there are a total of 12 * 16 = 192 pairs.

Sources: Eurostat; OECD; authors' calculations.

Because the estimated slope coefficients are much smaller than for the fixed nominal exchange rate country pairs, and the rejection of the null is much more frequent, we can conclude that there must be something else driving the rejections of UIP among country pairs that have floating nominal exchange rates.

To examine the PPP puzzle or excess persistence of real exchange rates, Engel and Zhu (2017) follow Rogoff (1996) and compute the half-life of real exchange rates based on the estimates of the AR(1) coefficients for the rates. Their results suggest that the real exchange rate is quite persistent under both fixed and floating nominal exchange rates, but it is not any more persistent than the relative foreign-to-home and non-tradable-to-tradable prices.

We study the exchange rate disconnect puzzle by estimating the cointegrating relationship between the real exchange rate and the relative productivity variables, focusing on pairs of countries for which we have at least 15 years of data. We find that, proportionally, far more pairs of euro area countries have the correct positive sign than those country pairs with floating exchange rates. In addition, for those country pairs that have the correct positive sign, estimated error correction models suggest that the speed of adjustment is actually lower in the euro area countries on average.

We find that q_t and q_t^{IP} are very highly correlated in the country pairs with rigidly fixed nominal exchange rates, both in levels and first differences, but much less for the floating-rate countries. With both measures of fundamentals, there appears to be less disconnect between the real exchange rate and the economic variables under rigidly fixed nominal exchange rates than under floating rates.

In terms of the consumption correlation puzzle, a key result is that the primary difference does not involve the nominal exchange rate system, but rather country borders. While there appears to be evidence of some risk-sharing for about half of the euro area pairs and OECD country pairs, consumption correlation is higher than income correlation for all 45 Canadian provinces, whether we look at total income or income available for consumption.

In addition, we compare the correlation between relative consumption growth rates and the growth rate of the real exchange rate for pairs of countries with fixed exchange rates, to that of floating-rate pairs. Across countries, whether within the euro area, or among floating-rate pairs, the average and median correlation is close to zero. In contrast, the real exchange rates among Canadian provinces are mostly positively correlated with the relative consumption growth.

Comparing the correlation of nominal domestic and foreign consumption with the correlation of nominal and foreign domestic available consumption, we find strong evidence of risk-sharing by consumers among different countries and regions, whether or not exchange rates are floating.

4. Conclusion

Engel and Zhu (2017) examine six exchange rate puzzles focusing on countries within the euro area, regions in China and Canada, and Hong Kong SAR vis-à-vis the United States. Their empirical tests yield results which suggest that some of these puzzles are less "puzzling", ie less severe, under a rigidly fixed exchange rate regime, while other puzzles remain. This evidence may provide clues to the types of model that would be useful for resolving the puzzles – and therefore, the types of model that are most useful for open-economy macroeconomic analysis.

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