An Overview of Exchange Rate Models

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Abstract

Theoretical research on the movements of nominal and real exchange rates falls roughly into two schools of thought. Equilibrium models of exchange rates presume that real exchange rates are driven by relative price changes and that the real exchange rate, in turn, drives movments in nominal exchange rates. Disequilibrium models take a polar opposite stance. This class of model assumes that prices are ¯xed in the short run. Therefore, changes in the supply of money a®ect the nominal exchange rate and these changes are passed on to real exchange rates. While ultimately the strengths and weaknesses of each explanation lies in empirical research, this paper discusses the relative merits of each.

1 Stylized Facts

Most of the large industrialized countries °oated their exchange rates in early 1973, after the demise of the post-war Bretton Woods system of ¯xed exchange rates. While there have been extensive academic disputes over the relative merits of ¯xed and °oating exchange rates, most discussions have been carried out on a largely hypothetical basis. The move to a generalized °oating regime provided economists with the empirical data set required to resolve such academic disputes. Successes in this arena have been few. The most damaging result was produced by Meese and Rogo® (1983), who compared the predictive abilities of various models of exchange rate models. Their key ¯nding was that no existing structural model could reliably outpredict the naive alternative of a random walk[1] at short and medium horizons. This extreme negative ¯nding has never been convincingly overturned despite numerous attempts. The most important regularities remain what they were 15 years ago.[2]

1) Real and Nominal exchange rates are highly positively correlated.

2) Real and nominal exchange rates are well approximated by a random walk.

3) Exchange rates are much more volatile than any underlying fundamentals.

4) Countries with high in°ation rates tend to experience nominal depreciations.

5) There appears to be little correlation between interest rate di®erentials and exchange rates.

The ¯rst two observations are directly related to the concept of purchasing power parity (PPP). PPP suggests that currencies should have the same

[1] A random walk suggests that exchange rate changes are completely unpredictable. Therefore, the best forecast of a tomorrow's exchange rate is today's exchange rate.

[2] For a more detailed discussion, see Mussa(1979) or Frankel & Rose (1994)

purchasing power in any country. This is represented by the following equation.

$$P = sP^{¤} \tag{1}$$

Where P and $P^{¤}$ are the domestic and foreign price levels respectively and s is the nominal exchange rate in terms of the domestic price of foreign currency. Note that PPP implies a constant real eachange rate.

$$e = \frac{sP^{¤}}{P} = 1 \tag{2}$$

Observation (1) suggests that real exchange rates are not constant, but rather they follow very closely the movements of nominal exchange rates implying a failure of PPP. Observation (2) makes an even stronger statement. To say that a variable follows a random walk is to say that it has no tendency to return to some long run value. The fact that real exchange rates are closely approximated by a random walk means that failure of PPP is not transitory but rather a long run phenomenon.

2 Equilibrium models of exchange rates

The equilibrium model makes three underlying assumptions: 1) The supply of goods and services is determined by technological capacity and is una®ected by the supply of money (Aggregate Supply is Vertical) , 2) all prices are fully °exible, 3) PPP holds at all times. Money demand is represented by the following equation

$$M^{d} = kPY \tag{3}$$

Where Y is real output and k is negatively a®ected by the nominal interest rate. Money supply is an exogenous policy variable controlled by the Federal Reserve.

$$M^{s} = M \tag{4}$$

Output is ¯xed and, hence, the price level adjusts to clear the money market.

$$M = kPY \tag{5}$$

Solving the above equation, we get the equilibrium price level.

$$P = \frac{M}{kY} \tag{6}$$

Finally, PPP gives us the following relationship between nominal exchange rates and the "Fundamentals".

$$s = \frac{P}{P^{\alpha}} = \frac{\frac{M}{kY}}{\frac{M^{\alpha}}{k^{\alpha}Y^{\alpha}}} = \left(\frac{M}{M^{\alpha}}\right)\left(\frac{Y^{\alpha}}{Y}\right)\left(\frac{k^{\alpha}}{k}\right) \tag{7}$$

Where starred variables are the corresponding foreign counterparts.

3 Disequilibrium Exchange Rate Models

The Disequilibrium framework was originally put forth by the seminal papers of Mundell (1962) and Fleming (1962) and later by Dornbusch (1976). There are several variations of the model with varying degrees of complexity. The version presented here was chosen simply for simplicity. The main under,lying assumptions are: 1) Prices are ¯xed in the short run, and the supply of goods is demand determined (aggregate supply is horizontal). 2) Due to price rigidity, PPP fails in the short run, 3) in the long run, prices are fully °exible and PPP is satis¯ed, 2) uncovered interest parity always holds, both in the short run and long run. Given these assumption, the disequilibrium framework has three components.

3.1 Capital Markets and the IS curve

Recall the income accounting identities. The ¯rst says that income equals expenditures. This is given by

$$Y = C + I + G + NX \tag{8}$$

Where Y is real income, C is consumption expenditures, I is investment expenditures, G is government purchases, and NX is net exports.. The second relates personal income with uses of income

$$Y = C + S + T \tag{9}$$

Where S is savings and T is taxes. Combining the two expressions gives us the relationship between savings, investment, the government de¯cit, and the trade balance.

$$S = I + (G - T) + NX \tag{10}$$

Government purchases, taxes and, hence, the government de¯cit are taken as exogenous policy parameters. For simplicity, assume that the budget is always balanced. Therefore, $(G - T) = 0$: It is assumed that savings is a positive function of real income and the interest rate. Investment is assumed to be negatively related to the interest rate. For simplicity, it is assumed that the trade balance is only a®ected by the real exchange rate. As the real exchange rate increases, foreign goods become more expensive relative to domestic goods. Domestic residents buy less imports while foreign consumers buy more domestic products, so net exports (exports-imports) increases. The IS curve represents all the combinations of interest rates and output so that equation (10) holds, for a ¯xed level of the real exchange rate. Consider an increase in real income. With more income, consumers save more causing the left hand side of equation to be bigger than the right. What must happen to restore equality? If the interest rate falls, savings falls and investment rises. Therefore, higher levels of income must be associated with lower interest rates and the IS curve is downward sloping (see ¯gure 1). Now, suppose that, all else equal, the real exchange rate increases (a real depreciation). Foreign good become relatively more expensive while domestic goods become relatively cheap. This acts to increase net exports. Now, the right side of equation (10) is bigger than the left. What needs to

happen to restore equality? Either income must increase to raise savings, or the interest rate must rise to lower investment (and raise savings). Therefore, a depreciation is associated with a rightward shift in the IS curve (see ¯gure 2) Likewise, a currency appreciation causes a leftward shift of the IS curve.

3.2 Money Markets and The LM Curve

Money demand and supply in the disequilibrium framework are identical to the equilibrium model.

$$M^d = kPY \tag{11}$$

Where Y is real output and k is a preference parameter which is negatively a®ected by the nominal interest rate. Money supply is an exogenous policy variable controlled by the Federal Reserve.

$$M^s = M \tag{12}$$

However, in this framework, the price level is ¯xed. Therefore, when the supply of money changes, something other than price must adjust to clear the money market. The LM curve represents all the combinations of interest rates and output levels that, for a ¯xed money supply, accomplish this feat. Suppose that the supply of money is ¯xed, and real output increases. With more goods to buy, money demand rises. Ordinarily, prices would fall to o®set this increase in money demand, but with prices ¯xed, another variable must take up the slack. The rise in money demand is now o®set by a rise in interest rates. Therefore, for a ¯xed supply of money, higher output is associated with higher interest rates and the LM curve is upward sloping. (see ¯gure 3). Now, suppose the Federal Reserve increase the money supply. Ordinarily, prices would rise to induce consumers to hold the extra money. Again, with ¯xed prices, something else must take up the slack. An increase in money demand must now be accomplished by either an increase in output or a drop in interest rates - the LM curve shifts to the right (see ¯gure 4). Similarly, a decrease in the money supplied shifts the LM curve to the left.

3.3 Expectations and Uncovered Interest Parity

The final piece stresses the role of expectations and the relationship between interest rates and exchange rate movements. Recall, uncovered interest parity suggests that consumers should expect to earn the same return on similar assets from any country. This is written compactly as follows.

$$(i - i^{\star}) = \left(\frac{s' - s}{s}\right)^{e} \tag{13}$$

The right hand side is the difference between domestic and foreign interest rates. The right side is the (expected) appreciation/depreciation of the domestic currency. For example, if interest rates in the US are higher than Japan (the left hand side is positive), then consumes believe that the dollar is overvalued and expect a depreciation in the future ($s' < s$):

3.4 Putting it all Together

The Long Run The disequilibrium model assumes that while prices are fixed in the short run, they are fully flexible in the long run. Therefore, If we assume that long run output levels, money supply levels, are given by $(\bar{y}, \bar{y}^{\star})$ and $(\bar{M}, \bar{M}^{\star})$; the long run exchange rate is given by the fundamentals as in the equilibrium story.

$$\bar{e} = \frac{\bar{P}}{\bar{P}^{\star}} = \left(\frac{\bar{M}}{\bar{M}^{\star}}\right)\left(\frac{\bar{y}^{\star}}{\bar{y}}\right)^{\phi}\left(\frac{\bar{R}^{\star}}{\bar{R}}\right)^{\theta} \tag{14}$$

Further, because PPP holds in the long run, the real exchange rate is constant and changes in the nominal exchange rate are completely attributed to differences in inflation rates.

$$\left(\frac{e' - e}{e}\right)^{e} = \left(\frac{P' - P}{P}\right)^{e} - \left(\frac{P^{\star\prime} - P^{\star}}{P^{\star}}\right)^{e} = \pi - \pi^{\star} \tag{15}$$

Combined with UIP, we get that differences in nominal interest rates are due only to differences in inflation rates (therefore the real rates of return are equal).

$$
\begin{aligned}
(i - i^{\alpha}) &= \frac{\left(e^{0} - e\right)}{e} = \frac{1}{4} - \frac{1}{4}^{\alpha} \\
i - \frac{1}{4} &= i^{\alpha} - \frac{1}{4}^{\alpha} \\
r &= r^{\alpha}
\end{aligned}
\tag{16}
$$

The Short Run In the short run, prices are ¯xed. Therefore, given a supply of money, interest rates, output , and the exchange rate is determined so that both the capital market and money market clears (the intersection of the IS and LM curves - see ¯gure 5), and given long run expectations, UIP is satis¯ed.

$$
(i - i^{\alpha}) = \frac{\left(s - e\right)}{e} \tag{17}
$$

3.5 Example: A monetary expansion

Consider a monetary expansion of 10% by the domestic country. First consider the long run e®ect. In long run, prices can fully adjust to the monetary expansion and output returns to its long run level. Therefore the long run change in the exchange can be seen from the fundamentals in equation (14). The nominal exchange rate increases (depreciates) by 10% and the real exchange rate is unchanged (PPP holds in the long run). In the short run, however, prices are ¯xed, so output and interest rates must adjust to take up the slack. Figure 6 shows the e®ect of an increase in the money supply. With the increase in the supply of money, consumers are now holding on to more money than they want. Without rising prices, something else must change to make consumers satis¯ed to hold the extra cash. A combination of lower interest rates and higher output results as the LM curve shifts to the right. However, now the domestic interest rate is lower than the foreign interest rate. Something must happen to prevent a °ood of capital leaving the domestic ¯nancial markets in search of a higher return. In order for domestic assets to remain attractive to investors, it must be the case that the dollar is expected to appreciate. This can be seen by looking at equation (17)

$$0 \hat{A} (i \; ¡ \; i^{¤}) = \frac{\mu_{S \; i \; e}^{\P}}{e} \tag{18}$$

Therefore, at some point, the dollar must appreciate, but we know that in the long run, the dollar must be worth 10% less. How can these two facts be reconciled? It must be the case that the dollar initially depreciates by more than 10%, and then appreciate to its new long run value. That is, in the short run, the dollar "overshoots" its long run value. This is the main result of the disequilibrium framework. The time path for the nominal exchange rate is plotted in ¯gure 7. Remember that prices are ¯xed in the short run, so any changes in the nominal exchange rate are passed on to the real exchange rate. When the dollar depreciates (in real terms), domestic goods become cheap relative to foreign goods. This acts to improve the trade balance and shift the IS curve to the right, which counters some of the initial impact e®ect. Figure 8 plots the time path for the real exchange rate. On impact, the change in the real exchange rate is identical to that of the nominal exchange rate. As prices begin to adjust, the real exchange rate returns to its initial value.

4 Conclusions

The main conclusion of the equilibrium framework is that the real exchange rate is in°uenced by relative price changes such as the terms of trade or the relative price of non-traded goods. These relative price changes cause changes in the real exchange rate which in turn in°uence the nominal exchange rate. While this is consistent with long run failure of PPP, it appears that there is not enough volatility in relative prices or fundamentals to explain the degree of variability in nominal exchange rates.

The dis-equilibrium framework assumes that PPP fails in the short run due to the "stickiness" of goods prices. Therefore, changes in money supply causes changes in the nominal exchange rate which are passed on to the real rate. Further, because of UIP and investor expectations, the nominal and real exchange rates "overshoot" their long run levels in the short run. This result is appealing for explaining exchange rate variability. However, the disequilibrium story relies on UIP which would suggest a strong degree of correlation between exchange rates and interest rates. This correlation is simple not found in the data.

The bottom line is that neither framework can outpredict a naive random walk model (which implies the best predictor of future exchange rates is the current rate). Clearly, there is a signi¯cant amount of work to be done.

5 References

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Figure 1: The IS Curve

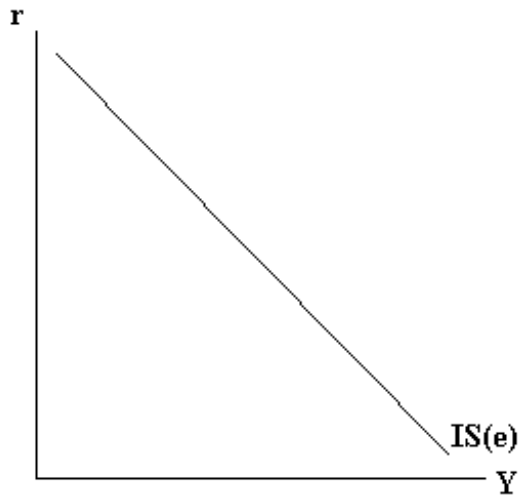

Figure 2: A Currency depreciation and the IS Curve

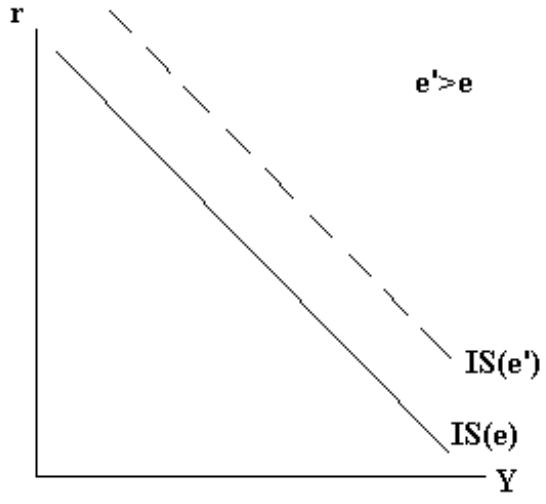

Figure 3: The LM Curve

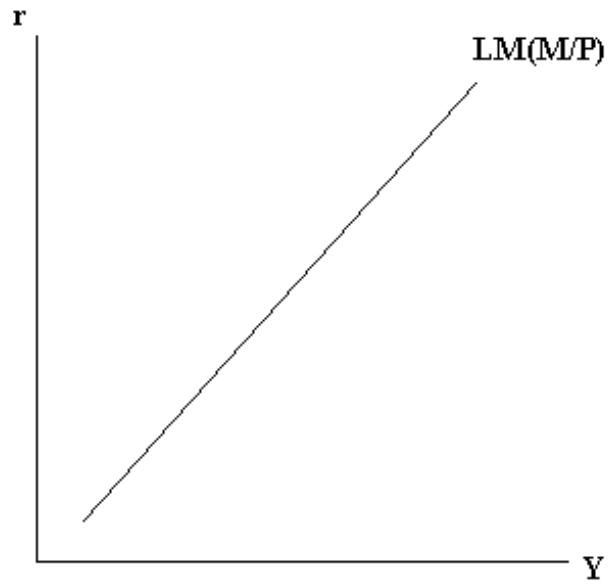

Figure 4: A Monetary Expansion and the LM Curve

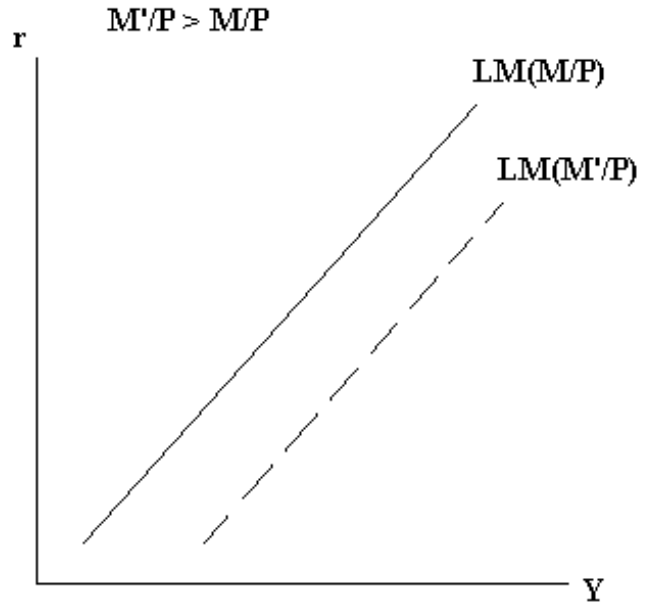

Figure 5: Short Run Determination of Y and R

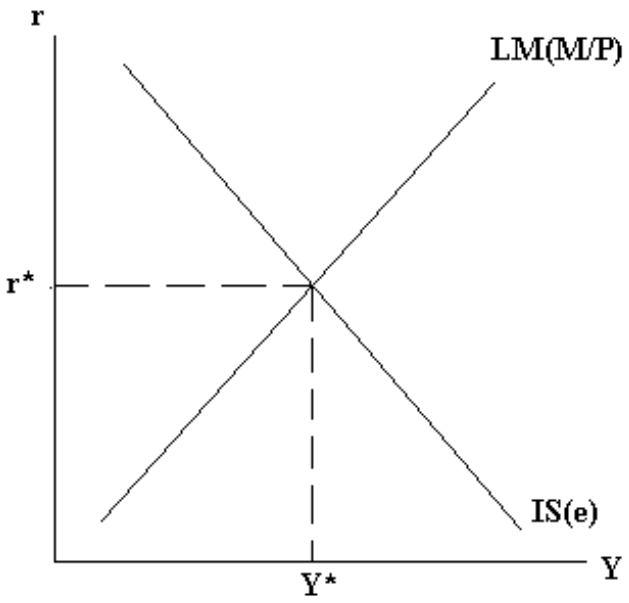

Figure 6: A Monetary Expansion

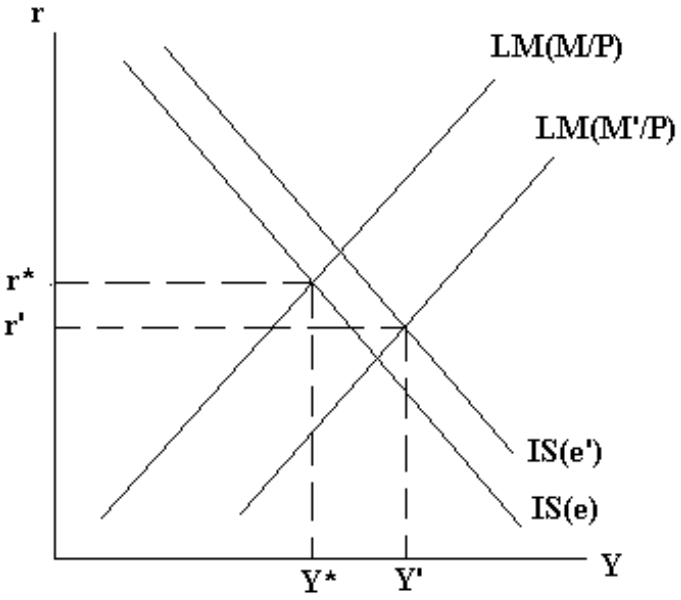

Figure 7: Time Path for the Nominal Exchange Rate

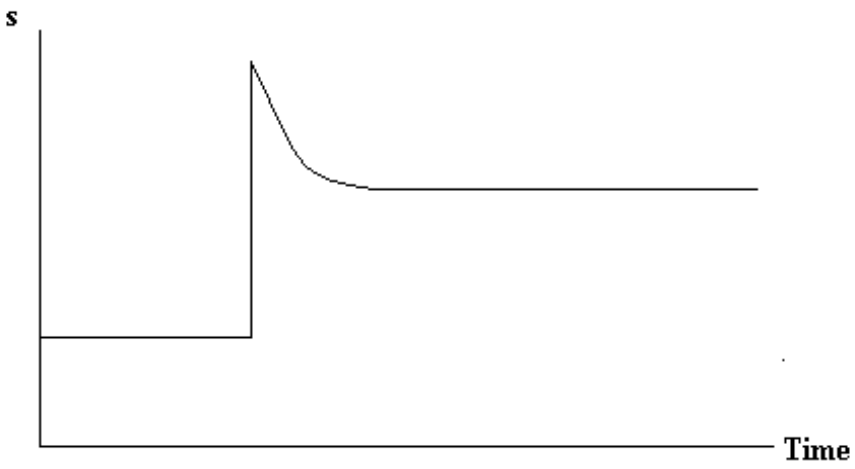

Figure 8: Time Path for the Real Exchange Rate