

Lectures #5 and 6: Exchange Rates in the Short Run and the Long Run

1. Exchange Rates in the Short Run. The Zero Lower Bound on Interest Rates.

The attached figure shows that the Japanese interest rate essentially reached zero in 1999, and it has stayed there since then. In the US, interest rates fell very close to zero for a brief period of time after 2000, but they have risen since then. In the Euro area, interest rates have been low in recent years, though they have not hit zero, as in Japan. It is interesting to think about the implications for monetary policy of the zero interest rate in Japan.

(a) Why (at least in theory) Can't Market Interest Rates be Negative?

- i. No one would want to lend. Imagine a lender when  $R = -0.10$  (i.e., the interest rate is minus 10 percent). In this situation, if you lend \$1.00, you get \$0.90 back later. Note that you could make more money simply by sitting on your money. If you just sit on your dollar, you still have the dollar at the end of the period. Clearly, you 'make' more money sitting on money than lending it out when the interest rate is negative.
- ii. Borrowers would like to borrow an infinite amount with  $R = -0.10$ . A person who borrows \$1.00 at  $R = -0.10$  has to pay back only 90 cents, and gets to keep 10 cents for themselves. So, borrowing is free money. Might as well try to borrow an infinite amount!
- iii. So, with a negative rate of interest, supply would be zero and demand infinite, in the loan market. Markets for foreign exchange cannot clear under these circumstances!

- (b) Suppose the interest rate is zero and the assumptions justifying UIP are satisfied. The money demand equation must be flat when  $R = 0$ , since at this point traders are indifferent between money and bonds.<sup>1</sup> That is, when the central bank conducts an OMO ('open market operation') there is no change in the interest rate. People are indifferent between money and bonds when  $R = 0$ , so exchanging money and bonds produces no change in any market

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<sup>1</sup>I'm ignoring the possibility that they *wouldn't* be indifferent because money has a greater liquidity value. Implicitly, I'm assuming that taking this into account wouldn't significantly change the basic thrust of the analysis. For the traders with whom the central bank does open market operations, the difference in liquidity between money and government debt is tiny.

price or rate of return. In this way, the key channel by which an increase in  $M$  leads to a depreciation in the exchange rate is cut when the interest rate is zero.

- (c) The result in (b) above may seem strange, so it's worth discussing it some more. Couldn't the central bank depreciate the exchange rate simply by printing up tons of money and exchanging it directly for foreign currency? The answer is no, under UIP. As before, I'm assuming the foreign rate of interest stays unchanged. Following is an explanation. For concreteness (and realism) suppose that the country with the zero interest rate is Japan, and that the foreign currency it buys is US dollars.

- i. From the point of view of Americans, UIP implies:

$$R_{\$} = R_Y + \frac{E^e - E}{E},$$

where  $E$  is the number of dollars per Japanese yen and  $R_Y$  is the nominal rate of interest in Japan. Under UIP, the only way to have  $R_{\$} > 0$  and  $R_Y = 0$  is for market participants to be anticipating a depreciation of the dollar. In particular, Americans holding zero-interest Japanese financial assets don't mind doing this because they anticipate being able to sell them for more dollars than they paid for them when  $(E^e - E)/E > 0$ . According to UIP, this extra amount of dollars matches exactly the extra dollars they get from the interest,  $R_{\$}$ , on US government debt. That is, if the rate of interest on a 1-year US government security is 5%, they must be anticipating that the US dollar will depreciate 5% over one year relative to the yen.

- ii. Suppose the Japanese central bank buys 1 US dollar from an American, in exchange for Japanese Yen. From the point of view of the US, it's the same as if the US central bank had just done an open market purchase of an interest bearing US government security. A US government security pays explicit interest, while the 'interest' on yen corresponds to the gains the American can hope to make from the expected appreciation of the yen over time. So, the BOJ's (Bank of Japan) purchase of US dollars would have the same effect as if the Federal Reserve (Fed) had done an open market purchase of 1 US dollar. If that were to happen, then  $R_{\$}$  would rise and  $E$  would fall...the dollar would appreciate and the Yen would depreciate. But, recall our assumption that the foreign interest rate does not change, that is, that  $R_{\$}$  does not change. For the Fed to keep  $R_{\$}$  requires an OMO where they buy

US government debt in just the right quantity so that the number of US dollars in circulation does not change after the BOJ and Fed actions. (This action by the Fed, neutralizing the impact of the BOJ's OMO on the quantity of US money is called *sterilization*. 'The Fed acts to sterilize the impact of the BOJ's OMO on the quantity of US money.')

- iii. Note what the net effects of the BOJ's action is when the Fed sterilizes. The quantity of yen in the world increases and the quantity of US government debt decreases. The changes are exactly offsetting, when the two quantities are measured in terms of the market exchange rate. Because Japanese yen and US government securities are perfect substitutes when  $R_Y = 0$  and UIP holds, there is no reason for any market price or rate of return to change with these OMO's.
- iv. Message: on its own, the BOJ cannot change the exchange rate when  $R_Y = 0$ , under UIP. Of course, if the US changed its policy and increased  $R_{\$}$ , this *would* lead to a depreciation of the Japanese exchange rate. (The analysis above held  $R_{\$}$  unchanged.)

At the moment, we have not developed our model far enough to let us think about why the BOJ might *want* to depreciate the value of the yen, and why the Fed might not want to oblige the BOJ. Later, we'll develop a theory which implies that a depreciation in the Japanese exchange rate would, by making Japanese goods cheaper, reorient world demand towards Japan and thereby stimulate the Japanese economy. That theory suggests that non-Japanese governments might not like this policy because, by reorienting world demand away from them, it might cause output in their economies to fall. (Here, I have in mind not just the US economy, but also other economies in Asia.) For now, we cannot discuss these things because we simply assume output,  $Y$ , is fixed.

## 2. The Short and Long-Run Effects of a Permanent Change in the Stock of Money.

- (a) Assumptions about long run - A permanent increase in  $M$  results, in long run, in proportional increases in  $P$ ,  $E^e$  and no change in  $Y$ . Rationale:
  - i. In long run,  $Y$  is determined by pace of technical progress, size and quality of the work force, etc., not  $M$ .
  - ii. Countries with big increases in  $M$  have big increases in  $P$  (see Italy in Figure 14-10, and the Latin American countries

in the case study on page 377, and attached data on Bolivia in Figure 2, taken from page 380-381 of KO).

- iii. With respect to  $E$ , countries with big rise in  $M$  also have big depreciations. Example: Bolivia data in figure 2, taken from page 387 of KO.
  - iv.  $E$  is a price (it's the number of dollars it takes to buy one unit of foreign currency), so the notion that, in long run,  $E$  rises in proportion to rise in  $M$  seems consistent with notion that all the prices summarized in  $P$  rise in proportion to  $M$  in the long run.
- (b) Assumptions about short run - Output and the price level,  $Y, P$ , are fixed in the short run.
- (c) Experiment: Permanent increase in US money supply. This results in exchange rate overshooting in the short run. To see why, first do the analysis in our graphical representation of  $UIP$  and money demand (see Figures 3 and 4). Note that the rise in  $E^e$  shifts the  $UIP$  curve up (see Figure 3). For the short-term analysis, increase  $M$  holding  $P$  fixed. This produces a fall in  $R$ , which leads to a rise in  $E$ . Note that the rise in  $E$  is bigger than what would occur if  $E^e$  had remained unchanged. As the short run turns into the long run, the price level starts to rise, driving  $M/P$  down. This stops when  $M/P$  is where it was before, so that the interest rate in the long run returns to where it was before. As  $R$  returns to its original position,  $E$  'rides' the new  $UIP$  curve up to its final, higher position.
- (d) Exchange Rate Overshooting. Note that in the previous experiment the exchange rate overshoots its final, higher value. This is the 'exchange rate overshooting' result. The intuition for this is simple. To illustrate it, suppose  $R_{\$} = R_{\text{€}}$  initially, so that  $(E^e - E_1)/E_1 = 0$ , where  $E_1$  is the exchange rate in the old equilibrium. That is,  $E^e = E_1$ , so that the exchange rate in the future is expected to coincide with its value in the present. With the permanent rise in  $M$  to  $M_2$ , say, the expected future exchange rate jumps equiproportionally:

$$\frac{\tilde{E}^e}{E^e} = \frac{M_2}{M_1},$$

where  $\tilde{E}^e$  denotes the new expected future exchange rate.

We know that the jump in  $M$  causes  $R$  to drop in the short run. While  $R_{\$}$  is low,  $UIP$  requires there to be an expected apprecia-

tion in the exchange rate:

$$\frac{\tilde{E}^e - E}{E} < 0,$$

since  $R_{\$} - R_{\pounds} < 0$  in the short run. Thus, we need the exchange rate,  $E$ , to *fall* towards its new, higher long run value. The only way this can happen is if it overshoots  $\tilde{E}^e$ .

### 3. Expectations.

Note that the interest rate impact of a given change in the money supply is the same, whether that change in the money supply is temporary or permanent. But, the exchange rate effect of a change in the money supply is heavily dependent on what people believe about the persistence of that change. Figure 5 describes the time path of the exchange rate under the permanent and temporary scenarios.

Figure 5 also considers a third scenario. Suppose that the increase in the money supply in fact is permanent, but initially everyone believes it's temporary. Then the impact of the money shock on the exchange rate initially coincides with what it is in the case that the increase in the money supply is temporary and everyone knows it. But, eventually, people start to learn that their initial expectation was incorrect. They see that the money supply continues to be high, and they come to understand that the initial increase actually was permanent. As the probability that people assign to this being the case increases, the exchange rate rises towards what it would have been if everyone actually knew the rise was permanent. Eventually, when everyone knows for sure that the rise in the money supply was permanent, then the new curve traced out by the exchange rate begins to coincide with the curve traced out by the exchange rate when everyone correctly knows that the increase in the money supply is in fact permanent. In the example in Figure 5, the path traced out by the exchange rate initially involves a *rise* in the exchange rate. That is, a depreciation. Thus, we have an example in which the interest rate on the domestic currency is low and yet the exchange rate depreciates, at least for a while. We constructed this scenario under UIP, by making the (plausible) assumption that there is uncertainty about whether the shocks driving the current interest rate are permanent or temporary.

Would we expect this to pattern happen often? Absolutely not. The way we got the exchange rate to depreciate over time in the example, despite the low domestic interest rate, is precisely because we assumed the underlying monetary shock was unusual. That's why, in the example, it takes time for people to catch on that the usual thing in fact did not happen. When the *usual* thing happens in the example - the

interest rate drops because of a temporary money disturbance - then the shock is met contemporaneously by an instantaneous depreciation, followed by appreciation.

4. Uncovered Interest Rate Parity. Figure 6 displays a scatter plot with the US minus German one year (risk-free) interest rate on the horizontal axis, and the depreciation of the US dollar that occurred over the same period on the vertical axis. The interesting thing to note is that very often the US dollar appreciates when the US interest rate is high. This suggests that actual short-term movements in the exchange rate are driven by additional factors beyond what are captured by our UIP theory as it stands. Changes in the risk characteristics of US versus foreign assets may be such a factor. That is, let

$$R = R_{foreign} + \frac{E^e - E}{E} + \rho.$$

When  $\rho$  is big, in order to induce people to hold US assets, they need a higher return on US than foreign assets. Suppose that when the money supply is increased and the interest rate goes down, that this also makes the US look less risky - i.e., it makes  $\rho$  go down. For illustration, consider the (admittedly extreme) case where  $\rho$  drops more than  $R$ . In this case, there has to be an anticipated depreciation over time, after the cut in the interest rate. Instantaneously, the exchange rate could either appreciate or depreciate. If the effect on risk is very strong, then the currency could appreciate in the moment of the increase in  $M$ .

The intuition for the latter case is simple. The cut in the interest rate boosts confidence in the US economy and, in particular, the safety of US financial assets. It triggers a desire to purchase assets by everyone. As people try to buy the US currency, it appreciates. It does so until the point where the anticipated depreciation over time makes the US and the rest of the world look the same, after risk adjustment.

5. Purchasing Power Parity

- (a) The Law of One Price. This says that the same good sold in two different places should have the same price. Thus, if  $P_G^i$  is the price of some good called  $i$  in Germany and  $P_{US}^i$  is the price of the same good in the US, the law of one price says that the dollar (or, mark) price of the two goods must be the same:

$$P_{US}^i = P_G^i E,$$

where  $E$  is the number of dollars per euro. The idea is that if this equality were violated, say because the left exceeds the right, this

would trigger a reduction of demand for the US  $i^{th}$  good and an increase in demand for the German  $i^{th}$  good. This reallocation of demand would result in some combination of a fall in  $P_{US}^i$ , a rise in  $P_G^i$  and a rise in  $E$ .

To understand this ‘law’, it is interesting to look at the box on page 382-383 of KO. That shows that the dollar price, computed using the above formula, of a McDonald’s Big Mac is very different in different countries in the world. One interpretation of the difference is that Big Mac’s are really different goods around the world. Each Big Mac represents the services of some poor, unwilling cow, bundled with a lot of locally generated services: transportation, food preparation, beautiful views, etc. Since these are hard to trade, and they are a large part of the price of a Big Mac, there are no really strong forces forcing the price of a Big Mac to be the same everywhere. Of course, the raw hamburger meat *is* likely to be highly tradeable, and the price of this part of the hamburger should vary less across countries. However, in places where there are restrictions on trade, or other factors that hinder transportation, then even the price of hamburger meat would be different. The upshot is that the law of one price should apply internationally only to goods which are easy to ship, i.e., which are highly tradeable.

- (b) Purchasing Power Parity. This says that the relationship in the law of one price holds for bundles of goods in different countries. For example, if  $P_{US}$  is the consumer price index (CPI) in the US, then  $P_{US}$  is the price of a specific bundle of goods in the US. The bundle is composed of the goods that government statisticians determine are bought by the typical family. Suppose  $P_E$  is the corresponding price in Europe. According to *PPP*,  $P_{US} = EP_E$ . According to a weak version of *PPP*,  $EP_E/P_{US}$  can differ from unity. However, it should always return to the same constant. Thus, if  $P_E$  rises more rapidly than  $P_{US}$ , eventually  $E$  should fall (i.e, the US dollar should appreciate) and return  $EP_E/P_{US}$  to its underlying constant value.

Informally, at least, *PPP* is sometimes motivated by the Law of One Price. The following example illustrates this.

- (c) The Relationship between *PPP* and the Law of One Price. The first example shows how the law of one price could hold for each individual good, and Purchasing Power Parity holds too. The second example illustrates the possibility that the law of one price holds for each good, but *PPP* does not hold. So, *PPP* and the Law of One Price are different theories.

**Example 1** *Here is a case in which the Law of One Price holds,*

and PPP holds too. Suppose  $P_{US} = a_1 P_{US}^1 + a_2 P_{US}^2$ , where  $P_{US}^1$  is the price of good  $i = 1$  in the US consumption basket and  $P_{US}^2$  is the price of good  $i = 2$ . The numbers,  $a_1$  and  $a_2$ , are the fractions of these two goods in the basket. (For the sake of the illustration, I assume there are only two goods in the consumption basket.) Suppose, similarly, that  $P_G = a_1 P_G^1 + a_2 P_G^2$ . Also, suppose that the law of one price holds with each good. Then, because  $P_{US}^i = E P_E^i$ ,  $i = 1, 2$ :

$$\frac{P_{US}}{P_E} = \frac{a_1 P_{US}^1 + a_2 P_{US}^2}{a_1 P_E^1 + a_2 P_E^2} = E \frac{a_1 P_E^1 + a_2 P_E^2}{a_1 P_E^1 + a_2 P_E^2} = E,$$

so that PPP holds too.

Although it is possible that PPP holds when all goods satisfy the law of one price, it is not necessary. If the consumption basket in different countries is different (as seems quite reasonable!), then even if the law of one price applied to each good in the basket, PPP would still not hold. The following example illustrates this:

**Example 2** Here is a case where PPP does not hold, even though the Law of One Price holds for each good. Suppose that the basket of goods in Europe assigns different weights to the two goods (not an implausible assumption, since the typical European and American families do not have identical expenditure patterns). Suppose that in Europe the weight on the first good is  $b_1$  and the weight on the second good is  $b_2$ , where either  $b_1 \neq a_1$ , or  $b_2 \neq a_2$ , or both. Then, going through the same algebra as in the previous example,

$$\frac{P_{US}}{P_E} = E \frac{a_1 P_E^1 + a_2 P_E^2}{b_1 P_E^1 + b_2 P_E^2} = E \frac{a_1 + a_2 \frac{P_E^2}{P_E^1}}{b_1 + b_2 \frac{P_E^2}{P_E^1}} \neq E.$$

Note that if there is a trend over time in  $P_E^2/P_E^1$ , there would be a trend in  $E P_E/P_{US}$ , even though the law of one price applies to each good. This example is not surprising. When the weights are different, the baskets of goods being priced by  $P_{US}$  and  $P_E$  are different. Even if the law of one price applied to each one individually, we'd still not expect the two baskets to have the same price. Two different shopping bags, one with 3 apples and 2 oranges, and the other with 3 oranges and 2 apples, will not have the same price. This is true, even if the oranges and apples in the two bags individually have the same price.



- (d) Real Exchange Rates in the Data. An attached figure displays the real exchange rate between the US and six other countries. Note that in the cases of Italy, Japan, France, UK and Germany, there is a trend increase in the real exchange rate: the price of the consumer basket of goods has risen more in those six countries than it has in the US. We can adapt the previous two examples to obtain an explanation for this. We'll look carefully at the Japanese/US exchange rate.

Suppose there are two goods, a traded good and a non-traded good. In the US they have prices  $P_{US}^T$  and  $P_{US}^{NT}$ , respectively (in practice, each of these 'goods' is really a basket of goods). The corresponding Japanese prices are  $P_J^T$  and  $P_J^{NT}$ . For simplicity, suppose the weights in the baskets of goods in the two countries are identical. Then,

$$\begin{aligned} E \frac{P_J}{P_{US}} &= E \frac{a_1 P_J^T + a_2 P_J^{NT}}{a_1 P_{US}^T + a_2 P_{US}^{NT}} \\ &= \left( E \frac{P_J^T}{P_{US}^T} \right) \frac{a_1 + a_2 \frac{P_J^{NT}}{P_J^T}}{a_1 + a_2 \frac{P_{US}^{NT}}{P_{US}^T}} \\ &= \left( E \frac{P_J^T}{P_{US}^T} \right) q, \end{aligned}$$

say. The last figure in these notes shows how the real exchange rate between the US and Japan has depreciated over time. The figure also shows the real exchange rate, when the prices considered are just import prices (IPI, 'import price index').<sup>2</sup> The idea is that IPI corresponds to the price of traded goods, so that the IPI real exchange rate is a measure of the object in parentheses in the previous expression. Notice how this real exchange rate has essentially no trend. This means (given the decomposition in the previous equation) that the trend in the CPI real exchange rate is coming from a trend in  $q$ . This in turn means that the relative price of nontraded goods in Japan (i.e.,  $P_J^{NT}/P_J^T$ ) is rising faster than the corresponding relative price in the US.

KO offer an explanation for this. According to them, the discipline of competition forces technical progress in the traded sector to be about the same everywhere in the world. At the same time, some

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<sup>2</sup>I am grateful to Ariel Burstein for supplying the IPI data, and for sharing some of the insights he has obtained in an ongoing research project with Eichenbaum and Rebelo.

countries' nontraded sector is sheltered from competition, with the result that the drive to keep up with the latest technology is relatively weak in the nontraded sectors of those countries. In these cases, costs are high in the nontraded sector so that the relative price of nontraded goods is expected to rise faster than it does in a more competitive economy. This may be a good explanation of why the relative price of nontraded goods seems to rise so fast in Japan.

Figure 1: Interest Rate Experiences in Euro Area, US and Japan

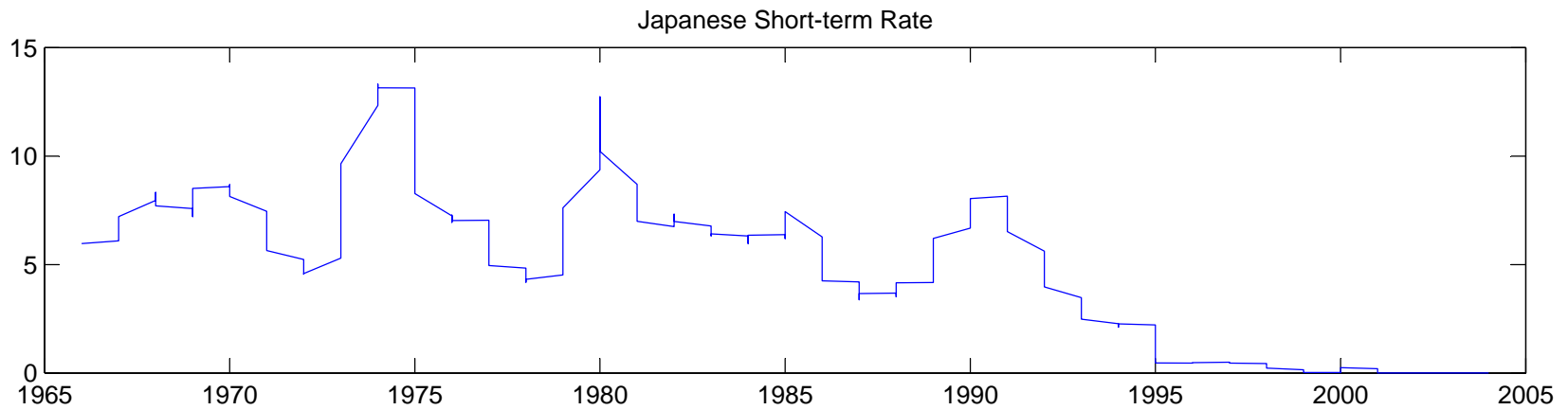
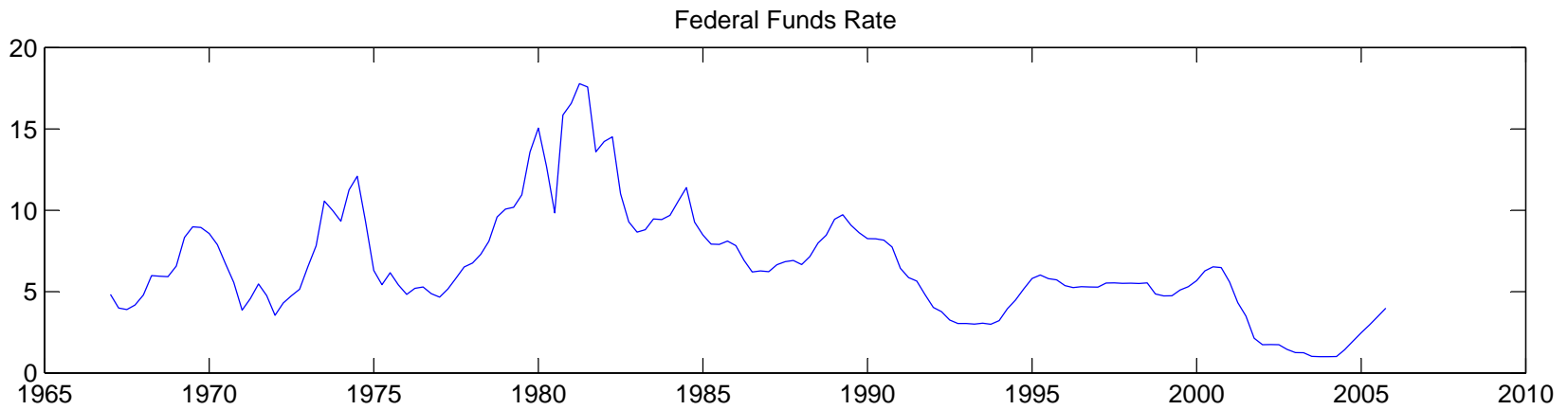
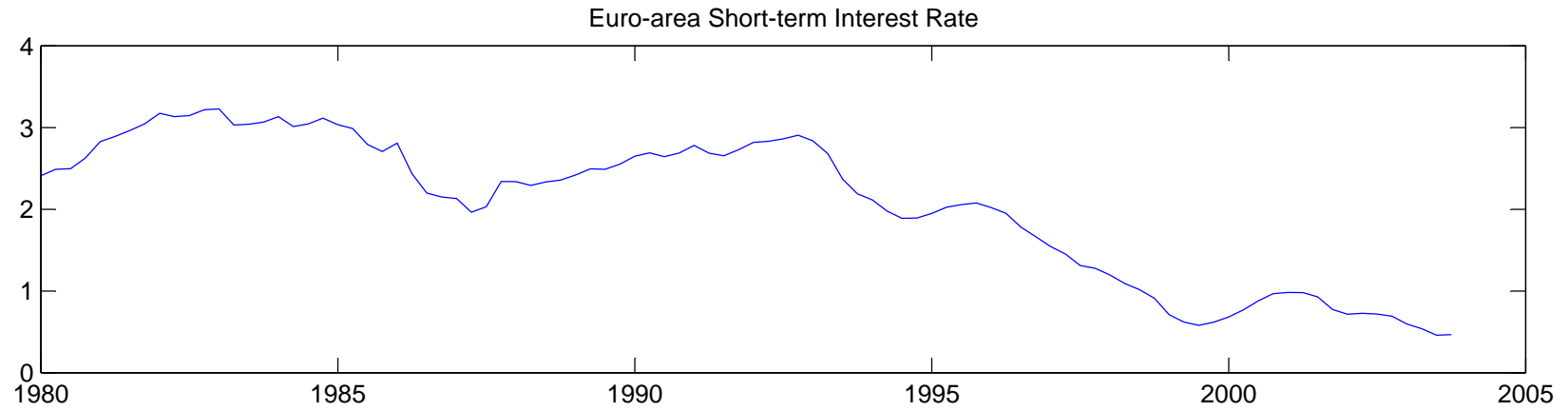


Figure 2: Impact on Exchange Rate and Price Level of Huge Increase in Money Supply - the Case of Bolivia

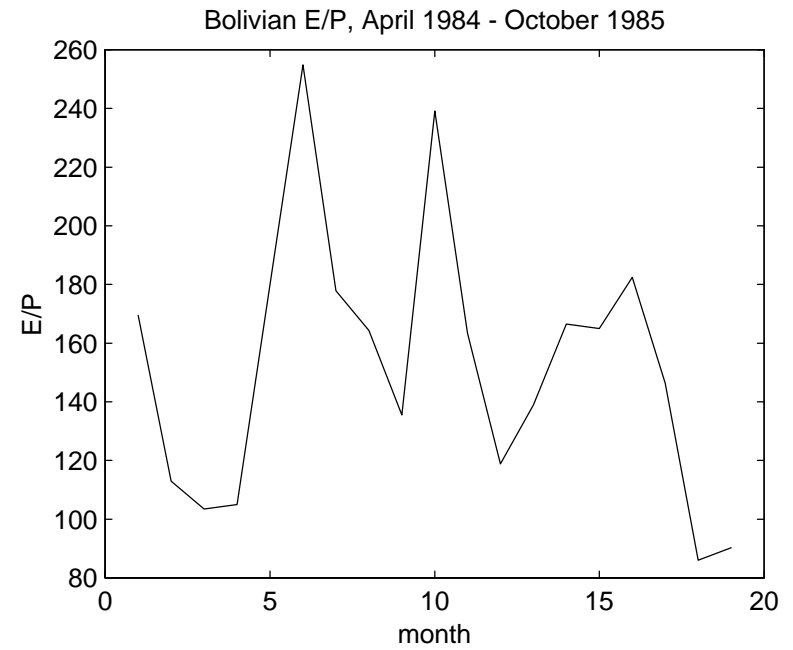
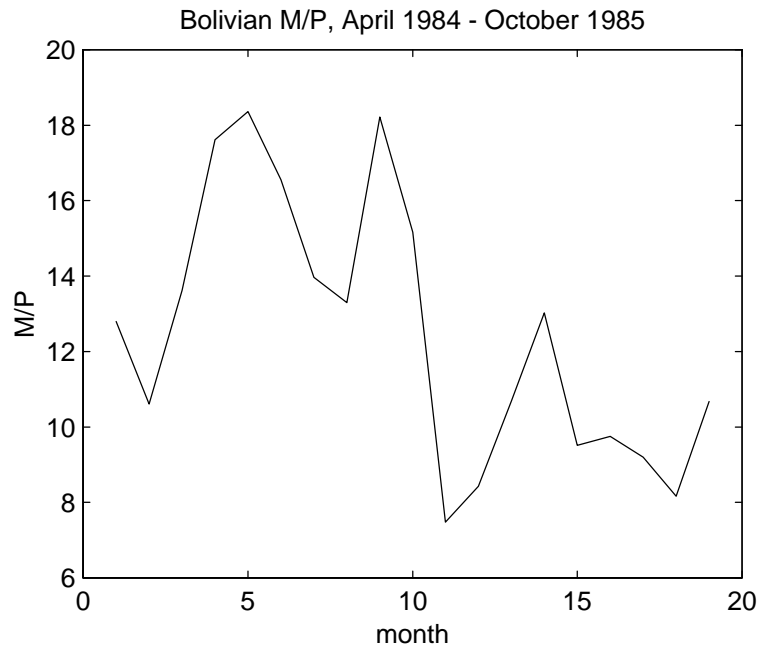
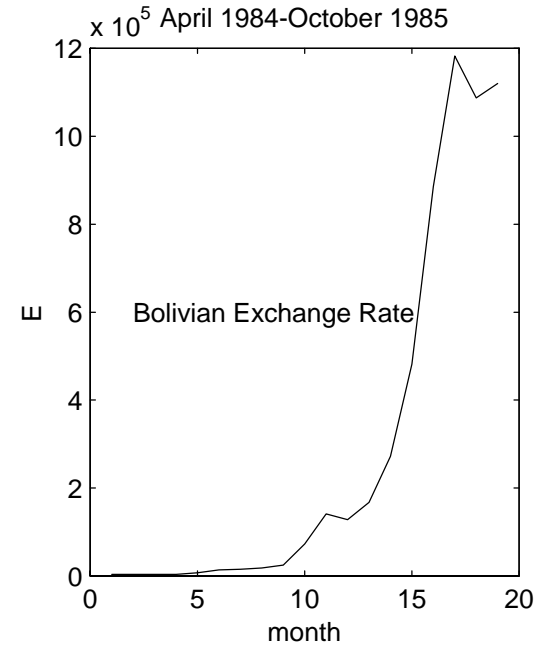
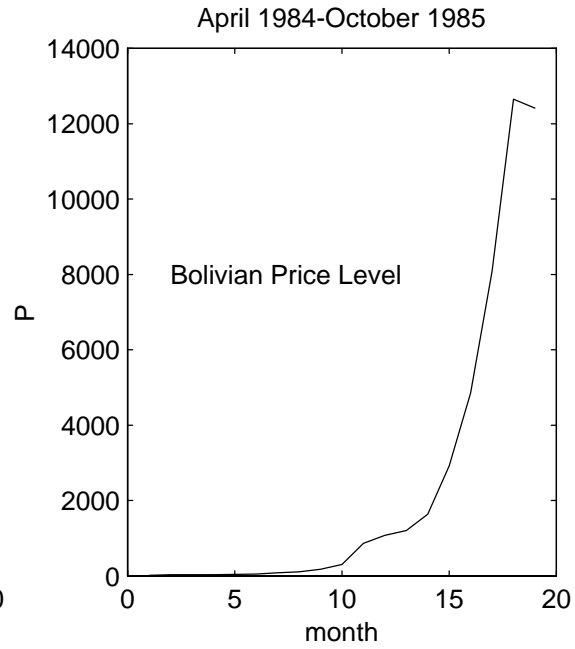
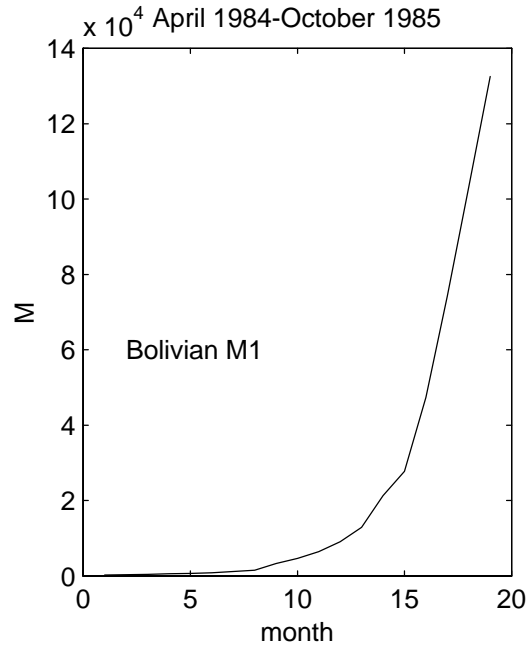


Figure 3: Effect on Exchange Rate of Rise in M that is Permanent

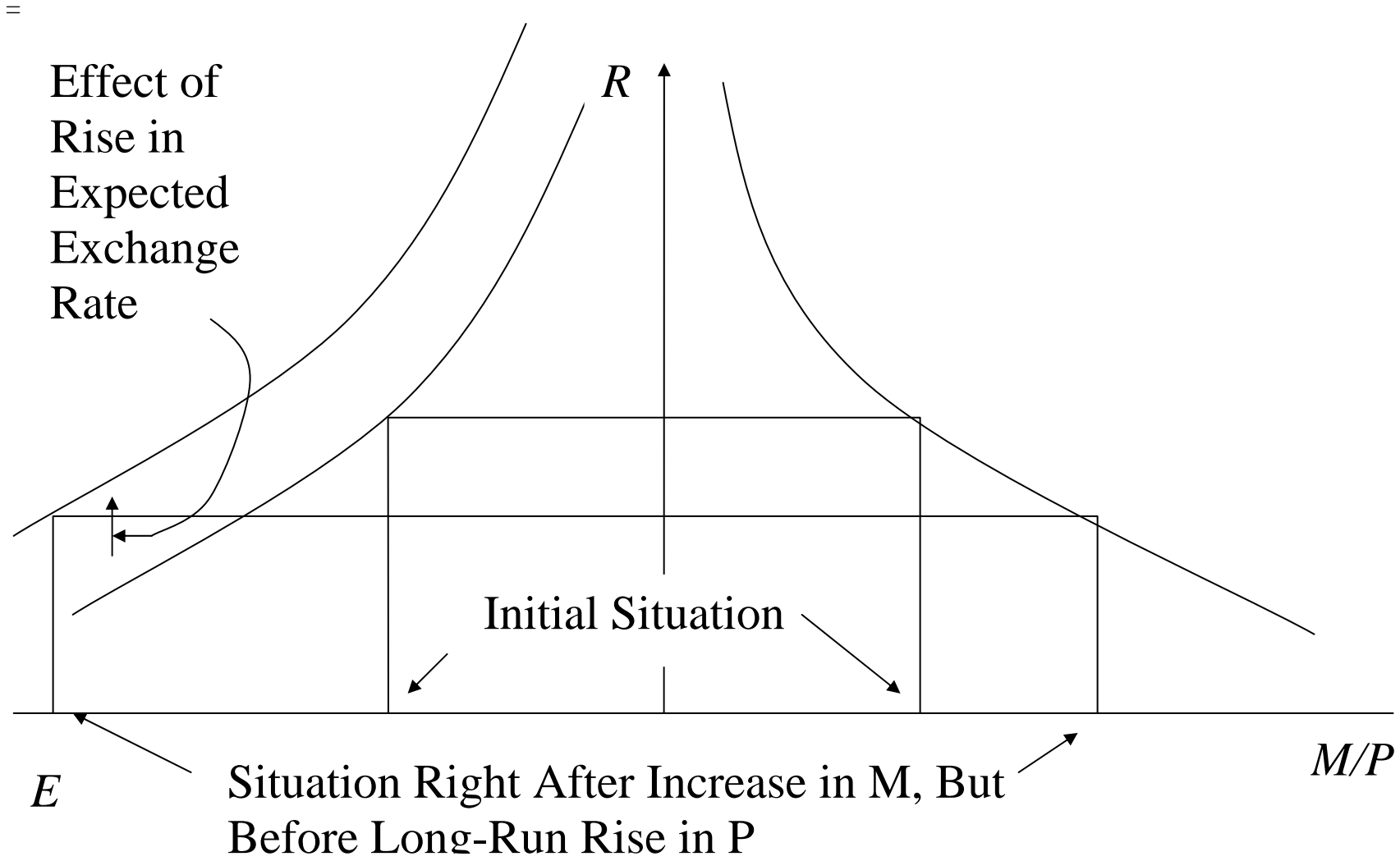
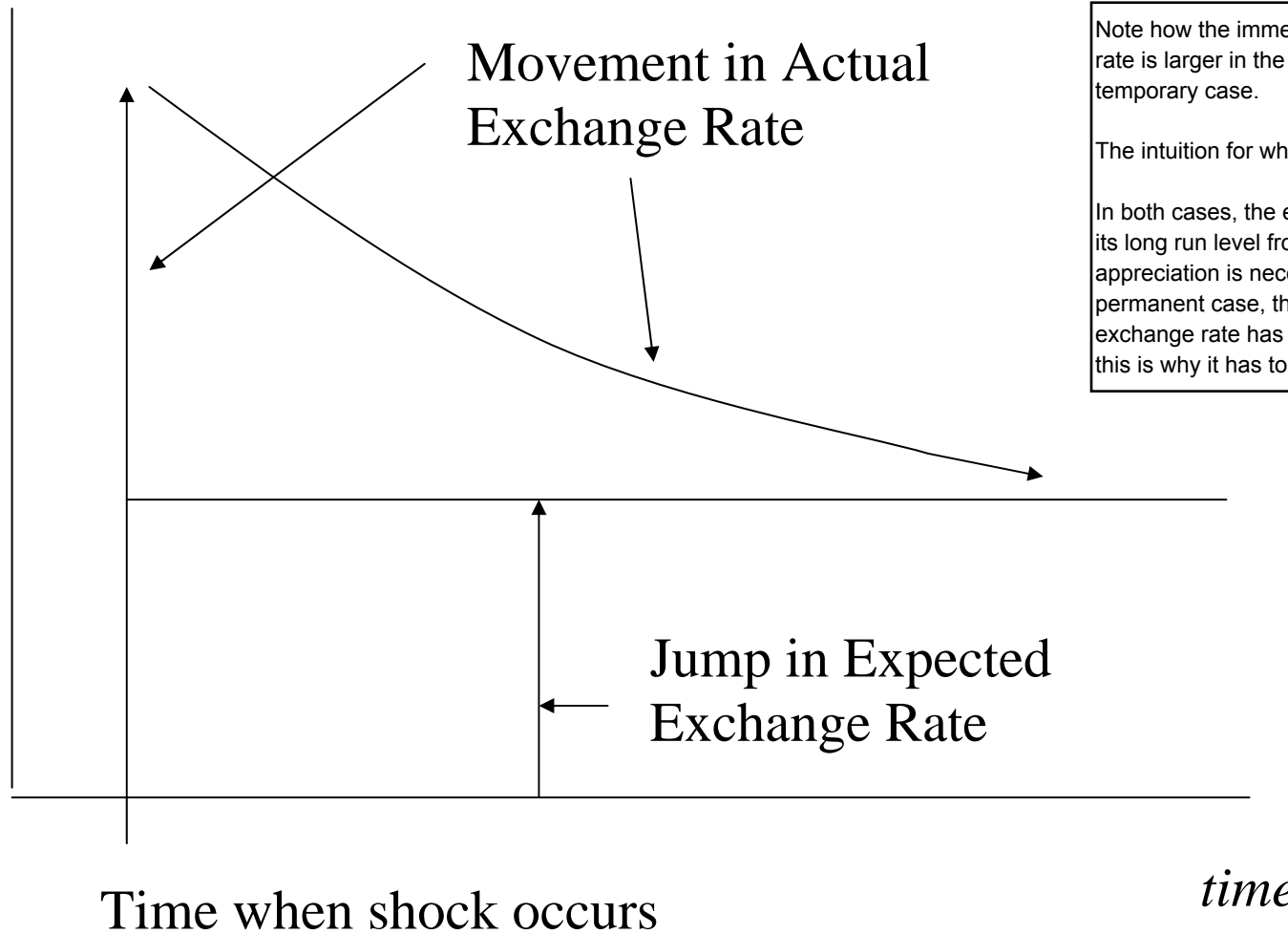


Figure 4: Dynamic Path Followed by Exchange Rate in Response to Permanent Increase in Money Supply

$E$



Note how the immediate rise in the exchange rate is larger in the permanent than in the temporary case.

The intuition for why this must be so is simple.

In both cases, the exchange rate has to approach its long run level from above, because appreciation is necessary for UIP. In the permanent case, that long run level to which the exchange rate has to come down to is higher, and this is why it has to jump more initially.

Figure 5: Effects of Increase in M Under Three Different Scenarios About Persistence of that Increase

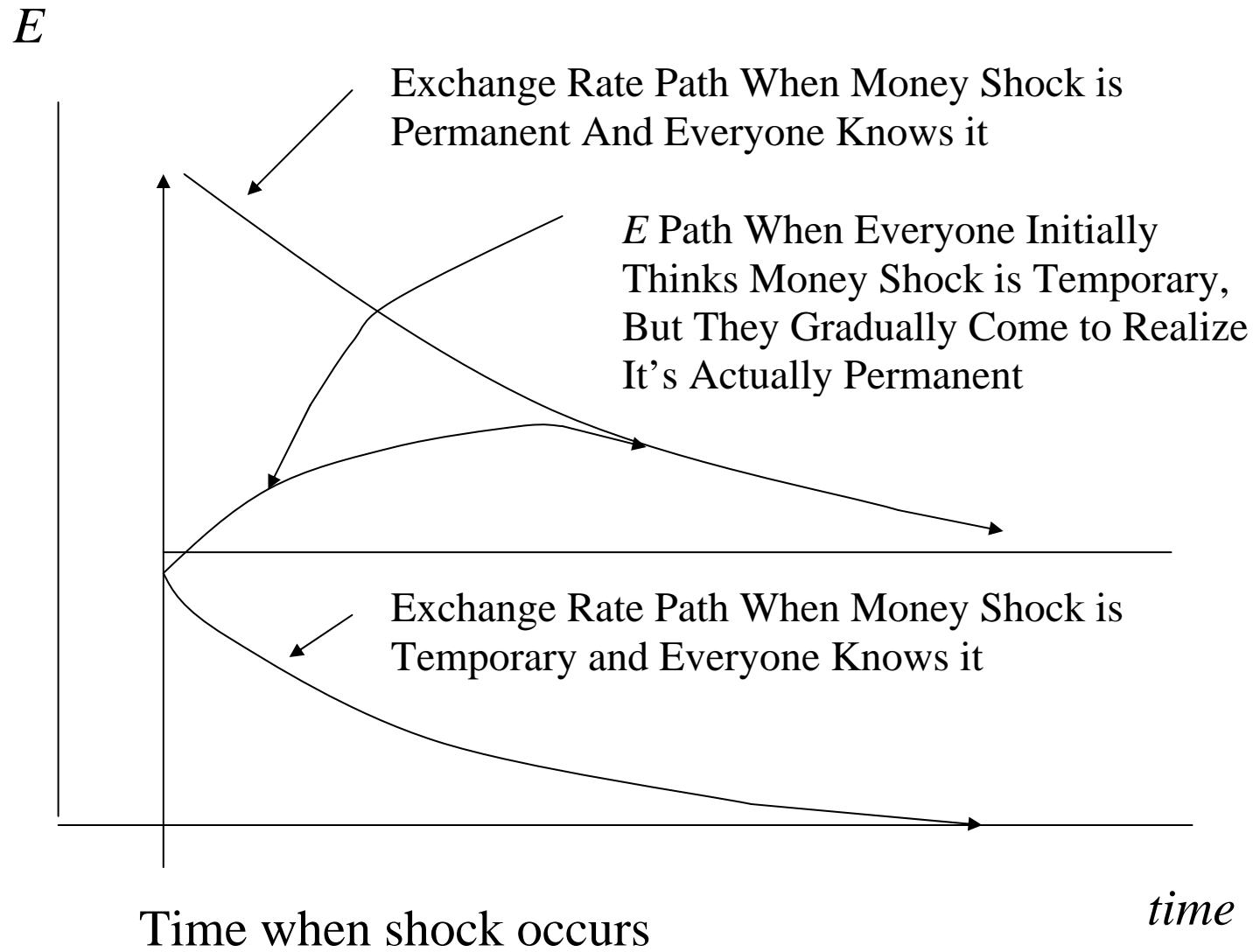
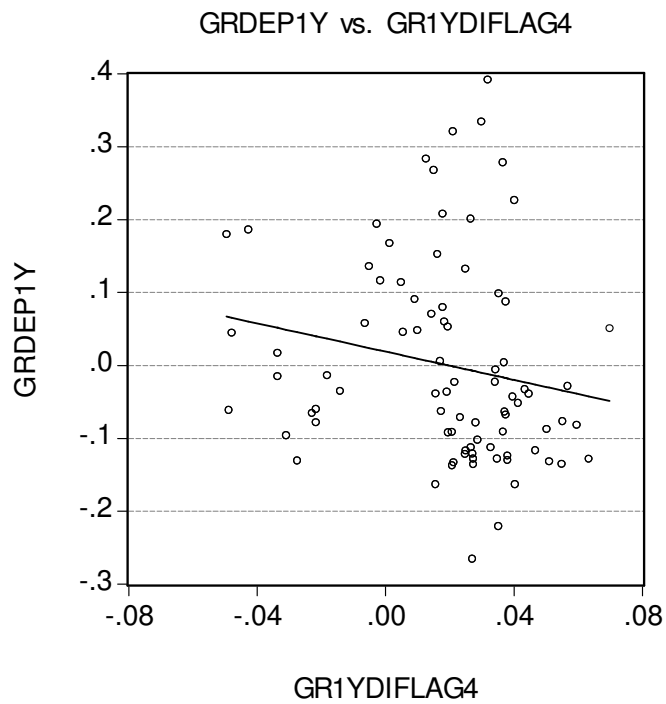


Figure 6: Evidence on UIP

Horizontal Axis - US Interest Rate Minus German Interest Rate (One Year Rate)

Vertical Axis - Depreciation of US Dollar Over Period to Which Interest Rates Apply



Note: US Dollar Appreciates Quite Often After US Interest Rate Rises Above German This Seems Like a Problem for UIP (Although we have to be Cautious in Concluding this Because UIP Applies to Expected Exchange Rate, While Data Involve Actual Interest Rates)

Figure: Deutschemark/U.S. dollar depreciation against interest rate differential, 1 year horizon



Figure 7: Real Exchange Rates

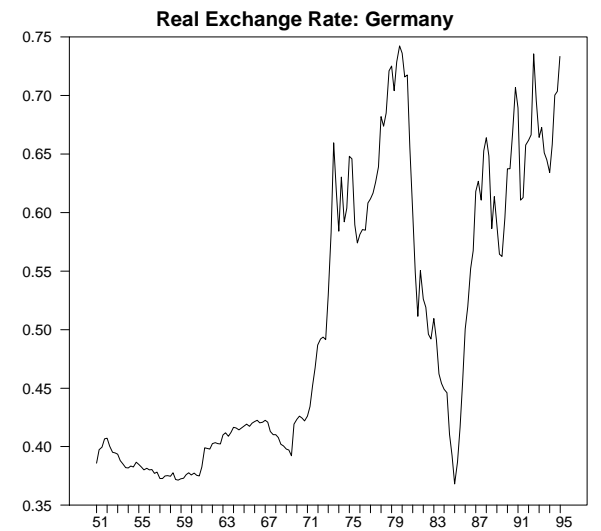
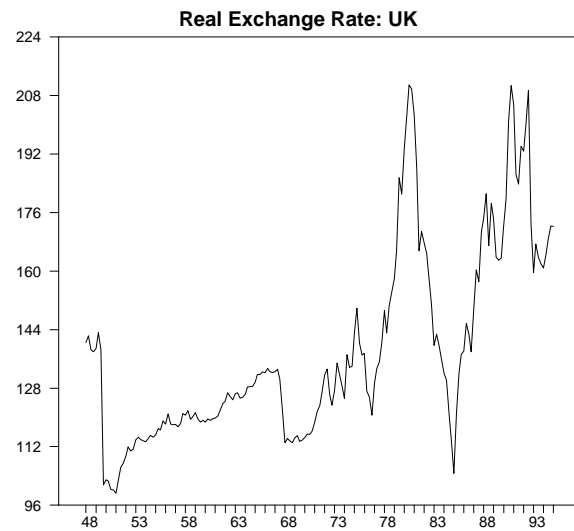
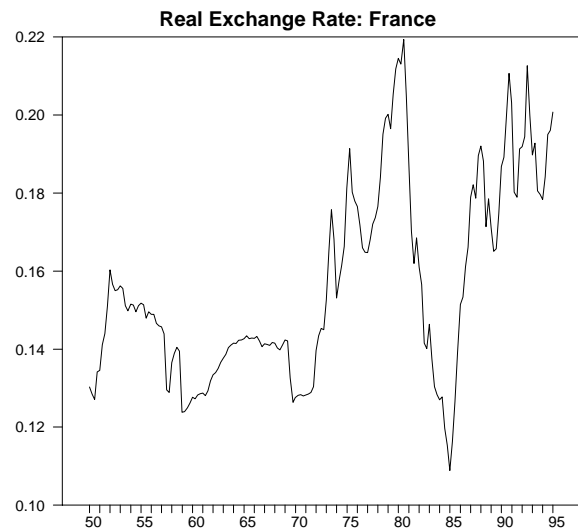
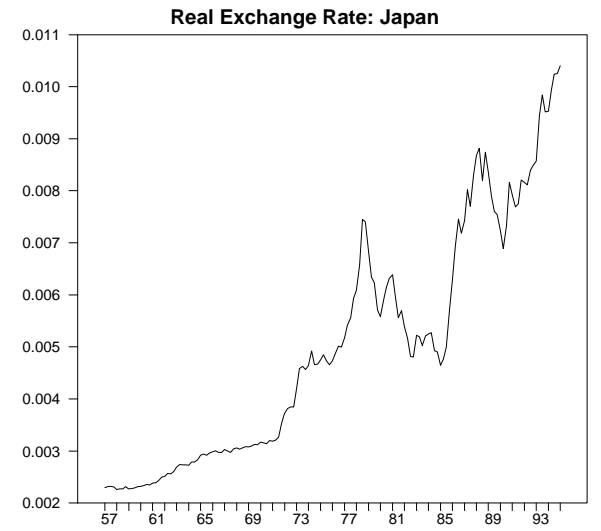
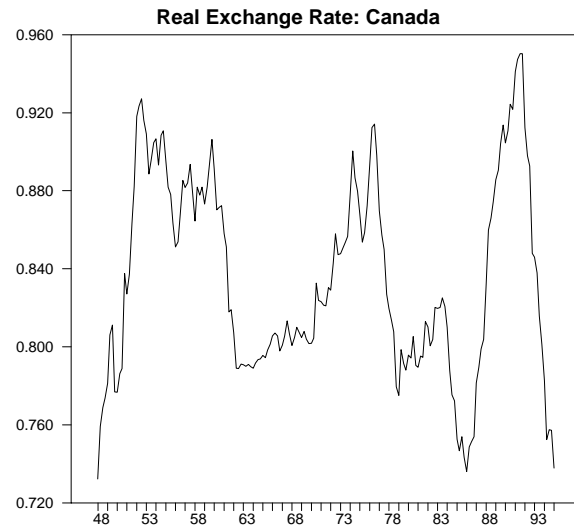
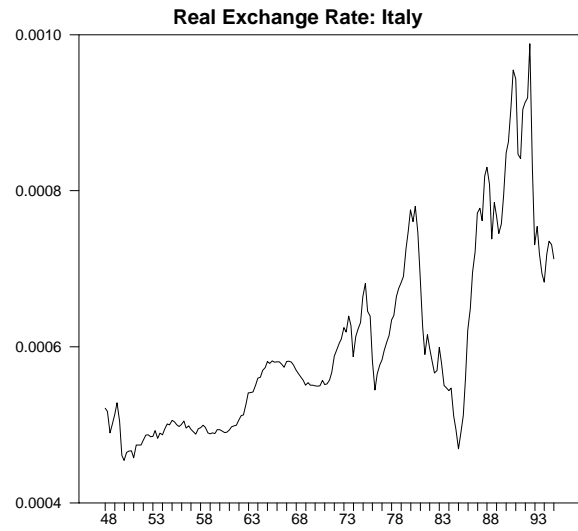


Figure 8: Understanding the Reasons for the Real Depreciation of the Dollar Against Japan

