Exchange Rates, Interest Rates and Expectations

Our final example of the role of expectations in macroeconomics is an important one: The link between interest rates and exchange rates and the behaviour of flexible exchange rates.

Why Exchange Rates Matter

Why do exchange rates matter? Consider the Euro-Pound exchange rate, so that €1 = £X. Now suppose X goes up, so the Euro is worth more relative to the pound. What will happen to exports from Ireland to the UK and imports to Ireland from the UK?

1. *Exports*: For each pound in sterling revenues that an Irish firm earns, they now get less revenue in euros unless they increase their UK price. Because most of their costs (in particular wages) will be denominated in euros, this means that exporting will become less profitable at prevailing prices. Irish firms may react to this by increasing the price they charge in the UK: This will reduce demand for their product, so exports will still decline. Alternatively, some firms that feel they cannot raises prices to restore profitability may simply exit from exporting. Between these two mechanisms, an increase in the value of the euro relative to the pound will reduce Irish exports to the UK.

2. *Imports*: Because the value of the euro has increased, UK firms will get more sterling revenues from exporting to Ireland at the same prices, so UK firms that hadn't previously been exporting to Ireland may start to do so. Alternatively, UK firms already exporting to Ireland may decide to lower their euro-denominated prices in Ireland and increase their market share while still getting the same sterling revenue per unit. Either way, imports to Ireland from the UK will increase.

So while an increase in the value of a country's currency may sound like a good thing, it tends to reduce exports, increase imports, and thus reduce the country's real GDP. In contrast, a depreciation of the currency boosts exports and has a positive effect on economic growth. For these reasons, a depreciation of the currency is often welcome in a recession and the absence of this tool when the exchange rate is fixed is often pointed to as a downside of such regimes.

That said, exchange rate depreciation has its downsides also:

1. *Inflation*: Depreciation tends to make imports more expensive and so add to inflation. This is one reason why central bankers tend to say they favour a strong currency—they are indicating their preference for low inflation. For small open economies that import a lot, the inflationary effects of depreciation are much bigger.

2. *Temporary Boost*: The boost to growth from a devaluation is often temporary. Over time, the increase in import prices may feed through to higher wages and this gradually erodes the competitive benefits from devaluation. The more open an economy is, the stronger the subsequent erosion of the competitive improvement.

Free Movement of Capital: Uncovered Interest Parity

Consider the case where there is free mobility of capital: In other words, people can move money from one country to another immediately and without incurring any fees or taxes. Specifically, consider the case where money can flow easily between the US and the Euro area.

Suppose now that investors can buy either US or European risk-free one-period bonds. European bonds have an interest rate of i_t^E and US bonds have an interest rate of i_t^{US}. Let e_t

represent the amount of dollars that can be obtained in exchange for one Euro: Currently e_t is about 1.30.

Now let's think about about the return to a US investor who wants to invest \$1 in a Euro-denominated bond at time t and then convert the money back into dollars at time $t+1$. They do this as follows. First, they exchange their \$1 for for €$\frac{1}{e_t}$ and use this money to buy a European bond worth. The bond pays an interest rate of i_t^E and then next period the US investor exchanges their €$\frac{1+i_t^E}{e_t}$ back into dollars, so they expect to end up with \$$\left(1+i_t^E\right)\left(\frac{E_t e_{t+1}}{e_t}\right)$.

If we abstract from risk aversion (the exchange rate movement is presumably uncertain) then the US investor will be indifferent between this buy-European-bond-and-swap-back-into-dollars strategy and purchasing a US bond as long as

$$\left(1+i_t^E\right)\left(\frac{E_t e_{t+1}}{e_t}\right) = 1 + i_t^{US} \tag{1}$$

An alternative expression for this is

$$\left(1+i_t^E\right)\left(1+\frac{E_t e_{t+1} - e_t}{e_t}\right) = 1 + i_t^{US} \tag{2}$$

which can be re-written as

$$1 + i_t^E + \frac{E_t e_{t+1} - e_t}{e_t} + i_t^E\left(\frac{E_t e_{t+1} - e_t}{e_t}\right) = 1 + i_t^{US} \tag{3}$$

Subtracting the 1 from each side, we get

$$i_t^E + \frac{E_t e_{t+1} - e_t}{e_t} + i_t^E\left(\frac{E_t e_{t+1} - e_t}{e_t}\right) = i_t^{US} \tag{4}$$

Since both i_t^E and $\frac{E_t e_{t+1} - e_t}{e_t}$ are going to be relatively small, the product of them will usually be close to zero, so the condition for the investor to be indifferent between the two investment strategies is

$$i_t^E + \frac{E_t e_{t+1} - e_t}{e_t} \approx i_t^{US} \tag{5}$$

This condition—which says that the foreign interest rate plus the expected percentage change in the value of the foreign currency should equal the domestic interest rate—is known as the *Uncovered Interest Parity* condition.

Why should we expect this condition to hold? Why would be expect investors to be indifferent between US and European bonds? Well, suppose it turned out that the European bonds offered a better deal than the US bonds: The combination of interest rate and expected exchange rate appreciation makes the rate of return on European bonds better than that on US bonds. Well, if there is perfect capital mobility, then this would mean that there would be a rush for investors to purchase European bonds rather than US bonds. European institutions who borrow via selling these bonds (governments, highly rated corporations) would figure out that they could borrow at a lower interest rate and still find investors willing to buy their bonds as well as US bonds. By this logic, deviations from Uncovered Interest Parity (UIP) should be temporary with borrowers adjusting the interest rates on their bonds to ensure that investors are indifferent between various international investments.

Note that it states that if European interest rates are lower than US rates, then the Euro must be expected to appreciate. This might seem counter-intuitive: Before reading this, you might expect the country that has higher interest rates to be the one with an appreciating currency. More on this below.

The Trilemma of International Finance

If the UIP relationship approximately holds, then this has important implications for the links between a country's choice of exchange rate regime and its choice of monetary policy. Specifically, if UIP holds, then it is not possible to have all three of the following:

1. Free capital mobility (money moving freely in and out of the country).

2. A fixed exchange rate.

3. Independent monetary policy.

You can have any two of these three things, but not the third:

1. You can have free capital mobility and a fixed exchange rate (so that $E_t e_{t+1} = e_t$) but then your interest rates must equal those of the area you have fixed exchange rates against ($i_t^{US} = i_t^{E}$). For example, Ireland had a fixed exchange rate with the UK for many years and interest rates here were the same as in the UK.

2. You can have free capital mobility and set your own monetary policy ($i_t^{US} \neq i_t^{E}$) but then your exchange rate cannot simply be fixed (so that $E_t e_{t+1} \neq e_t$). For example, in the UK, the Bank of England sets short-term interest rates and the sterling exchange rate fluctuates freely in financial markets.

3. You can set your own monetary policy and fix your exchange rate against another country, but then you must intervene in capital markets to prevent people talking advantage of investment arbitrage opportunities. For example, China has a fixed exchange rate with the US dollar and also sets its own monetary policy but it does not allow free movement of capital.

This idea that you can only have two from three of free capital mobility, a fixed exchange rate and independent monetary policy is commonly known as the *trilemma* of international finance.

Flexible Exchange Rates Under Capital Mobility

Let's think about how exchange rates should behave free under capital mobility. Recall our example involving US and European bonds. The condition for the expected return on the two investments to be the same was

$$\left(1+i_t^E\right)\left(\frac{E_t e_{t+1}}{e_t}\right)=1+i_t^{US} \tag{6}$$

You may have thought at this point that you had escaped from first-order stochastic difference equations. Unfortunately not. Equation (6) isn't a linear first-order stochastic difference equation of the type that we have studies up to know. However, if we take logs, it becomes

$$\log\left(1+i_t^E\right)+E_t\log e_{t+1}-\log e_t=\log\left(1+i_t^{US}\right) \tag{7}$$

This is a linear stochastic difference equation describing the properties of the log of the exchange rate. It can be re-arranged to be in our more familiar format as

$$\log e_t=\log\left(1+i_t^E\right)-\log\left(1+i_t^{US}\right)+E_t\log e_{t+1} \tag{8}$$

Going back to our description of first-order stochastic difference equations, this is an another example of one these equations of the form $y_t = ax_t + bE_t y_{t+1}$, this time with $y_t = \log e_t$, $x_t = \log\left(1+i_t^E\right) - \log\left(1+i_t^{US}\right)$, $a = b = 1$. If we apply the repeated substitution technique to this equation, we get

$$\log e_t=\sum_{k=0}^{\infty}E_t\left[\log\left(1+i_{t+k}^E\right)-\log\left(1+i_{t+k}^{US}\right)\right] \tag{9}$$

It turns out, however, that this is not the only possible solution. To see this, note that for any arbitrary number $\log \bar{e}$ we could re-arrange equation (8) as

$$\log e_t - \log \bar{e} = \log\left(1 + i_t^E\right) - \log\left(1 + i_t^{US}\right) + E_t \log e_{t+1} - \log \bar{e} \tag{10}$$

In other words, because the coefficient on the expected future exchange rate equals one (because the $b = 1$) then the repeated substitution method works not just for e_t but for any $e_t - \bar{e}$ where $\bar{e}$ is any arbitrary number. So, the general solution is

$$\log e_t = \log \bar{e} + \sum_{k=0}^{\infty} E_t \left[\log\left(1 + i_{t+k}^E\right) - \log\left(1 + i_{t+k}^{US}\right)\right] \tag{11}$$

where the theory does not predict what the value of $\bar{e}$ is. Because the natural log function has the property that $\log(1 + x) \approx x$, we can simplify this to read

$$\log e_t = \log \bar{e} + \sum_{k=0}^{\infty} E_t \left(i_{t+k}^E - i_{t+k}^{US}\right) \tag{12}$$

We can make a number of points about this equation.

- UIP tells us something about the *dynamics* of the exchange rate but it does not make definitive predictions about the level an exchange rate should be at, i.e. it does not pin down a unique value of $\bar{e}$. Other theories, such as Purchasing Power Parity (the idea that exchange rates should adjust so each type of currency has equivalent purchasing power) do make such predictions, though they don't work very well in practice.

- This unexplained $\bar{e}$ can be seen as a sort of long-run equilibrium exchange rate because this is the rate that holds when the average interest rate on European bonds in the future equals the average interest rate on US bonds.

- The model predicts that deviations from the long-run exchange rate $\bar{e}$ are determined by expectations that interest rates will differ across areas. In this example, the euro will be higher than $\bar{e}$ if people expect European interest rates to be higher in the future than US rates.

The model explains the slightly puzzling result we discussed earlier: That higher interest rates in Europe imply the euro is expected to depreciate. Suppose in period $t-1$, Euro and US interest rates were equal to each other and expected to stay that way. Equation (12) implies that under these circumstances we would have $\log e_{t-1} = \log \bar{e}$. Now suppose that, in period t, Euro interest rates unexpectedly went above US interest rates just for one period. What would happen? The Euro must end up back at $\bar{e}$ (because interest rates in the two areas are going to equal each other after period t) and the Euro must also be expected to depreciate (because of the higher current interest rate in Euro).

So, in response to the surprise temporary increase in European interest rates, the Euro immediately jumps upwards and then depreciates back to $\bar{e}$. This conforms with our intuition that higher European interest rates should make the Euro more attractive.

UIP and Exchange Rate Volatility

During the period after the second world war up to the 1970s, most of the world's economies operated the so-called Bretton Woods system of quasi-fixed exchange rates. The 1970s saw the widespread introduction of market-determined flexible exchange rates. Prior to the introduction of this system, advocates of market-based flexible exchange rates had predicted that rates would change very little over time.

The truth turned out to be the opposite: Exchange rates change by very large amounts on a daily, weekly, monthly basis. See Figure 1 which shows the Euro-dollar exchange rate. It also gone through big swings: Reaching lows of 0.8 in 2000 and highs of 1.6 in 2008. In addition, there are often large day to day movements where the exchange rate will go up or down by one or two percent.

The model just developed—combining the UIP with rational expectations—helps to explain why exchange rates are so volatile. Using equation (12) for the level of exchange rates, we can derive the change in the exchange rate at time t as

$$\Delta \log e_t = \sum_{k=0}^{\infty} E_t \left(i_{t+k}^E - i_{t+k}^{US} \right) - \sum_{k=-1}^{\infty} E_{t-1} \left(i_{t+k}^E - i_{t+k}^{US} \right) \tag{13}$$

We will simplify this a bit via a slightly dodgy bit of terminology, meaning that we will write $(E_t - E_{t-1})\, x_{t+k}$ to mean $E_t x_{t+k} - E_{t-1} x_{t+k}$, i.e. this means the change between time $t-1$ and time t in what people expect x_{t-k} to be. Given this, we can re-write the previous equation as

$$\Delta \log e_t = i_{t-1}^{US} - i_{t-1}^{E} + \sum_{k=0}^{\infty} (E_t - E_{t-1}) \left(i_{t+k}^E - i_{t+k}^{US} \right) \tag{14}$$

This equation tells us a lot about how exchange rates should behave if investors have rational expectations. Exchange rate changes reflect not only the *expected* change due to past interest rate differentials expiring (the $i_{t-1}^{US} - i_{t-1}^{E}$ term); they also reflect *unexpected* changes in the projected path of future interest rate differentials. This means that all information that affects expectations of future Euro-area and US interest rates feed directly into today's exchange rate. Because interest rates are set by central banks in response to developments in the macroeconomy, this means that exchange rates should react to all types of macroeconomic news.

Figure 1: Daily Data on the Euro-Dollar Exchange Rate

Problems for the UIP-Rational Expectations Theory

The UIP theory helps to explain a number of important aspects of the behaviour of exchange rates. However, there have been many examples of where the theory just outlined does not seem to work well. Indeed, quite commonly, there have been examples where the theory predicts for an extended period of time that a currency depreciation or appreciation should be expected, when what actually happens is the opposite.

One potential explanation for this apparent failure that could still be consistent with the model is that $E_t e_{t+1} - e_t$ is not the same as $e_{t+1} - e_t$: The mathematical expectation of something and its actual outcome can sometimes differ from each other for quite a while. This is sometimes called *the Peso problem*. Sometimes interest rates in developing economies (such as Mexico, after which the term is named) are high because markets think there is a probability (perhaps a small probability) that a large depreciation may be coming. Just because the depreciation doesn't happen during a particular sample doesn't mean the expectation was unreasonable or that it won't be correct at some point.

But evidence also seems to exist of more systematic errors for the UIP theory. Take one example. For most of the last decade, Japanese interest rates were well below European levels for most of this decade. The UIP-Rational Expectations approach would have predicted that the Yen should have been appreciating against the Euro: In fact, the opposite happened systematically from 2001 to 2008. See Figure 2. Many traders systematically exploited this, borrowing at low interest rates in Yen, using the funds to buy Euro bonds that yielded higher interest rates and then repaying their debts in depreciated Yen—the so-called Yen carry trade. That said, as Figure 2 also shows, the "carry trade" unwound itself fairly spectacularly in 2008.

The leading explanations for the apparent failures of the UIP-RE theory involve introducing risk aversion (we have assumed investors are risk-neutral) and home-bias (the preference for assets denominated in your home currency). For instance, in relation to the theory's failure to explain the Yen carry trade period, it's worth noting that many Japanese investors have a strong preference for Yen-denominated assets and don't want to take on the extra currency-related risk of investing in dollar or euro-denominated assets.

These kinds of preferences may lead to short-term violations of the stronger predictions of the UIP-RE theory. However, they will not allow countries to escape from the restrictions of the Trilemma: A country that attempts to adopt a systematically different interest rate policy than another country simply will not be able to have a fixed exchange rate with that country unless it imposes capital controls.

Figure 2: Daily Data on the Euro-Yen Exchange Rate

Things to Understand from these Notes

Here's a brief summary of the things that you need to understand from these notes.

1. How do changes in exchange rates affect the economy?

2. Effects over time of devaluations.

3. Uncovered interest parity.

4. The Trilemma.

5. The joint implications of predictions of UIP combined with rational expectations.

6. Why we should expect flexible exchange rates to be volatile.

7. Problems with the RE-UIP theory.