**CHAPTER 1**

**MONEY AND CURRENCY**

Introduction

This lecture will discuss the topic of money. Why do we use money? I then present the “Cagan model”—a framework that provides a useful view on the relationship between money and prices. In the next lecture we will use this model as a basis for a first discussion of foreign exchange rates.

Money and currency

If you ask a non- economist what he thinks of when he hears the word economics he will probably say money. But as you are approaching a last months of a four year study in economics, how much have you actually learned about money? Economics is not about money. Economics is about maximising utility under constraints. To achieve this prices must adjust to clear markets. Prices are only ratios—the price of good 1 is the number of good 2 you need to obtain one unit of good 1. You don’t need “money”—that is currency—for that. You only need more than one good. However, without money the economy turns into a barter economy. I will trade with you only if you have a good that I need, and you will trade with me only if I have a good you need. For a barter economy to work, there must be a high coincidence of wants. That might work in an economy where every one supplies most of their own needs. In a more advanced economy individuals become specialised, and coincidence of wants become scarce. The economy needs an asset used for transactions. That asset is money. Money is introduced to play three main roles. It is supposed to be:

- a unit of account,
- a means of payment, and
- a store of value.

The unit of account is just an accounting measure. We need something so standardised that everyone has a common understanding of its value. We can then measure the value of other things in quantities of this unit. The means of payment is the physical thing we use for transactions. Instead of exchanging one good for another we can exchange the good in

... → the bill works as

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Gold coins.

Metal became the leading fabric used for currency in the European economies. Three metals were used: copper for smaller purchases, silver for medium sized purchases and gold for larger purchases. These were all commodity money. That means that they had a value independent from their value as money. One is willing to hold precious metals even if one can not use them in day-to-day transactions.

As a unit of account: gold works well if one can agree on a stan- dardised weight. However, often one can not. This is one reason why currency, even in the time of the gold standard, was national. Weight measures were national specific to the end of the last cen- tury. They still to some degree are—i.e. the difference between US and European standards. As a means of payment: gold as such is not a good means of payment. First, it is very expensive. For most purchases the amount need is so small that other metals, like copper, is more useful. Second, it needs to be meticulously measured each time to assure that one pay the right amount.

To alleviate the last problem public authorities or banks—like the banks in Florence—issued gold coins. Each coin had a standardised value. However, even such coins can be problematic. A coin can be “shaved”—i.e. people take some of gold and hope to sell the coin for its original value. Or the issuing institution can attempt to make money by issuing coins with less gold content, but sell the coin for its original value. This is called debasing the currency. In fact, debasing might lead to currency crises—people will try to store the coins with high gold content, and sell the coins with low gold content. Such currency crises were frequent in the later years of the Roman empire.

Store of value: over time the value of gold depends on who much gold is available. If much gold is found, the value of gold will fall. However, gold is scarce. And as gold has an intrinsic value in its beauty, it can be considered fairly.

Gold backed currency.

Gold is bulky, heavy and difficult to carry around. So instead of using gold directly, people started to use claims on gold. A bank issues a “bill of credit” that states that a given amount of gold can be redeemed from the bank with this bill. E.g.: I deposit 1 ounce of gold in Bank A. That gives me a bill stating that I get one ounce of gold if I make a claim with this bill in bank A. I use this bill to purchase a radio. The radio salesmen uses the bill to pay his rent. The landlord uses the bill to pay ... → the bill works as

... → the bill works as

... → the bill works as

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The currencies above are all based on commodities. That means that the currency have a potential value as money. Even if not used as money, gold could be expected to lose value when the war ended.

A means of payment: cigarettes are easily transportable. One problem is that they lose value if they get wet.

Store of value: cigarettes can be stored for some time without losing flavour. And there was a stable underlying real demand, assmokers would demand cigarettes even if they were not used as money. However, cigarettes could be expected to lose value when the war ended.

Examples of money

Different periods have solved the need for money by different means. Here is a number of examples of money.

In World War 2 prison camps the Red Cross supplied prisoners various goods, like food, clothing and cigarettes. However, the goods were distributed without attention to the prisoners actual needs; one might get cigarettes even if one was not a smoker. In these camps there evolved a system for trading the Red Cross rations. The “money” in this system was cigarettes.

- A unit of account: all prices were stated in cigarettes. Mankiw (1992) reports that one shirt costed about 80 cigarettes. As a unit of account cigarettes is adequate. However, note that it would not work if the quality of different types of cigarettes differ to much. If e.g. American cigarettes were much better than e.g. German cigarettes, the price would have to specify the type of cigarette as well.

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not perfectly true: the mining activity for gold would to some degree depend on its monetary value. However, over time the gold supply is independent of how much money the economy actually needs.

Fiat currency
Fiat money is an asset that only has value as a medium of exchange. An example of fiat money is a bill issued by a national monopoly stating that it is the standard means of payment in a given country. The bill is however not redeemable in any commodity from the side of the issuer. Norges Bank is not obliged to give anything else in return for paper money than new paper money—a 50 NOK bill will only return you a new 50 NOK bill. It only has value because it is accepted as a means of payment.

– As a unit of account? Actually fiat money is not very good. The problem is that the issuer, in theory, can issue as much such currency as he likes. But of course, it an infinite amount of currency is issued, then the currency loses all value. So in practice the issuer will limit the amount issued. However, inflation is or has been a problem in almost every country with a fiat currency. If inflation is high or unpredictable, the currency is no longer a good unit of account. In countries with extreme inflation one of ten changes the unit of account to a foreign currency, although the national currency is still the means of payment. E.g. in many high inflation countries the USD is used as a unit of account.
– As a means of payment: fiat currency works good, as long as people trust the issuer. But it depends on how many uses the currency. If everyone accepts it, it is very handy. If no-one accepts it, it has no value—the value of a currency depends on its use.
– As store of value: very uncertain, and clearly dominated by a number of other goods, including gold and bonds.

The creation of a national currency
In modern times we have seen a movement from gold backed currency to fiat currency, and a movement from the use of currency issued by private banks to currency issued by a state monopoly. Those two movements probably depended on each other. The issuer of a currency need to be trustworthy, stable and have good credit. The mod- ern state came to fulfill these criteria during the 19th-century, as national governments were firmly established, and tax systems were implemented. The private banking system seems to have worked in a satisfying manner. As an example the USA had no national currency from 1838 to 1863. All currency was issued by private banks. The Federal Reserve System was first established in 1913. However, there are potential problems:

– "Wild-cat banking”—banks issues bills with no backing, or they keep insufficient reserves.
– Potential instability. A currency becomes more valuable the more people who uses it. However, to extend the use of its currency, the bank needs to extend the number of customers. More customers generally means more bad customers as well. So a big bank might become more unstable, and the currency more unsafe. We get the potential of cur-rency crashes.
– Private banking creates uncertainty among general users, as it is difficult to evaluate if a bank is safe or not.
– The state loses possible income from seignorage—the profit from issuing money.

Money versus currency
Is money and currency the same thing? Currency is money, but money is not only currency. Currency is very liquid money, money used as means of payment and unit of account. However, other forms of money exists:

– A short term bank deposit is money. But it is not as liquid as currency (there are stores that do not accept a debit card).
– A savings account is money. However, these money are more illiquid than the primary account. One can not make purchases directly on a traditional savings account.
– If one holds long term bonds, these can be bought and sold, but is not redeemed before after a certain number of years.

Different types of assets have different degrees of liquidity. One moves one’s holding between different types of money all the time. Traditionally, and everything else equal, the return of an asset is decreasing in the degree of liquidity. Currency, i.e. very liquid money, usually returns no interest. Money has been divided into groups, like M1, M2 and M3. M1 is the most liquid money (currency and short term deposits), M2 is less liquid money and so on. Note: in modern banking the distinctions between different types of money is falling. My credit card offers an account with free debit card access and an interest rate formerly only expected on long term deposits. More and more money is stored electronically as we extend the use of bank cards. Most people no longer holds large holdings of non-interest bearing currency.

Figure 1.2: Notes and coins in the Norwegian economy. Millions of NOK

Figure 1.3: M1 versus notes and coins

Figure 1.4: Inflation and money growth in Argentina, 1974-91
Money and prices—the Cagan model

In the IS-LM model the relationship between money and prices is given by the LM-curve,

\[ \frac{M^d}{P_t} = L(Y_t, r_{t+1}) \quad (1.1) \]

where \( M \) is money demand, \( P_t \) is the price level at time \( t \), \( Y \) is output and \( r_{t+1} \) is the nominal interest rate. The LM curve assumes that real money demand is rising in \( Y \) (because when output grows on needs higher real money holdings) and falling in \( r \), as a higher interest rate rises the alternative cost of holding money (remember that money here is the same as currency). Phillip Cagan argued that during a period of hyperinflation expected inflation would swamp all other influences on money demand. Figure 1.4 illustrates the relationship between money growth and price inflation in Argentina over the period from 1974 to 1991. This was a period with very high inflation. As we can see, as inflation gets higher, the relationship between money growth and inflation becomes stronger.

Under high inflation one can therefore ignore the effect of output and interest rates, and instead write

\[ \frac{M^d}{P_t} = E_t \left( \frac{P_{t+1}}{P_t} \right)^{-\eta} \quad (1.2) \]

Equation (1.148) tells us that if expected inflation rise, we reduce our demand for real money balances. If we know that prices will rise tomorrow, we want to hold less money today, as these money will lose value tomorrow. It shows us how we look at expectations at time \( t \). \( \eta \) is the semielasticity of demand for real balances with respect to expected inflation. It is parameter that tells us how much demand for real balances—the money stock divided by the price level—reacts to a change in expected inflation. If \( \eta \) is large this indicates that we would make a large adjustment in money balances if we know that prices will change tomorrow. If \( \eta \) is close to zero we do not care about inflation when deciding the level of real money balances.

If we take logarithms on both sides we obtain

\[ m_t - p_t = -\eta E_t(p_{t+1} - p_t) \quad (1.3) \]

where small letters are the logarithms of large letters. We will use the equa-tion on logarithmic form, as this simplifies the analysis.

Solving the Cagan model

We want to study the relationship between money and prices. So we need to find the equilibrium of the model. We have an equation for money demand. However, we know that in equilibrium supply must equal demand. So we must have

\[ m^d = m_e \quad (1.4) \]

We can then restate equation (1.148) as

\[ m_t - p_t = -\eta E_t(p_{t+1} - p_t) \quad (1.5) \]

Further, let us assume that all agents are rational and have perfect foresight. If so we can eliminate the expectation term. We get

\[ m_t - p_t = -\eta(p_{t+1} - p_t) \quad (1.6) \]

Equation (1.53) is a first order difference equation. We want to find the relationship between \( p \) and \( m \), in other words we want an expression of the type

\[ p_t = \gamma m_t \quad (1.7) \]

The easiest way to solve a first order difference equation is by iteration. First, write equation (1.53) with \( pt \) on the left hand side. We get

\[ p_t = \frac{1}{1 + \eta} m_t + \frac{\eta}{1 + \eta} p_{t+1} \quad (1.8) \]

We see that today’s price level depends on the unforeseen price level of tomorrow. What does the price level of tomorrow depend on? Lead equation (1.8) with one period, and we get

\[ p_{t+1} = \frac{1}{1 + \eta} m_{t+1} + \frac{\eta}{1 + \eta} p_{t+2} \quad (1.9) \]

We can now substitute the expression from equation (1.9) into equation (1.8). Doing so we obtain

\[ p_t = \frac{1}{1 + \eta} \left( \frac{m_t + \frac{\eta}{1 + \eta} p_{t+1} + \left( \frac{\eta}{1 + \eta} \right)^2 p_{t+2} \right) \quad (1.10) \]

If we repeat this procedure, eliminating \( pt+2 \) and then \( pt+3 \) and so on, we will in the end get

\[ p_t = \frac{1}{1 + \eta} \sum_{i=1}^{\infty} \left( \frac{\eta}{1 + \eta} \right)^i m_{t+i} + \lim_{T \to \infty} \left( \frac{\eta}{1 + \eta} \right)^T p_{t+T} \quad (1.11) \]

How shall we interpret equation (1.11)? We often choose to assume that

This is the same as assuming that there is no “speculative bubbles” in the price level. Indeed, equation (2.10) will be zero, unless the level of prices changes at an ever increasing proportional rate.

Bubbles

What is a speculative bubble? One can say that a bubble is an explosive path which brings the level progressively farther away from economic funda-mentals. However, “economic fundamentals” is something we define—it is a “model specific term”. A better definition is probably that a bubble is a movement that leads to increasing divergence from the equilibrium value defined by an economic model. Notice that in this model we assume perfect foresight and rational agents. Despite this quite strong assumptions we can not rule out the existence of rational bubbles. We can only assume that they do not exist. However, it is reasonable to believe that rational bubbles exist?

Bubbles can not exist if we know that it will “burst” at a given point of time. Why? If we know the price level will revert to its “true value” at a given time, we will try to make a fortune going short in the asset. However, if everyone does this, prices must fall today. A bubble can never exist if there is certainty about when the bubble will collapse. It is easier to see this if think about e.g. stocks instead of the general price level. Assume that there is stock price bubble. If we expect the prices to fall at time \( t \), we will go “short” today—i.e. we will sell assets for delivery at time \( t + 1 \). Why? Because we expect that we can buy stock at a much lower price than in the forward contract when time \( t + 1 \) arrives. At \( t + 1 \) we buy stock in the spot market at a low price to fulfill our forward contract.

However, if the timing of the crash of the bubble is uncertain, a bubble can exist even if everyone knows it is a bubble. If we expect prices to rise in this period, and the next period, and the period after that, we can make money by buying the asset today. But doing so, we just fuel the bubble—the more people who buy the asset, the more do prices rise. In fact everyone find it profitable to let the bubble exist—although everyone knows that a some time in the future the prices need to revert to a lower level. “Rational bubbles” are models where the there is much uncertainty about when the bubble will collapse.

Note that it is very difficult to test if a bubble really exists. If we test for the existence of a bubble, we will simultaneously test whether

1. there is a divergence from the values predicted by the economic model, and
2. whether the economic model in fact is the true model, or
3. if the diverg-ence only is the product of bad modelling. It is more or less impossible to distinguish these two issues from each other.

the price level and money is what we have defined in economic models. If the price level does not behave as in the model we say that it does not behave according to “economic fundamentals”. However, notice that we do not know if the behaviour of the price level defies logic, or if it is our model that is flawed.

Prices and money—a solution?

We assume no bubbles. We can then rewrite equation (1.11) as

\[ p_t = \frac{1}{1 + \eta} \sum_{i=1}^{\infty} \left( \frac{\eta}{1 + \eta} \right)^{i-1} m_{t+i} \quad (1.13) \]

We can draw several interesting conclusions from equation (1.13): First, note that

\[ \sum_{i=1}^{\infty} \left( \frac{\eta}{1 + \eta} \right)^{i-1} = \frac{1}{1 + \eta} \left( \frac{1}{1 - \frac{\eta}{1 + \eta}} \right) = 1 \quad (1.14) \]

\[ \sum_{x=1}^{\infty} k^x = \frac{1}{1 - k} \]

We do not know if the behaviour of the price level defies logic, or if it is our model that is flawed.
If the money supply is constant, i.e. \( m = m \) we have that

\[
p_t = \bar{m}.
\]  

(1.15)

Not only is inflation zero for all periods, the price level is also fixed at the level \( m \). However, if the money supply makes an unexpected jump at time \( t \) to a new level, i.e.

\[
m_t = \begin{cases} \bar{m}, & t < t, \\ \bar{m'}, & t \geq t, \end{cases}
\]  

(1.16)

this implies that

\[
p_t = \begin{cases} \bar{m}, & t < t, \\ \bar{m'}, & t \geq t. \end{cases}
\]  

(1.17)

As we see, if there is an unexpected shock to \( m \) the price level will change immediately. The change in the price level will be equipropor- tionate with the change money stock. These results imply that in this model, money is fully neutral. Changes in the level of money supply or changes in the denomination used, i.e. a change in the unit of account, leads to an immediate equal proportionate change in the price level. For example, exchanging 8 “old NOK” with 1 “new NOK” will only lead to all prices being divided by 8. This result will be found in all models that have no nominal rigidities, such as sticky prices, and no “money illusion”. Real variables are not affected by a change in money supply—we have 3Money illusion is the idea that people do not understand the consequences of a change in the money supply immediately.

real-monetary dichotomy

money affect only prices. Money is a “veil” — and rational agents are able to look through it without letting it affect their decisions. Notice that prices depend on expectations of the future. This implies that

- it will matter whether a shock is expected to be temporary or permanent, and
- it will matter whether the shock is expected or unexpected.

Above we illustrated the case of an unexpected shock. Assume instead that at time \( t \) the government announces a change in the money supply at some future time \( T \). Suppose

\[
m_t = \begin{cases} \bar{m}, & t < T, \\ \bar{m'}, & t \geq T, \end{cases}
\]  

(1.18)

One will then find that the path of the price level becomes

\[
p_t = \begin{cases} \bar{m} + \frac{\eta_1}{1+\eta_1}(\bar{m}'-\bar{m}), & t < T, \\ \bar{m'}, & t \geq T. \end{cases}
\]  

(1.19)

The price level will make a small jump when the news is announced. It will so accelerate over time until it reaches its new level at time \( T \). News will immediately be incorporated in the price setting. Last, consider the case when the money supply grows at a fixed rate. Assume that \( m_t = m + \mu t \). It is reasonable to believe that if money grows at the rate \( \mu \), prices must grow at the same rate, so that inflation also equals \( \mu \). If we insert this in the real money demand function, equation (11.48), we have

\[
m_t = p_t = -\eta \mu,
\]  

(1.20)

or

\[
p_t = m_t + \eta \mu.
\]  

(1.21)

This result will be used later in the course.

**Does the Cagan-model fit Norwegian data?**

According to the above model an unexpected increase in the money stock should lead to an immediate, equipropor- tionate increase in the price level, and causality should go from money to prices, not the other way around. One empirical methodology to identify unexpected shocks is to do a so-called Vector Auto Regression (VAR) and find impulse response functions. A VAR is a system of equations estimated simultane- ously. An impulse response function estimates how the variables in the system will react to a shock in the error term of one variable. The error term is something that is not explained in the model. A shock to the error term is therefore by definition unexpected. Figure 1.6 illustrates the impulse response functions from a shock in the 12-month growth rate of M1. The results can be summarised as follows:

- Prices react to a change in the money stock. However, the reaction occurs with a lag of between 4 and 10 months.
- We see that a shock to money affects prices, but a shock to prices do not affect money. This should imply that causality runs from money to prices.

There is a correlation between money and prices. However, the prediction of an immediate jump in the price level is not reflected in the data. This might have two causes:

- the shocks in the model are not “unexpected”, or
- prices only react to a shock in money with a lag.

The first explanation is not implausible, as we only estimate a model containing lagged values of changes in the CPI and M1. However, it is reasonable to believe that prices do indeed only react with a certain lag. Three expla- nations are offered for why prices do not react immediately to a shock to money:

- Sticky prices. This is the traditional assumption in Keynesian models. It is built on the argument that contracts take time to adjust.
- Money illusion. When people get more money between their hands, they are not able to conclude if this is the result of increased produc- tivity on their part, or of more money in circulation.
- Portfolio balancing. People will not adjust their money holdings im- mediatly. As a result the effect of increased money supply will take time to dissipate through the economy.
These theories have different implications. However, on one account they all agree: if prices do not adjust immediately, a change in money growth might have real effects on the economy. Money will no longer be neutral.

Seignorage
Seignorage is the revenue the government acquires by using newly issued money to buy goods or repay debts. It is assumed that most hyperinflations are results of the government’s need for seignorage revenues. Seignorage in period $t$ is defined as

$$\text{Seignorage}_t = \frac{M_t - M_{t-1}}{P_t}.$$  \hspace{1cm} (1.22)$$

This is the real increase in the money supply from period $(t-1)$ to period $t$. However, above we saw that the price level depends on the present money supply and future expected money growth. This implies that there must be a limit to how much the government can collect as seignorage. To see this, let $\mu$ be a period when prices rise at a rate averaging 50 per cent per month. The highest monthly inflation recorded is in Hungary in July 1945 when prices rose 19800 per cent in one month.

Rewrite equation (1.22) as

$$\text{Seignorage}_t = \frac{M_t - M_{t-1} M_t}{P_t}. \hspace{1cm} (1.23)$$

If higher money growth leads to higher expected inflation, demand for real balances (M/P) will fall. So higher money growth might not always increase seignorage revenues. We can use the Cagan model to find the optimal rate of money growth that maximizes seignorage revenues. We had that

$$\frac{\mu_t}{\mu} = (1-\frac{1}{1+\mu})(1+\mu)^{\eta} = \mu(1+\mu)^{-\eta-1}, \hspace{1cm} (1.28)$$

If money supply grow at a constant rate $\mu$, we have seen that prices grow at the same rate $\mu$, so we have that

$$M_t \equiv M_{t-1} + \mu \Rightarrow m_t = \mu. \hspace{1cm} (1.26)$$

If we substitute (1.24) into (1.23) and rearrange a little, we get

$$\text{Seignorage}_t = \frac{M_t - M_{t-1} M_t}{P_t}. \hspace{1cm} (1.25)$$

We now assume that the government can commit itself to a certain rule for money growth. More specifically, we assume that money growth is given by

$$\frac{M_t}{M_{t-1}} = 1 + \mu \Rightarrow m_{t+1} - m_t = \mu. \hspace{1cm} (1.26)$$

Substituting (1.27) into (1.25) we obtain

$$\text{Seignorage}_t = (1 - \frac{1}{1+\mu})(1+\mu)^{-\eta} = \mu(1+\mu)^{-\eta-1}. \hspace{1cm} (1.28)$$

We find the $\mu$ that optimises seignorage by taking the first-order condition of (11.73) and setting equal to zero, so that

$$\frac{\mu}{1+\mu} = \frac{1}{\eta}, \hspace{1cm} (1.29)$$

The revenue maximizing net rate of money growth must equal

$$\mu^\text{MAX} = \frac{1}{\eta}. \hspace{1cm} (1.30)$$

This is the inverse of the semielasticity of real balances with respect to money. In fact, we have just found out that an optimising central bank will behave in exactly the same way as a monopolist with zero marginal cost of production (we simplify by ignoring the cost of printing currency). That should not be a surprise; after all a central bank is just a monopolist in the “currency issuance market”. An other way to see the result from equation (1.30) is illustrated in figure 1.7. We can draw a “Laffer-curve” for seignorage revenue. There will be a level of money growth that maximises seignorage revenue—to issue more money than this will only be counter productive.

In a hyperinflation it is reasonable to believe that the government exceeds this optimal level of money growth. But why? If expectations are not forward looking, but backward looking, the government might earn money by printing money at an increasing speed. If expectations are backward looking, everyone believes that last periods money growth will be next periods money growth. Increasing money growth in the next period over the money growth in this period will by definition exceed expectations. It is however doubtful if one can fool the public for a long time in this way.

A problem with the above analysis is that we assume that the government can commit itself to a given rate of money growth for an infinite future. However, if this is credible, the government has an incentive to fool the public by increasing the rate of money growth for one period, thereby getting an extra revenue. If the public does not trust the government, the optimal rate of money growth might be less than what implied from the above analysis.

Figure 1.7: “Laffer-curve” for seignorage revenue

In the end, how large is actual seignorage revenue? For most industrialised countries the yearly revenue is about 0.5 per cent of GDP. In the case of Norway that would be about 500 million USD. In developing countries it can be much more of total government expenditure, however it reportedly rarely exceeds 5 per cent of GDP on a sustained basis.

The balance sheet of the central bank
The government is often seen as one entity in economic models. It should not matter that one public institution has a surplus on its books, if another public institution has a deficit. What matters are the net position over all government institutions. However, in monetary matters it is useful to distinguish between the “fiscal authority” and the “central bank”. In fact this distinction is artificial. As long as the central bank is publicly owned, it is part of the governments balance sheet. Money, a liability on the central bank, is at the same time a liability on the government. However, because money is so important for the workings of the modern economy, there tends to be a separation between government expenditure and the central bank. If there was no separation between the central bank and the government, the government would have two choices if it needed to finance a deficit: it could issue more money, or it could issue bonds.

An independent central bank is supposed to be a guarantee against monetary financing of public expenditure. However note that the distinction between issuing bonds and money is only a “veil”. If the central bank issues money to purchase government bonds, the two cases are exactly the same. In most advanced economies there is a tight wall separating the fiscal and monetary authorities. If the government uses money to finance public deficits, the money will lose value, and no longer fulfill its purposes as unit of account, means of payment and store of value. In the long term the cost of undermining the value of money exceeds the potential gains from financing public deficits by printing money. However, leading experts on monetary economics (like Michael Woodford) have argued that a target for inflation will only be credible if there is some target for public spending as well. Over time the one needs to see the government accounts from a consolidated standpoint—and one can not expect that the central bank balances its book if other parts of the government do not balance their books.

A central bank typically holds four types of assets. These are

1. claims on foreign entities, i.e. foreign currency, and foreign-currency-denominated bonds
2. gold (although the stock of gold has been reduced in the later years) and SDR’s (claims on the International Monetary Fund, so-called “paper gold”), and home-currency-denominated bonds.

On the liability side the central bank has two types of assets,

1. currency and
2. required reserves.

Required reserves are accounts domestic banks must hold in the central bank to be able to borrow money from the central bank. Currency plus required reserves make up what is called the “monetary base”. The
Some final remarks on the importance of money

In Lecture 1 we discussed the nature of money. The value of the currency we hold at a given point of time depends on how much we can purchase for this amount. If the price level increases, our currency loses value. The value of money depends on the price level. Currency is an asset whose level of return is given by inflation. The higher inflation, the lower the return on holding currency, as high inflation implies a falling value of your currency holdings. Several points were made in the first lecture:

- For all types of money, even for a commodity currency, there is a need for trust between the issuer of a currency and the holder of currency for the currency to be accepted.
- The Cagan model showed us that the trust in a currency depends on the future expected supply of the currency. This implies that money is an asset—its value depends on expectations of the future.
- Our example of seignorage revealed that a fiat currency is indeed only a product supplied by a monopolist. However, for this monopolist to maximise profit, given perfect foresight, there is an absolute limit to how fast money supply can grow. This limit depends on the semielasticity of money demand in expected inflation.

The value of money depend on the credibility of the issuer of money. In that respect money does not differ from other assets we are holding, like bank deposits, bonds or equity. However, why are money special? Two things make the credibility issue of special importance when we talk about money:

1. Money is one of the few assets that encompass the whole economy.
2. For many people money the only financial asset they hold. For them money is an asset with no alternatives.

For a large group of people, especially among the poor, financial markets are incomplete. Most important are perhaps that the poor have difficulties getting loans. This implies that they do not possess the credit necessary to buy e.g. their own home. For these people money or short term deposits are the only store of value. Further, almost all expenses are based on nominal prices. If prices rise very fast, wages tend to lag prices. At the same time their holdings of money are diminished by inflation. Loans are and real assets are both a hedge against inflation. Even though interest rise, the cost of a loan tends to fall if inflation is high, because a loan is fixed in nominal terms. The price of real assets should be expected to rise with inflation. The value of the holdings of money is however diminished by inflation. The problem of incomplete financial markets grows the less sophisticated the financial market is. One implication is that instability in the value of money might is especially costly in developing countries.

Introduction to a discussion on international money

In the first lecture we argued that the economy needed money; something that could work as a unit of account, means of payment, and also be a store of value. It was also pointed out that the value of money depended on the use of money. However, why are money national? There has always (i.e. as long as there has existed money) existed international money—means of payment accepted across borders. However, generally small change and money used in daily transactions have been national currency. That is probably a question of both trust, standards and, with the emergence of a national state, the ability of a government to impose a monopoly.

- If e.g. gold is used as a currency, everyone must agree on a weight unit if gold is going to work as a unit of account. However, weight measures have traditionally differed between countries.
- The value of money is a question of trust in the institution that has issued the money. Proximity traditionally increases the ability to trust.
- The revenue from seignorage has been an important factor when governments have imposed a state monopoly in currency issuance.

Would it be optimal to have only one currency? One has compared a currency to a language: the more people who use a language, the more useful does it get. But would it be optimal for everyone to speak the same language? In a world where communication is difficult, languages get specialised. Even if one starts up with one language, the different needs of different areas turn a common language into different dialects, and over time into distinct languages. In the current world, with easy communication over long distances a common language could probably be an option. However, is it optimal? Perhaps one would have created only...
one language if we could redraw the world from scratch. Given that multiple languages already exist it would probably not be optimal to impose one language on everyone. However, for international communication only a few languages are in fact actively used. These function as “international languages”. This is also the case with money: side by side there exists national currencies and international monies. In this lecture we will discuss what determines the use and value of currencies in international markets. How is the value of national currencies determined? How does monetary policy affect the value of an exchange rate? And what is the role of international money?

The relationship between the national currency and the international currency

In the last lecture we used the Cagan model to say something about the relationship between money and prices. However, one can also use the Cagan model to get an understanding of how the currency is priced in international markets. This is a starting point for our discussion of monetary policy and exchange rates.

A model of the exchange rate

We can use the Cagan model to derive a monetary model of the exchange rate. However, we want the model to be more general than the one we discussed in the first lecture, so we reintroduce nominal interest rates and real income in the equation. If we assume that expected inflation is low or non-existent, we can write the demand for real money balances on log-form as

\[ m_t - p_t = -\eta (\bar{y} + 1) + \phi_y q. \]  

(2.1)

Here \( i \) is the nominal interest rate 1 and \( y \) is real output. We want to find a link between the model of money and the exchange rate. Let us first define the exchange rate \( s \), as the price of one unit of foreign currency denominated in domestic currency. This is the standard denomination in most countries. It implies that

\[ e \cdot (\text{domestic currency}) = (\text{one unit foreign currency}). \]  

(2.2)

Note that seen from the point of view of the home country, a higher exchange rate implies that the home currency has depreciated, or has lost value. A higher exchange rate means that it takes more units of the home currency to buy one unit of the foreign currency. Similarly, a lower exchange rate implies an appreciation of the home currency. Also note that the log of \( s \) will have the label \( e \). To be able to say anything about an exchange rate we need to make two assumptions, linking the value of local money to the value of foreign money. If we shall be able to say something about relative prices we must assume

- free trade, and
- free capital mobility.

Unless these two requirements are fulfilled, the monetary model will not give a good empirical fit. However, what does these two assumptions imply for our model?

1. The assumption of free trade makes it possible to assume purchasing power parity, or PPP. PPP implies that the exchange rate between two countries shall equal the relative ratio of the price levels between two countries,

\[ P_t = e_t P^*_t. \]  

(2.3)

where \( s \) is the exchange rate and \( P^* \) is the foreign price level. On logs (2.3) can be expressed as

\[ \ln P_t = \ln e_t + P^*_t. \]  

(2.4)

The PPP states that the price level should be the same in all countries if prices are re-calculated to one currency. One way to look at this is through the “law of one price”. LOP states that if a good is priced differently in two countries, arbitrage would assure that the good is bought in the country where it is cheap, and transported to the country where it is expensive. Over time this should trade away the price difference. There is a number of problems concerning the PPP. Although the free trade of non-physical products, there are e.g. restrictions on the trade of labour, so one should assume it to be considerable price differences in labour intensive products. This is taken account of in the “Balassa-Samuelson-type” model, presented in your prior macro course. However, for the time being we assume the PPP to hold.

2. If markets are efficient, free capital mobility should assure that the return on capital assets are equalised between currencies. This relationship is formalised in the uncovered interest rate parity (UIP), that can be written as

\[ \frac{1 + i_{t+1}}{1 + i^*_t} = E_t \left( \frac{e_{t+1}}{e_t} \right). \]  

(2.5)

What does the UIP say? It states that the expected return on investment should be independent on the currency the bond is denominated in. If I hold NOK I should get the same return if I invested my money in a Norwegian bond, or if I exchanged NOK for EUR today, invested in a perfectly similar bond in the Euro zone, and exchanged back to NOK after the bond came up for payment. Why should this be so? In the UIP it is assumed that the UIP can be written as

\[ E_t = E_t e_{t+1} - e_t. \]  

(2.6)

Deriving the exchange rate

If we substitute equations (2.4) and (2.6) into equation (11.31) we obtain

\[ m_t - (p^*_t + e_t) = -\eta E_t e_{t+1} - e_t + \phi_y q. \]  

(2.7)

Again we assume perfect foresight, so that we can dispose of the expectation term. Then equation (2.7) can be rewritten as

\[ e_t = \frac{1}{1 + \eta} (m_t - \phi_y q + \eta (e_{t+1} - p^*_t) + \eta \phi_y q). \]  

(2.8)

If you remember back to lecture 1, you will see that this is the same difference equation as we derived in the stochastic Cagan hyperinflation model. The only change is that we have exchanged \( p \) with \( e \) and \( m \) with \( (m - \phi_y q + \eta (e_{t+1} - p^*_t) + \eta \phi_y q) \). In the same way as we solved for \( p \) in lecture 1 we can now solve for \( e \). The solution will be

\[ e_t = \frac{1}{1 + \eta} \left( \sum_{\tau = 0}^{\infty} \left( \frac{\eta}{1 + \eta} \right) \left( m_t - \phi_y q + \eta (e_{t+1} - p^*_t) + \eta \phi_y q \right) \right). \]  

(2.9)

As in the case of the solution for the price level we obtain two terms. The last term is a potential bubble term. A rational model with perfect foresight, and where the PPP and the UIP hold at every point of time is not enough to be certain that bubbles does not exist. However, it is usual to assume that

\[ \lim_{T \to \infty} \frac{e_t}{T} = 0. \]  

(2.10)

If so we can express the exchange rate as

\[ e_t = \frac{1}{1 + \eta} \left( \sum_{\tau = 0}^{\infty} \left( \frac{\eta}{1 + \eta} \right) \left( m_t - \phi_y q + \eta (e_{t+1} - p^*_t) + \eta \phi_y q \right) \right). \]  

(2.11)

We see that an increase in the money stock will lead to a higher exchange rate. In other words, an increase in the money stock leads to a depreciation as a higher rate implies that you must pay more for foreign currency because the local currency loses value. A lower money stock will imply a stronger exchange rate. Higher output will imply a stronger currency. However, if foreign interest rates rise, the currency will depreciate.

Implications

As we will later discuss, this model does not have a very good empirical fit in the short term. Whether this is due to

- the fact that the assumptions of free trade and free capital mobility do not hold,
- whether it is due to bubbles actually being a factor,
- whether it is due to public interference not captured in the model,
- whether we do not understand how expectations are formed, or
- whether markets are just as rational as this model assumes, is not easy to tell. These are important questions in current economic re-

However, a monetary model of this type is not an unreasonable approxi-

mation to the exchange rate in the long term. And there are several impor-

tant implications that can be derived from the monetary approach.

1. The exchange rate must be seen as an asset price—the exchange rate depends on the expectation of future variables. That is a very import-

tant finding. One should analyse the exchange rate in the same way as one analysis e.g. a stock or bond. In fact, we still know very little about how asset markets are actually priced. As we will find later in this course, this is also the case for exchange rates.

2. The exchange rate is determined by stocks, not flows. Up till the 1970’s most models of supply and demand in the FX market was based on a flow approach. Foreign exchange was seen as medium of exchange for executing international trade transactions. In this model the currency is
treated as an asset—something that is infinitely durable, which can be transferred but not destroyed. One important implication of this shift: 
- in the flow approach exchange rate movements are expected to be sluggish, as flow specifications would be slow to change,
- in the stock approach exchange rate movements are expected to be quick to reflect new information.

The last is clearly a better description of a floating exchange rate than the first.

3.It is important to distinguish between different types of shocks. The consequence of a temporary shift in a variable will differ from the consequence of a permanent shift. Likewise, the consequence of an anticipated shock will differ from the consequence of an unanticipated shock. In the last lecture we distinguished between an unexpected and expected shock. Let us see how a permanent shock will differ from a temporary shock. Let \( y, i \) and \( p \) all equal zero, and assume that there is no bubble. Assume that at time \( T \) the government announces a permanent change in the money supply. Then the exchange rate must rise equiportionate with the money stock, i.e.

\[
\begin{align*}
\pi_{t+1} &= \left\{ \begin{array}{ll}
\pi_t & t < T \\
\pi_m & t \geq T,
\end{array} \right. \quad (\pi_m > \pi_t)
\end{align*}
\]

implies that

\[
\begin{align*}
\epsilon_t &= \left\{ \begin{array}{ll}
\epsilon_t & t < T \\
\epsilon_m & t \geq T.
\end{array} \right. \quad (\epsilon_m > \epsilon_t)
\end{align*}
\]

Assume that at time \( T \) the government announces a temporary increase in the money supply. However, at \( T \) the money supply reverts to its level before \( T \):

\[
\begin{align*}
\pi_t &= \left\{ \begin{array}{ll}
\pi_t & t < T \\
\pi_m & t \geq T,
\end{array} \right. \quad (\pi_m > \pi_t)
\end{align*}
\]

We find that the path of the exchange rate becomes

\[
\epsilon_t = \left\{ \begin{array}{ll}
\epsilon_t & t < T \\
\epsilon_t - \frac{1}{\gamma} (\pi - \pi_m) & t \in (T, T'] \\
\epsilon_m & t > T.
\end{array} \right. \quad (\epsilon_m > \epsilon_t)
\]

The price level will make a jump in period \( T \). However, the jump will be less than if the shock was permanent. The exchange rate will then fall, just to reach its previous level at time \( T \). Both cases are illustrated in figure 2.1.

Figure 2.1: Temporary vs. permanent shock to the money supply

Choice of exchange rate regime
Let us assume two extreme cases.

1. The government fixes the exchange rate, i.e.

\[
\epsilon_{t+1} = \epsilon_t.
\]

For simplification we set \( s = 1 \), which implies \( e = 0 \) ⇒ \( p_t = p \) and

\[
\begin{align*}
t_{t+1} &= \phi_{t+1} + \phi_t.
\end{align*}
\]

It follows that

\[
\begin{align*}
t_t &= \phi_t - \eta \phi_{t+1} + \phi_t.
\end{align*}
\]

2. The government fixes the money supply. The money supply is the only variable the central banks can control directly in this system. Fixing the money supply is the most extreme example of an exogenous rule for money supply. For simplicity we assume the central banks sets \( m = 0.6 \). Using the equations above, we obtain that the exchange rate is given by

\[
\epsilon_t = \frac{1}{1 + \gamma} \sum_{k=0}^{\infty} (\eta \gamma)^k \left( -\phi y_t + \eta \phi_{t+1} - \epsilon_t^* \right).
\]

The central bank can not influence any of the variables in equation (11.43). This implies that the exchange rate become an endogenous variable—it is determined within the system. The exchange rate is outside the control of the central bank. The central bank can not control the money supply and the exchange rate at the same time.

The central bank and the supply of money
A choice of exchange rate regime is the same as a choice of a rule for money growth. But how do the central bank affect the money supply in the first place?

The balance sheet of the central bank
The government is often seen as one entity in economic models. It should not matter that one public institution has a surplus on its books, if another public institution has a deficit. What matters are the net position over all government institutions. However, in monetary matters it is useful to distinguish between the "fiscal authority" and the "central bank". In fact this distinction is artificial. As long as the central bank is publicly owned, it is part of the government balance sheet. Money, a liability on the central bank, is at the same time a liability on the government. However, because money is so important for the workings of the modern economy, there tends to be a separation between government expenditure and the central bank. If there was no separation between the central bank and the government, the government would have two choices if it needed to finance a deficit:
- it could issue more money, or
- it could issue bonds.

An independent central bank is supposed to be a guarantee against monetary financing of public expenditure. However note that the distinction between issuing bonds and money is only a "veil". If the central bank issues money to purchases government bonds, the two cases are exactly the same. In most advanced economies there is a tight wall separating the fiscal and monetary authorities. If the government uses money to finance public deficits, the money will lose value, and no longer fulfill its purposes as unit of account, means of payment and store of value. In the long term the cost of undermining the value of money exceeds the potential gains from financing public deficits by printing money. However, leading experts on monetary economics (Frankel and Woodford) have argued that a target for inflation will only be credible if there is some target for public spending as well. Over time the one needs to see the government accounts from a consolidated standpoint—and one can not expect that the central bank balances its book if other parts of the government do not balance their books.
A central bank typically holds four types of assets. These are:
- foreign currency,
- foreign-currency-denominated bonds,
- gold (although the stock of gold has been reduced in the later years) and
- SDR’s claims on the International Monetary Fund, so-called "paper gold”,
and home-currency-denominated bonds.

On the liability side the central bank has two types of assets,
1. currency
2. required reserves.

Figure 2.3: The balance sheet of the central bank

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net foreign-currency bonds</td>
<td>Monetary base</td>
</tr>
<tr>
<td>Net domestic-currency bonds</td>
<td>Net worth</td>
</tr>
<tr>
<td>Foreign money</td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td></td>
</tr>
</tbody>
</table>

Required reserves are accounts domestic banks must hold in the the central bank to be able to borrow money from the central bank. Currency plus required reserves make up what is called the “monetary base”. The liability side will also contain an accounting term, “net worth” to assure that the accounts balance. The balance sheet is presented in figure 2.3.

Central bank interventions
If the central bank wants to reduce the monetary base, it sells one of its assets to the public. When it wants to increase the money supply, it buys assets from the public. The central bank can adjust money supply in two ways:
1. it can intervene in the FX-market by buying or selling currency, or
2. it can change the short-term interest rates.

The first alternative implies a change in the holdings of the foreign currency denominated assets held by the central bank. The second alternative implies a change in some of the domestic currency denominated assets of the central bank. However, in theory these types of interventions are equivalent. To see this, remember that for every change made on the asset side of the central bank’s balance sheet, an equivalent change needs to make on the liability side. If the central bank intervenes in the FX-market by selling foreign currency, it must at the same time reduce its liabilities. So the stock of currency falls. This implies an increase in the interest rate.

Likewise, a change in the interest rate will be an indirect change in the money supply. When the central bank increases an interest rate it offers government bonds in the market at the new rate. When the central bank sells a bond, it gets domestic currency in return. The supply of domestic currency in the market will fall, and the supply of bonds will increase. The money supply will contract. In fact the central bank will not set an exact target for neither exchange rate nor money supply. In a fixed exchange rate regime the exchange rate will be allowed to fluctuate inside a defined target zone. If demand shift so much that the going rate will be at the boundary of the target zone, the central bank will adjust money supply to keep the exchange rate within the target zone.

In a inflation targeting regime the central bank will (indirectly) target the money supply. The money supply shall be kept inside a certain band, the central bank will no longer intervene in the markets because of fluctuations in the exchange rate. Rather it will intervene because of fluctuations in the money supply. The choice between an inflation target and an exchange rate target will therefore imply a choice between price volatility and exchange rate volatility.

Sterilised vs. unsterilised interventions
In the discussion above i assume that the central bank uses interventions to change the domestic money supply. Such an intervention will affect prices and interest rates. However, in many instances the central bank would like to influence the exchange rate without affecting prices and interest rates. A sterilised intervention means that while the central bank e.g. buy NOK in the foreign exchange market it will simultaneously buy bonds (or in the Norwegian case, something called F-loans). In other words, when the central bank reduces its holdings of foreign currency assets, it will at the same time increase its holdings of domestic currency assets. That way it leaves the total supply of NOK unaffected. However, in our model only an actual change in m can affect the exchange rate. In the monetary model presented above, sterilised interventions make no sense. Two reasons have been presented for why sterilised interventions might work:
1. Portfolio balance effects: if investors believe that foreign and domestic assets are imperfect substitutes, a change in the relative supply of foreign and domestic assets might have real effects.
2. Signaling: an intervention, even if it is sterilised, can signal to the market that the central bank believes the exchange rate to be out of bounds. Unless the market corrects this itself, the central bank might go in with real interventions in the future.

Economist often argue that the effect of sterilised interventions are low. However, central banks continue to use them. Making things even more curious, most interventions are done in secret, which should in fact reduce the signaling effect.

Appendix
Proof of equation (2.15).

\[
P_i = \frac{1}{1 + \eta} \left( \sum_{j} \left( \frac{\eta}{1 + \eta} \right)^{j} \right) \frac{m^{-}}{m^{+}} + \frac{1}{1 + \eta} \sum_{j} \left( \frac{\eta}{1 + \eta} \right)^{j} \frac{m^{-}}{m^{+}}
\]

\[
P_i = \frac{1}{1 + \eta} \left( \frac{1 - (\eta / (1 + \eta))^{T}}{1 - (\eta / (1 + \eta))} \right) \frac{m^{-}}{m^{+}} + \frac{1}{1 + \eta} \left( \sum_{j} \eta \left( \frac{\eta}{1 + \eta} \right)^{j} \sum_{i} \eta \left( \frac{\eta}{1 + \eta} \right)^{i} \right) \frac{m^{-}}{m^{+}}
\]

\[
P_i = \frac{1}{1 + \eta} \left( \left[ 1 + \eta \right]^{-1} - \left[ \left( 1 + \eta \right) \eta^{-1} \right] \left[ 1 + \eta \right]^{-1} \right) \frac{m^{-}}{m^{+}} + \frac{1}{1 + \eta} \left[ \left( \eta / (1 + \eta) \right)^{-1} \right] \frac{m^{-}}{m^{+}}
\]

\[
P_i = \frac{m^{-}}{m^{+}} - \left( \frac{\eta}{1 + \eta} \right)^{-1} \left( \frac{m^{-}}{m^{+}} \right)
\]
RELATING THE NATIONAL CURRENCY TO THE INTERNATIONAL CURRENCY MARKET

A country that wants to trade with an other country without adopting the other country’s currency, there needs to be some mechanism that assures that a currency can be used for international transactions. Most important, it must be some system for converting the local currency into the other currencies. The government has three measures to assure international convertibility.

1. It can use coercion or control—all trade with abroad must be approved, and conducted at a given rate. This was the system in Europe after the Second World War, in the Soviet Union and Eastern Europe until 1989, and is still the case in some developing countries.
2. It can commit to a certain fixed exchange rate, and guarantee that it will use all measures to defend that rate.
3. It can depend on the trust of the markets, and let the market set the rate.

If trade is severely restricted, coercion is the only way to assure some balance in currency flows. However, most developed economies allow a relatively high degree of free trade, which means that only a limited commitment and a free float. Classical economic doctrine argues that markets will give the optimal solution. However, for this to be true markets need to have a certain degree of sophistication and a sufficient number of participants to work effectively. If these requirements do not hold, markets can be manipulated. Whether this is a real problem in the FX-market is uncertain. But remember that the financial market of small and/or developing countries are often very small compared to the financial markets of large and/or developed countries. There are a number of American funds managers that control resources that exceeds the total Norwegian GDP—and measured in GDP Norway is a large country.

Second, and perhaps more important for political decision makers, open markets might imply serious limitations on the degrees of freedom in national policies, as the exchange rate is vulnerable to swings in the moods of market participants. This have lead governments to limit the mobility of capital. If capital flows are limited it is possible to achieve some degree of freedom in monetary policy at the same time as the exchange rate is fixed. This is because the UIP will not hold if capital can not move freely. However, most economist believe that it is impossible to have both an independent monetary policy, a fixed exchange rate and free mobility of capital at the same time. For the markets to work properly, the national economy must be developed and financial markets sufficiently sophisticated. In fact, the combination of a fiat currency and free convertibility was first introduced in the early 1970’s. Before that all forms of currency exchange across boarders had imposed either coercion or commitment to guarantee the value of the currency.

1. A short history of exchange rate regimes

The gold standard describes a system where national currencies were convertible to gold at fixed rates. This implied that the exchange rates were fixed as well. The gold standard was in existence from about 1870 to 1914, although it worked properly only in the first part of that period. This was a period with very strong commitment. Even if a “crisis” of some kind made a country unable to fulfill the requirements of the gold convertibility for a certain period, it was usual for governments to make a strong effort to return to the previous parity after the crisis had ended. At the same time it was little or no coercion, as there existed no limitations on capital flows.

During the First World War most countries abolished the convertibility to gold, and instead imposed strong coercion, as trade flows were restricted. After the war many countries attempted to return to their old parity values. However, as prices had risen quite extensively during the war, a return to parity implied that prices had to be deflated. This became a very costly affair for a number of countries. Norway included. Britain, the leading country in international relations up till the First World War, managed to restore the old parity in the late 1920’s, only to be forced of gold in 1931. Canada was soon followed by other countries. During the 1930’s many countries restricted the flow of goods, and limited trade to bilateral agreements. In 1944 a number of economists met at the Bank for International Settlements (BIS) in Basel. There it was worked out an agreement on how the exchange rate system should work after the war. To make a long history very short, the gold standard (where every currency was convertible into gold) was changed into a dollar- gold standard: all currencies was to be convertible into USD, and USD was to be convertible into gold at a given rate (USD 35 per ounce of gold). The International Monetary Fund (IMF) was founded to oversee the international currency system.

After the Second World War there was a large demand for investments in most European countries. At the same time many people had money they wanted to spend on luxury imports from abroad (i.e. the US). European governments were afraid that if they let people exchange home currency into USD without restrictions, to much of private spending would be used on the imports of luxury goods, and not enough on more important investment. It was therefore enforced quite strong restrictions on capital movements and the private exchange of currency.

In the end of the 1980’s EMS changed character. EMS was now described as the forunner to the future European currency union that was expected to be established some time during the 1990’s. As a first step in this process the flexibility in the EMS was reduced. From 1987 until 1992 the EMS worked as a pure fixed exchange rate system. However, in 1992 severe speculative attacks forced many countries to leave the EMS. Despite this seeming setback the process towards the EMU continued, and a common European currency with 11 (currently 12) members was established January 1, 1999. The national bills and coins where exchanged in the market. It only means that the currency cross ARP/USD will be fixed. The ARP will be floating with regard to all currencies that are floating with regard to the USD. E.g the ARP/EUR will be a floating rate, as the USD/EUR rate is floating.

One can describe seven different types of exchange rate regimes:
1. Floating rate.
   The central banks make no attempt to stabilise the exchange rate in the short run. (Examples: USD/EUR, JPY/USD)

2. Managed float.
   There is little attempt at the central bank to allow only to much fluctuation in the exchange rate. If the exchange deviates much from a target value, the central bank might make limited interventions, either in the form of managed floats, or in the form of direct currency interventions. (Example: NOK/ECU (1993-1998))

3. Multilateral exchange rate pegs.
   Several countries agree to stabilise their currencies against each other. The currencies shall fluctuate within predetermined bands. All countries retain an independent monetary policy. However, for the country to remain in the system, monetary policy must be adjusted according to the monetary policy of the system as a whole. Mostly a multilateral peg is dominated by a single country. The countries are obligated to support each other if there is a speculative attack. One country that wants to make an adjustment in its exchange rate, the other countries in the system must be informed in advance. (Example: the European Monetary System (EMS)—European currencies were stabilised against ECU)

4. Unilateral peg.
   One country fixes its currency to some other currency. There is no obligation from the other country with regard to interventions. (Example: NOK/US Dollar from 1990 to 1992).
   However, more often a country fixes the value of its currency to a “currency basket”—an index value of several currencies. The basket weightings are often based on the composition of trading partners. (Example: NOK, SEK and FIM in the 1980's)

5. Currency board.
   The currency is fixed completely to the value of another currency. There is no allowance for a target zone as in a multi- or unilateral peg. The central bank promises to exchange the local currency into the foreign currency at the fixed rate, and must have sufficient reserves to make this promise credible. There is no longer an independent monetary policy. The only role of the central bank is to adjust the level of reserves to assure that the foreign currency is held at every point of time. The central bank can no longer adjust the money stock in periods of e.g. banking crises, and can therefore no longer work as credible lender of last resort. A speculative attack against a currency board can therefore often take the face of a speculative attack against banks (as in e.g. Argentina).

6. Dollarisation.
   The local economy adopts a foreign currency as its own. All local currency must be exchanged at a given rate, and de-structured. All contracts must be re-denominated in the foreign currency. There is no central bank in the sense of a monetary authority. All mon- etary policy is made in the country of the adopted currency, without considerasion for local needs. (Examples: Ecuador and Panama have adopted the USD. The Yugoslav province of Montenegro has adopted the EUR.)

7. Currency unions.
   Several countries come together and create a com- mon currency. A new central bank is created. Monetary policy is to be adjusted for the best of the currency union as a whole. (Example: EMU).
   Note that the distinctions between these groups are not strict. Even in a floating currency like the USD monetary authorities will from time to time make interventions to adjust what is perceived as an “extreme misalignments”. One example is the so called Louvre Accord in 1985 when the G-7 agreed that the USD was overvalued. In the following months the USD depreciated extensively. A currency board will often be followed by dollarisation of much of the economy. There will almost always remain uncertainty about the long-term prospects of the board. Many will therefore chose to use foreign currency instead of the home currency as a store of value.

If any exchange rate peg shall be successful, one must keep the inflation close to the inflation in country to which the currency is targeted. In shorter periods, an exchange rate peg can survive even if monetary policy is not fixed. In the long run a fixed exchange rate does demand a common monetary policy. As most exchange rate pegs are in reality unilateral, that will normally imply that the smaller country must adopt the monetary policy of the larger country if a fixed currency shall be credible. Over longer periods of time this only observed in every few cases. The Austrian peg to DEM is one of a few such instances. Obstfeld and Rogoff (1995) find that only a few so-called fixed exchange rates indeed had been fixed for more than 10 years. Unilateral exchange rate system will generally by unstable, as a fixed exchange rate by definition demands some sort of common monetary policy. This is first solved if the unilateral system evolves into a currency union.

Optimal currency areas

Lack of credibility has made governments turn to fixed exchange rates to assure convertibility. However, a fixed exchange rate might leave the open for sudden adjustments, so-called currency crises (to which we return in the next lecture). Although day-to-day volatility is less than in a flexible regime, the volatility that one might have to leave the exchange rate system at some time. This leaves us with the question of why a country needs an independent currency at all. In general one would at least keep a currency area as large as the area of political independence—i.e. an optimal currency area will at least contain the national borders of one country. That is not to say that the borders of this “optimal area” necessarily implies the political borders.

From the OCA theory it might well be that e.g. the US should have more than one currency. In practice political realities always overrule the OCA-theory.

If multinational organisations get a strong hand in national decision making one can extend the optimal currency area to the whole (or parts of) the organisation, as has been done in the EU through the European Monetary Union, EMU. The main benefits of entering a common currency area have been listed to be that a currency union
- reduce transaction costs from currency conversion
- reduce accounting costs and give greater predictability of relative prices for firms doing business with firms in the other countries of the currency area
- if prices are sticky, from monetary disturbances that could affect real exchange rates, and
- reduce political pressure for trade protection based on swings in the exchange rate.

For a small open economy the first two points are probably the most important. The potential costs of joining an optimal currency area include to
- forgo the possibility to use monetary policy to respond to regional specific real shocks.
- remember that if prices are sticky, the money supply is endogenous. It can no longer be adjusted by the government.
- further, one can no longer influence fiscal policy or increase revenues by extracting more seignorage.

In the end the choice of the size of currency unions remains a political one. The more integrated an area is, the less will the costs of a common currency be, and the higher will the potential gains be. However, areas that are highly integrated economically, are also often naturally integrated in other dimensions as well. How integrated an area needs to be for a currency union to work is uncertain. However, with increasing ease of communication, many of the traditional arguments for national currencies disappear. There is for example difficult to see why the citizens of EMU should trust the ECB less than they trusted their former central banks.

The death of fixed exchange rates?

To assure an efficient flow of trade it is necessary that there is some sort of convertibility between the national currency and the international currency. If the national currency is not accepted abroad the country reverts to defacto barter trade. This is the case for e.g. North Korea. Almost all trade with North Korea is in the form of bilateral trade agreements—North Korea gets a certain amount of one good against the delivery of a certain amount of North Korean goods. Until the early 1970’s it was accepted that to assure growth in trade there had to some sort of fixed value of the currencies to avoid to much uncertainty. The actual experience after 1970, with more liberalised capital flows, has shown us that floating exchange rates, although volatile, does not seem to be destabi- lising for world trade nor financial flows as long as there is sufficient trust in the governments issuing the currencies. For most developed countries a floating exchange rate does not seem to reduce national welfare.

With free capital flows speculative attacks cause abrupt adjustments in fixed exchange rates. These adjustments might be very destabilising. Many economist argue that the danger of such adjustments make fixed exchange rates very unfortunate. A popular argument today is that one no longer can make a unilateral decision to peg a currency. According to this argument, there is only two options:
   a. to float, or
   b. to “super-fix” the exchange rate, either through a currency board, dol- larisation or by joining a currency union.

This view is captured by the following quote made by then U.S. Secretary of the Treasury, Larry Summers in 2000:

“[f]or economies with access to international capital markets, [the choice of the appropriate exchange rate regime] increasingly means a move away from the middle ground of fixed but adjustable rates toward the corner regimes of either flexible exchange rates, or a fixed exchange rate supported, if necessary, by a commitment to give up altogether an independent monetary policy. ... [This policy prescription] probably has less to do with Robert Mundell’s traditional optimal currency areas considera- tions than with a country’s capacity to operate a discretionary monetary policy in a way that will reduce rather than increase the variance in economic output.”

From a historical perspective this view seems to be based more on a dis- torted view of what are the distortions—like pegged-but-adjustable rates or managed floats, than the historical merits of either of the two corners. In fact, there are only a small number of countries that

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have attempted to “super fix” their exchange rate. Likewise, with the recent exception of Mexico, one has no good example of a developing market with a long experience of a floating exchange rate.

The super-fixed exchange rate
A super fixed exchange rate includes a currency board and dollarisation. Super-porters of super-fixed exchange rates have argued that these arrangements provide

- credibility,
- transparency,
- very low inflation, and
- financial stability.

In addition, as in principle a super-fixed rate should reduce the risk of speculation and devaluation, domestic interest rates should be lower than under alternative regimes. The argument in favour of a super-fixed exchange rate is made even stronger if one can argue that there is a correlation between country risk and currency risk. Country risk is the risk of investing in a given country. This can be measured as the premium on long-term domestic government bonds relative to foreign government bonds. Country risk should, among other things depend on the long-term prospects of a country. Currency risk is the risk of devaluation. This can, assuming the UIP to hold, be measured as the premium on short-term domestic interest rates over foreign short-term interest rates. The argument is that a stable exchange rate results in an environment that is more conducive to long-term growth. So low currency risk should lead to lower country risk. As can be seen from figure 3.2, it does seem to be a relationship between these two measures in the case of Argentina. However, several things must be in place for a super-fixed rate to be credible.

a. Fiscal solvency. In a super-fixed rate regime the government can no longer reduce the burden of public debt through inflation. This increases the need for fiscal responsibility. Also, as monetary policy can not be used for stabilisation purposes, there must be in place an ability to run counter-cyclical fiscal policy.

b. The lender of last resort function, which under flexible and pegged-but-adjustable regimes is provided by the central bank, has to be delegated to some other institution. This can either be a consortium of foreign banks or some international organisation.

c. Related to the point above, there is a need for a very solid domestic banking sector, as the lender of last resort function will not function properly.

d. A currency board requires that the central bank holds enough reserves, an amount that in fact will exceed the monetary base.

For a super-fixed exchange rate to succeed, all the above points need to be satisfied. However, even then super-fixed regime will not be without problems. There will always remain the possibility of a regime switch. If the cost of the regime increases, e.g. due to an external shock, this can create uncertainty about the future of the regime. If investors start to move money out, domestic interest rates will increase, thereby further increasing the cost of maintaining a fixed regime.

Argentina adopted a currency board early in 1991. At that point the Argentinean peso had lost confidence. In the late 1980’s the USD had become the de facto unit of account. For many types of purchases the USD worked as means of payment as well. The currency board fixed the exchange rate between ARP and USD at 1:1. The currency risk from 1993 to 1999 is illustrated in figure 3.3. In the early years of the board, Argentina inflation exceeded US inflation, leading to a real appreciation at the the ARP. Argentina was hit hard by the ripple effects of the Mexican devaluation (the “Tequila-crisis”) in late 1994. However, as the board

At no time did expectations of devaluation disappear completely. The result was a certain interest differential between the ARP and the USD. One implication was that Argentines have to choose to deposit money as ARP—as ARP’s got the highest interest rate. However, if they borrowed money, they borrowed USD, as the interest rate in USD was lower. This made the banking sector very vulnerable to the effects of a change in the currency board. So what happened in Argentina? We will return to that question in the next lecture. Argentina’s government did fulfill most requirements of a stable currency board. However, they evidently failed on two important accounts: it was not able to get full control of fiscal policy, and it was never able to remove all doubts about the long term viability of the regime, not even among their own people. In the end these two things terminated the regime.
The floating exchange rate?
If a super-fixed regime is so difficult to achieve, a floating exchange rate remains the alternative. Table 3.5 shows that over the last twenty years more and more countries have chosen managed or flexible exchange rate regime instead of a regime with an exchange rate peg or limited flexibility. However, recent empirical studies show that this apparent “floating” of exchange rates might not be as clear cut as the IMF data suggests. In fact, to find that most developing countries that claim to have a float or a managed float do not let their exchange rate fluctuate much outside a band of ±2.5 per cent—equivalent to pegged regime. This is even true for a number of industrialised countries including, until recently, Norway. Floating regimes resemble non-credible pegs—observation Calvo and Reinhart attributes to a “fear of floating”.

Why should there be a fear of floating in emerging markets? This can probably be attributed to a lack of credibility.
- A fixed exchange rate provides a more clear-cut nominal anchor, as the exchange rate is observable today. An inflation target will depend on expectations about future inflation rates—and if credibility is low this might result in higher interest rate volatility.
- In emerging markets debts are often denominated in foreign currency. Large swings in exchange rates might impair the access to financial markets. Sharp depreciations can be very expensive as the cost of servicing debt rises.
- The pass through from exchange rates to inflation is traditionally higher in emerging markets than in developed markets.

Figure 3.6: Exchange rate volatility in recent of current “floating” exchange rate regimes

<table>
<thead>
<tr>
<th>Year</th>
<th>Peg</th>
<th>Limited flexibility</th>
<th>Managed</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>97.2</td>
<td>0.6</td>
<td>1.2</td>
<td>2.8</td>
</tr>
<tr>
<td>1975</td>
<td>63.9</td>
<td>11.1</td>
<td>13.9</td>
<td>11.1</td>
</tr>
<tr>
<td>1980</td>
<td>38.9</td>
<td>5.6</td>
<td>47.2</td>
<td>8.3</td>
</tr>
<tr>
<td>1985</td>
<td>33.3</td>
<td>5.6</td>
<td>36.1</td>
<td>25.0</td>
</tr>
<tr>
<td>1990</td>
<td>19.4</td>
<td>13.9</td>
<td>30.6</td>
<td>36.1</td>
</tr>
<tr>
<td>1995</td>
<td>13.0</td>
<td>8.3</td>
<td>38.9</td>
<td>38.9</td>
</tr>
<tr>
<td>1999</td>
<td>11.1</td>
<td>11.1</td>
<td>33.3</td>
<td>44.5</td>
</tr>
</tbody>
</table>

Why a fixed exchange rate system might be unstable
As we seen in the above discussion, there are benefits and costs of having a fixed exchange rate. However, even if a fixed exchange rate seems like an optimal solution, it is difficult to retain a stable exchange rate. As we have noted, few exchange rates remain fixed for a long period of time. The n-1 problem illustrates a problem that occurs if two countries fix their common exchange rate. A fixed exchange rate implies that if one country changes its money supply, the other country must do so as well if the fixed exchange rate shall survive. The second problem occurs when different shocks implies different policy strategies in the two countries. The third problem occurs because the two governments might have different goals for their monetary policy.

The n-1 problem
In the last lecture we found that if the exchange rate was fixed, money supply would be determined by real output, the foreign interest rate and the foreign price level:

$$m_t - p_t = \sigma - \delta q_{t+1} + \varphi y_{t+1}$$

(3.1)

The central bank must adjust the money supply to assure that equation (3.1) hold. In a unilateral exchange rate regime the country that fixes its exchange rate will take the interest rate and the price level in the other country as given. However, in a bilateral fixed exchange rate regime this becomes more tricky. The fixed exchange rate determines the ratio of the money stocks in the two countries, but not the level of the money stock. Either the two countries must agree on how the money stock shall be determined, or one country must accept the money stock set by the other country.

To see this we can use the following example. From the UIP we know that if exchange rates are fixed between two countries, the nominal interest rate must be the same in both countries. From the real money demand functions discussed in the Cagan model we know that there is a relationship between the interest rate and the money stock. For every level of the money stock there will be a certain interest rate. We illustrate this relationship in figure 3.8. If we have a fixed exchange rate, and the UIP hold, then the following relationship must hold: if the interest rate in the foreign country fall because the foreign country increases the money stock, then the domestic interest rate must fall as well. This can only be achieved by increasing the money stock in the home country. So a change in the money stock of one country must imply a similar change in the money stock of the second country. This is the n-1 problem. One has two countries, but only one exchange rate. The basis of a multilateral exchange rate agreement is that the two countries agree on how interest rates and money stocks shall be set. However, often a multilateral fixed exchange rate regime is containing developing countries, and some western economists as well, are in support of more fixed rates. As an example, several Asian countries have recently signed agreements to secure common interventions in the case of speculative attacks—certainly not what one would do in a floating exchange rate regime. For many countries some sort of fixed exchange rate regime is still the only option for gaining credibility in their monetary policies.
countries that are not willing to compromise their opinion of what is the optimal money supply. If the two countries can not agree, the fixed exchange rate will break down. Most fixed exchange rate systems has a de facto “base country” that is supposed to work as a “nominal anchor”—i.e. set the money stock. In the Bretton Woods the US was the base country. In the European Monetary System (EMS) Germany was the base country. In both cases this worked fine as long as the interests of the base country were the same as the interest of the countries who took part in the exchange rate system. However, in both instances situations occurred when that were no longer the case.

The breakdown of Bretton Woods

In the end of the 1960’s the USA were running considerable trade deficits. To maintain a country a trade deficit, we must expect the currency to be over-valued. As the exchange rate was fixed, an overvaluation can be alleviated either through deflation in the home country or by inflation abroad. According to the rules of the Bretton Woods system such deficits should not cause a problem to the exchange rate. The process was supposed to proceed as follows: if a country was running a trade deficit, there is increased demand for foreign currency in the home country. To meet this demand for foreign currency, the local central bank must set foreign exchange reserves. When the foreign exchange reserves are reduced, this should cause a proportionate change in the money base. When the money base is reduced the local price level shall fall. A falling price level will reduce the overvaluation. Over time the trade deficit will disappear.

A trade deficit in one country should be reflected in a trade surplus in another country. The country with a trade surplus will experience excess demand for the domestic currency. This will imply that the central bank increases its holdings of foreign reserves. An increase in the holdings of foreign reserves should imply an increase in the money base, and a rise in the domestic price level. The real exchange rate should appreciate.

The US experienced a an increase in home demand mainly due to the welfare reforms conducted under the Johnson administration, and due to the increasing costs of the Vietnam war. The US government financed its public deficit by printing more money. This money was used to purchase goods abroad. To reduce the money base would reduce the US ability to run a public deficit. The US administration was not interested in paying such a cost.

The countries running trade surpluses were countries like Germany, Japan and Switzerland. The US money stock had increased. To alleviate the misalignments in the system, these countries had to allow their money stocks to increase as well. However, a country like Germany was not interested in importing US inflation. When the demand for DEM increased, the Bundesbank chose to sterilise the increase in its currency reserves. At the same time as currency reserves rose, it sold domestic bonds. This way the German money base remained stable. However, at the same time the automatic stabilisation in the Bretton Woods system broke down.

The real problem here was perhaps not that Germany did not want to import inflation. In fact, the Bretton Woods system was supposed to include an additional check to assure that the US should use its all important position to impose inflation on other countries. Remember that the USD was fixed to gold at the rate of US$ 35 per ounce of gold. If the holdings of USD increased to much, central banks in other countries was supposed to bring these dollars to the Federal Reserve and claim gold in return. Doing so, they would reduce the asset holdings of the Federal Reserve. The Federal Reserve was supposed to react to such claims by reducing the money base.

However, the most important holders of excess USD reserves, Japan and Germany, chose not to do this. The reason was that both countries depended on the US for both political and military reasons. They did not want to endanger these relationships by forcing the US to reduce its money supply. The only country that to some degree did claim gold for USD was France. Over time it became “evident” to speculators that countries like Germany, Japan and Switzerland rather would revalue their exchange rates at a new level than stay at a fixed level with an increased money stock. At this time speculators started to move from USD to DEM, CHF and JPY. As no country was willing to compromise about the optimal money supply in the Bretton Woods system, the system was posed to break down. In early September 1971 US president Richard Nixon declared that the US was no longer committed to fixed parity between USD and gold. With this declaration the Bretton Woods system was de facto dead.

US money supply increased as a result of more public spending, due to welfare reforms and the Vietnam war.

The adjustment problem

The point is this: If a country has a fixed exchange rate, it can not use monetary policy for stabilising the economy. However, assume that there is a shock to only one of the countries in the exchange rate mechanism. Then the government must make a choice. Either it can use fiscal policy to stabilise the economy, or it can leave the fixed exchange rate and use monetary policy. Why might it choose the last strategy?

A money supply shock in the US increases demand for DEM. To hold the exchange rate within the target zone Germany has two alternatives: exchange USD-reserves for gold, and thereby contract the US money supply (however this was not politically feasible), or increase their own money supply (which they did not want to do, as this would imply importing US inflation to Germany).

There will be a cost of leaving a fixed exchange rate. E.g. the government might loose credibility if it wants to go back to a fixed exchange rate at a later stage. However, there might also be a cost of not using monetary policy for stabilisation. This will especially the case if prices and wages are sticky—i.e. that they adjust only slowly. Example: Assume that the cost of producing in the home country increases. This might e.g. be due to a restriction of working hours that have a negative effect on labour productivity. Implicitly this is a wage shock that will affect the domestic price level. If the domestic price level increases, Q will fall. The country experiences a real appreciation. A real appreciation implies that domestic goods are less competitive on international markets. This will have a real economic cost. However, to alleviate the real appreciation the government has two choices:

1. It can force the price level down, or
2. It can devalue the nominal exchange rate.

The last option will however imply a break with the fixed exchange rate policy. Why would a government choose this option over the option of devaluing the economy? In fact it is very difficult to impose a downward change in wages. It is also a process that might take a very long time, as most wages are set by long term contracts. By devaluing the exchange rate home goods will become cheaper abroad over night, without lowering wages at home. One should however note that the purchasing power of...
home wages of course will fall—as imports become more expensive. Note that if the shock is symmetric, i.e. both countries in the system get the same shock, monetary policy can be used for adjustment. Both countries now have incentive to move the money supply in the same direction. This can be done without affecting the fixed exchange rate. Remember that the fixed exchange rate can be sustained for an infinite number of different money supplies, but only for one ratio of home money over foreign money. However, in this case the real exchange rate will of course not be affected.

The problem of a credible policy—the Barro Gordon model

From your former lessons in macro, you know the concept of a Phillips curve. The Phillips curve implies a relationship between unemployment and inflation. In "modern macroeconomics" one thinks about the Phillips curve as a fluctuations around a "non-accelerating-inflation-rate-of-unemployment" (the NAIRU). The NAIRU is seen as the long-run rate of unemployment. In the short term unemployment can be higher or lower than the NAIRU, depending on whether inflation is higher or lower than expected inflation. If we call unemployment for u, the NAIRU for un and inflation for π, and we let ne be expected inflation, we can express the Phillips curve as

\[ u = \pi + \alpha(\pi^e - \pi) \]  

(3.2)

If inflation exceeds expected inflation, the unemployment rate can be higher than the NAIRU. However, one can not expect inflation to exceed expected inflation over time. We assume that the government has two policy goals: to keep inflation stable, and to keep unemployment low. In fact, the government has as a goal to keep unemployment at a level u < un. This can be rationalised if we think there are some sort of inefficiencies in the labour market that lead to an increase in the NAIRU rate. As a second best policy the government target an unemployment rate below the NAIRU. We specifically assume that

\[ u^* = \sigma u_n \]  

(3.3)

where 0 < σ < 1. The government minimises a loss function, L, that contains these two elements:

\[ L = \pi^2 + b(u - u^*)^2 \]  

(3.4)

where b (assumed to be > 0) is the weight on holding unemployment at u*. If we substitute in for the equations (11.85) and (11.86), we obtain

\[ L = \pi^2 + b(1 - \sigma)u_n + a(\pi^e - \pi)^2 \]  

(3.5)

The government want to set inflation such that it minimises the value of L. To do so we must take the derivative of L with regard to π, and set equal to zero. This gives us

\[ \frac{\delta L}{\delta \pi} = 2\pi - 2\alpha b(1 - \sigma)u_n + a(\pi^e - \pi) = 0 \]  

(3.6)

If we solve with regard to π we get

\[ \pi^mm = \frac{ab(1 - \sigma)u_n}{1 + ba^2} + \frac{ba^2\pi^e}{1 + ba^2} \]  

(3.7)

Assume that the government set π = 0, and that this is fully credible (the public believes the government, so that ne = 0 as well). The the loss would be

\[ L = b(1 - \sigma)u_n^2 \]  

(3.8)

However, if ne = 0 we know that the optimal inflation rate from the point of view of the government would be

\[ \pi = \frac{ab(1 - \sigma)u_n}{1 + ba^2} \]  

(3.9)

which would give a loss of

\[ L = \frac{1}{1 + ba^2}b(1 - \sigma)u_n^2 \]  

(3.10)

One can show that

\[ b[(1 - \sigma)u_n^2]^2 > \frac{1}{1 + ba^2}b[(1 - \sigma)u_n^2]^2 \]  

(3.11)

for all values of b > 0. So, in a one period game—if the government only cares about today, and not about the future, it will always be rational for the government to try to fool the public by setting inflation higher than they expect. However, if the public have rational expectations they will look through this strategy. In fact the public will understand which inflation rate will minimise the loss of the government, and expect this inflation rate. Indeed, equilibrium if we assume rational expectations must be that nopt = ne. We therefore know that

\[ \pi = \frac{ab(1 - \sigma)u_n}{1 + ba^2} + \frac{ba^2\pi^e}{1 + ba^2} \]  

(3.12)

which implies that the equilibrium rate of inflation will be

\[ \pi^e - \pi = ab(1 - \sigma)u_n \]  

(3.13)

This will give the government a loss of

\[ L = ab(1 - \sigma)u_n^2 + b(1 - \sigma)u_n^2 > b(1 - \sigma)u_n^2 \]  

(3.14)

The government will in other words be worse of than if it could follow a credible policy of no inflation. However, it can not, because if a zero inflation policy is indeed credible, the government has incentive to cheat by setting inflation above zero for one period. The government is not able to tie itself to the mast. How should this affect a fixed exchange rate regime? Assume that country A (e.g. Norway) has fixed its exchange rate to country B (e.g. Germany), and that Germany follows a "zero inflation" policy. That is, Germany has a btt = 0. If we assume the PPP to hold, the results from the Cagan model implies that Norway must follow a zero inflation policy too. However, if the Norwegian government has a bN > 0, such a policy will not be credible for Norway.

Appendix: The real exchange rate

One reason why exchange rates are important for international trade is that they are closely related to the real relative price of foreign goods. For example, let P be the price, in foreign currency, of a bushel of foreign wheat, and let P = the dollar price of a bushel of domestic wheat. We assume that the quality of foreign and domestic wheat is the same. Which good is more expensive? The relative price of foreign to domestic wheat is the ratio

\[ Q = \frac{P^*}{P} \]  

(3.15)

This makes sense. P* is the price of foreign wheat, and s is the domestic price of foreign currency, so sP* must be the price of foreign wheat in domestic currency. We then find the relative price by taking the ratio. Q is often referred to as the real exchange rate. This is another way of saying 'relative price of imports'. Also, in practice we often use prices of larger baskets of goods, such as the country specific CPIs, to form the relative price. Loosely speaking, the real exchange rate indicates how competitively priced foreign goods are in terms of domestic goods: higher relative exchange rates tend to make a country’s exports more attractive on world markets.

If you think domestic and foreign goods are very similar, and that there are relatively few barriers to trade it is reasonable to expect little variation in the real exchange rate. The extreme case is to assume Q = 1. To see why this is reasonable, assume that Q < 1. This implies that imported goods are less costly than domestic goods. Consumers will therefore tend to purchase foreign goods, creating a downward pressure on either (or both) the price of domestic goods or the value of the domestic currency, until Q = 1. In other words, prices of common goods should, expressed in units of a common currency, be the same. When we talk about one good, price equalisation is called the law of one price. When we talk about basket of goods, we call this assumption purchasing power parity, PPP. Remember that when we defined PPP in lecture 2 as

\[ \hat{e} = \frac{P}{P^*} \]  

(3.16)

we implicitly assumed that Q = 1.

Although in theory a fixed exchange rate can only be viable if the PPP holds, in practice on will find that the PPP does not hold exactly all the time. More specifically, if shocks differ between countries, Q might at any point of time be bigger or smaller than one. If Q exceeds one, domestic goods improve their competitiveness abroad, and we should expect that there evolves a trade surplus. If Q < 1, domestic goods have lost competitiveness abroad, and the country should turn to trade deficit.
CHAPTER 4
CURRENCY RISES

Introduction

Some definitions:
A “devaluation” is the move taken by the government to change the target value of the fixed exchange rate regime to a weaker (higher) exchange rate. A “revaluation” is the move taken by the government to change the target value of the fixed exchange rate regime to a stronger (lower) exchange rate.

A speculative attack is a situation where a large number of market participants go “one way” in the market—all participants either sell or buy the asset. In a speculative attack on a fixed exchange rate the central bank is obliged to stand as counter party to all transactions within the target zone, unless someone else takes the deal. The central bank will either do so by intervening in the markets directly, or by changing interest rates.

Speculative attacks are a problem especially when interest rates increase the cost of speculation. When (if) the central banks pulls out the price of the asset will fall (or rise). Often a period of turbulence occurs before a new equilibrium is established.

A “currency crisis” is a situation where a speculative attack forces the central bank to make a change in the fixed exchange rate not actually intended by the central bank.

What is the difference between a “controlled” change in the exchange rate and a currency crisis? If the markets believe that the central bank will change the target rate, rational investors would only trade on one side of the markets—i.e. behave like in a speculative attack. The central bank has incentive to present this as if it was forced to abandon the fixed exchange rate. Through its own behavior actually caused the markets to behave as they did. Note that a currency crisis might occur even if the exchange rate is not fixed. If the markets bring forth a large change in a floating exchange rate over a short period of time, the central bank will be expected to intervene, as large changes in an exchange rate might destabilize financial markets. The inability of the central bank to keep the exchange rate at the wanted target can be considered a “currency crisis”, even if it does not induce a formal devaluation.

There are three sides to all currency crisis: the government, investors with liquid assets and investors with illiquid assets. For the government, a currency crisis is a question of credibility, of flexibility in political decision making and about a possible fallout because of negative implications of a sudden change in the exchange rate. For a liquid, well informed investor a currency crisis is a question of potential financial gains. The illiquid investors are the most vulnerable to currency crisis. They might not have the financial strength to diversify investments, or they might be contained to long term contracts. Further, these investors also tend to be smaller and perhaps less informed than the liquid investors. The presence of illiquid investors is especially a problem in countries with underdeveloped financial markets. In this lecture we will discuss the interaction between government incen-
tives and the behavior of the markets, by which we mean the liquid investors. We will return to issue of the illiquid investors in the last part of the course.

Speculative attacks

In the last lecture we discussed three reasons for why a fixed exchange rate might break down. They were all based on the fact that in a fixed exchange rate system monetary policy is outside the full control of the central bank. Changes in the money supply must be symmetric between the countries involved in the system. If optimal policy makes for asymmetric monetary policy, a fixed exchange rate is not sustainable.

1. The n-1 problem: the countries involved can not agree on a proper rate of growth in the money supply.
2. The adjustment problem: if we have asymmetric shocks and sticky prices, it might be optimal with leave the fixed rate regime.
3. The credibility problem: a fix is not sustainable if the governments involved have different loss functions, i.e. they care about different things.

If these were all the reasons why fixed exchange rate systems broke down, one should expect that governments chose to leave such systems by purpose. However, countries often first leave a fixed exchange rate system after a “speculative attack”, an event where the whole market has sold the currency to the central bank because everyone believes that the central bank soon will break its promise of a fixed rate.

An example of this is the EMS-crisis in 1992-93. After 1990 the countries in the European Monetary System had attempted to limit fluctuations in their exchange rates more actively—they had agreed on a less lenient use of the escape clause. Some countries outside the EMS, as Norway, Sweden and Finland also attempted to fix their currencies closer to the ECU. In the August of 1992 the currencies came under great stress. First, investors sold ITL and FIM. Both countries choose to devalue (or more exact—they let the value of the currency float). In early September Great Britain left the EMS. This attack is famous for the role of George Soros. His Quantum Funds is said to have increased its value with 25 per cent due to exchange rate movements in the fall of 1992. The speculators then turned to Scandinavia. Sweden came under pressure. However, the Swedish government, eager to build credibility in a new monetary policy, attempted to defend the exchange rate by rising over night interest rates to 500 per cent. This policy was not sustainable, and when the rates came down the attack continued. In November Sweden devalued. Norway devalued in December after heavy interventions.

In a fixed exchange rate regime the central bank has promised to buy and sell the currency at specified levels. The distance between the sell and buy price will be the “target zone”, the room for fluctuations in the exchange rate. The target zone is usually about +/- 2.5 per cent around the stated “fixed rate”. However, a central bank can only buy the local currency in exchange for foreign currency as long as it has foreign reserves available.

In theory it can borrow reserves for interventions. However, one rarely sees this in practice. If the level of reserves become too low, the cost of standing by the promise of a fixed exchange rate might become to expensive—and the currency is devalued.

There has been much effort to understand the nature of speculative at-
tacks. Some of what we know about speculative attacks can be summarised in these points:

From the “first-generation model” (the Krugman model), we have that:
- A currency crisis will occur if the “shadow exchange rate”—the exchange rate that would have been if the rate was floating—is sufficiently different from the fixed rate ⇒ there must be some relationship between the fixed rate and a “fundamentally sound” rate:
- If there are any kind of “trend” that will affect the shadow ex-
change rate the timing of an attack can be calculated. The time will be independent of “news”—it will only be a function of the rate of growth in the trend and how this affects the shadow ex-
change rate.

If there is no trend affecting the shadow rate, the shadow rate might still fluctuate due to shocks.
- If fundamentals are very strong (the shock is weak) the govern-
ment will probably defend the currency no matter what.
- If fundamentals are very weak (the shock is strong) the govern-
ment will probably choose to devalue anyway.
- Between these levels there will be a “window of uncertainty”. For a speculative attack to occur in this window, a sufficient number of speculators must believe in a crisis at the same time. If only a few investors speculate against the currency, they might lose money. For a speculative attack to succeed many investors must act simultaneously.

This is the so-called “second generation model”, or the “Obstfeld model”. In this case speculation can cause a devaluation even if the government did not intend to devalue if there had been no speculation. In the last couple
of years (after the Asian crisis) new questions have been raised. Originally a trend that affected the shadow rate, as described in the Krugman model, was understood as growth in the money supply or depletion of foreign reserves. However, new models have emphasized the role of implicit obligations of the government: if the government has growing obligations to e.g. the banking sector, this might have the same implications for the shadow exchange rate as a fall in the actual level of foreign reserves. There has been much discussion on the question of contagion: why do currency crises tend to occur in “batches”—why do several countries experience currency crises at the same time? One has investigated whether e.g. hedge funds play a special role in- der speculative attacks. One can show that this might be the case if different investors have different information. If hedge fund have more information than others, and this is known to everyone, the presence of hedge funds might increase the volatility of capital flows. Last, much has been done on the role of regulating the exchange rate market. This is an issue we return to at the end of the course.

The Krugman model
We consider a small open economy where both the PPP and the UIP holds, and all investors have perfect foresight. Further, we assume for simplicity that \( y = 0, \dot{\epsilon} = 0 \) and \( p = 0 \). If we use a continuous time setting, and we let \( e \) be the rate of change in \( e \), we can write the Cagan equation from the lecture 2 on the form

\[
m_t - \epsilon_t = -\eta e. \tag{4.1}
\]

It follows from equation (11.96) that if the exchange rate is fixed at \( e \), the money stock is fixed at

\[
m = \text{constant}. \tag{4.2}
\]

We now assume that the money stock is composed by two parts, domestic credit, \( D \), and foreign reserves, \( R \), such that

\[
M_t = D_t + \epsilon R_t. \tag{4.3}
\]

when \( R \) is denominated in foreign currency terms. Let us further assume that the government follows a policy that expand domestic credit at a fixed rate \( \mu \), such that

\[
\frac{\dot{D}}{D} = \dot{\mu} = \mu. \tag{4.4}
\]

This can be thought of as a fiscal deficit monetisation by the central bank, i.e. that the central bank issues money to pay for government expenditure. However, if the central bank at the same time follows a fixed exchange rate policy, if can not let the expansion of domestic credit affect the exchange rate. So by definition we must have that

\[
\dot{\epsilon} = - \dot{\mu}. \tag{4.5}
\]

⇒ expansion of domestic credit must be followed by a fall in the level of reserves. Such a policy can not last. Domestic credit can increase forever. Foreign reserves have only a limited supply. At some point of time the foreign reserves must be zero. At this time the central bank will no longer be able to stand by its obligations in the fixed exchange rate regime—with no foreign reserves the central bank can not fulfill the promise to exchange the domestic currency into foreign currency at a given rate. So a policy of domestic credit expansion must necessarily lead to the fall of the fixed exchange rate system.

When will such a collapse happen? Will it be when the inconsistent policy is introduced? Or will the the exchange rate first collapse when the the reserves are zero? In fact we observe that “currency crises” often seem to occur independent of new information. How can we explain that in this framework?

Let us define a “shadow exchange rate”, \( e^\star \), as the exchange rate that would have been if the speculative attack had already occurred. After a speculative attack, foreign reserves must be zero. In this case the money stock will only contain domestic credit, so we must have that \( m = \epsilon dt \). However, we assume that domestic credit continues to grow at the rate \( \mu \). If the money supply grows at a fixed rate, the exchange rate must depreciate at the rate \( \eta \). So the shadow rate of the exchange rate will be

\[
\epsilon^\star = m_t + \eta \mu = \epsilon_t + \eta \mu = \dot{\epsilon} + \dot{\mu} + \eta. \tag{4.6}
\]

The Krugman model argues that by arbitrage the fixed exchange rate must collapse at the moment when the shadow rate equals the fixed rate, \( \epsilon = e^\star \). Assume that the fixed exchange rate equals the shadow rate at time \( T \). Let the fixed exchange rate collapses at a \( T + 2 \). In this case the shadow rate will exceed the fixed rate. The fixed rate is terminated at this point, the exchange rate must make a jump from \( e^\star \) to \( e \). A discrete jump in the exchange rate will imply infinite profit opportunities for rational speculators. As everyone have perfect foresight, everyone will try to sell the domestic currency at time \( T + 1 \). Hence, the speculative attack will take place at \( T + 1 \) However, at \( T + 1 \) the jump will still be discrete. So everyone will sell at \( T \).

Why not sell at \( T - 1 \)? Simply because one would lose money by doing so. If everyone sell at \( T - 1 \) the exchange rate actually will appreciate, as the shadow rate at time \( T - 1 \) is lower than the fixed rate. If we know when a speculative attack will occur, we can calculate the exact timing of an attack. We know that the attack will occur when

\[
\epsilon^\star = \dot{m}_t + \eta T + \eta. \tag{4.7}
\]

Further, we know that

\[
\ln(D_0 + R_0) = \epsilon + \dot{\mu} + \eta. \tag{4.8}
\]

so that

\[
\ln(D_0 + R_0) = \epsilon + \dot{\mu} + \eta \Rightarrow \ln(D_0 + R_0) - \epsilon = \dot{\mu} + \eta. \tag{4.9}
\]

We see that the larger the initial holdings of reserves, the higher must \( T \) be. Further, \( T \) will decrease in the rate of growth in domestic credit. \( T \) must occur at a time when \( R > 0 \). The speculative attack will occur when the central bank still has some foreign reserves left. The result will be a fall in the money supply at time \( T \) so the central bank must sell its foreign reserves during the attack. The reason why the money stock must fall is because the investors expect the growth in domestic credit to continue after the attack. Before the attack we had \( e = m \). After the attack we have \( e = m + \mu \). The money stock must fall so that

\[
\frac{1}{\epsilon} = m - m_\mu + \mu \Rightarrow \frac{1}{\epsilon} - m_\mu = \mu. \tag{4.11}
\]

There are a number of weaknesses in the Krugman model. These include that we assume perfect foresight, that we assume the UIP to hold at every point in time and that we assume that the government follow a totally incon- sistent policy over time. One relevant question is why, when everybody has perfect foresight, should the government care to follow an inconsistent policy of this kind? However, the model tells us that if we want to understand why a seemingly “irrational” event occurs—remember, here a speculative attack occurs even if the central bank still controls foreign reserves—It is impor- tant to understand long term underlying trends, and how these affect the expectations of market participants.

Crisis with no trend?
In the August 1993 the French franc, the Belgian franc and the Danish krone all experienced severe speculative attacks. As a result of this the countries agreed to widen their target zones within the EMS system from +/-2.5 per cent to +/-15 per cent. However, within two years of the attack all three cur- rencies were not far from the edge of the original band. Figure 4.3 illustrate the movements of the BEF over the period from 1990 to 1999. Over this time period little changed in the Belgian economic policy. Belgium had with success followed a low inflation policy in the late 1980’s.

Figure 4.2: Anatomy of a speculative attack

\[
\log \text{exchange rate} \quad \text{T} \quad \text{Shadow Cointing rate}
\]

\[
\log \text{money supply} \quad \text{time}
\]
The strategy of speculators

The following game theoretic approach illustrates the case of how speculative attacks might occur even in situations when the exchange rate peg is sustainable. The basis of the argument is that there is a correlation between the “discomfort” a government will feel about a devaluation and the level of reserves the government chooses to hold. Assume that if fundamentals are very strong, the government is not under any circumstances willing to give up the fixed rate. If the exchange rate is overvalued, the government might be willing to, or even interested in devaluing the exchange rate. So the level of reserves committed to defending the rate will be low. The problematic case is the "grey zone". Where do "good" fundamentals end and "bad" fundamentals start? Assume that the currency is slightly overvalued in real terms. However, there are reasons to believe that one can adjust this through lower inflation and tight fiscal policy. So the exchange rate peg is sustainable. However, given the economic difficulties, the government is not willing to put its full force behind the exchange rate peg.

In the model we assume that at such "intermediate" levels of fundamentals the government is only willing to commit an intermediate level of reserves to defend the exchange rate. More specific, we assume three possible states of the economy. In the good state the government commits reserves equal to 20 “domestic money units”, e.g. 20 billion NOK. For simplicity we assume that this equals the total monetary base. In fact, such a commitment will make it impossible for speculators to topple the exchange rate. In the intermediate stage the government commits reserves equal to 10. In this situation it is possible for speculators to topple the regime, but only if the whole markets reacts at the same time. In the bad state the government commits reserves equal to 6. In this case one large trader could topple the regime alone.

We assume the existence of two traders. Each trader control resources of 6 domestic money units. The traders incur a cost of −1 by attacking the exchange rate. Figure 4.4 presents the result of alternative strategies in the "good state". In this case the traders will not be able to topple the regime under any circumstances. They will gain 0 by doing nothing, and lose −1 by speculating against the currency. The case of "hold, hold" can be characterised as a "Nash equilibrium". Assume that we are in the low state, and that one trader attack the exchange rate. Then the central bank will offer this trader its whole portfolio of reserves, equal to 6. Assume the currency depreciates with 50 per cent. The trader makes a profit of 2—the income from the speculation is 3 and the cost of speculation is −1. However, if both traders sell at the same time, the traders will share the central bank reserves between each other. Both will make an income of 3/2, and a profit of 1/2. This case is illustrated in figure 4.5. In this case the "sell, sell" strategy will be a Nash equilibrium.

The most interesting case is made up by the intermediate fundamentals. In this case no trader can topple the regime alone. So if a trader acts alone, he will gain nothing, and lose the cost of speculation. However, if both traders attack at the same time, both will gain 5/2 − 1 = 3/2, as they will share the committed reserves of the central bank between them. This case is illustrated in figure 4.5. Her we have two Nash equilibria—it will be an equilibrium to "hold, hold", but it will also be an equilibrium to "sell, sell". The currency. She will make a profit of 9 − 6 = 3 units of domestic currency.

The strategy of speculators

The following game theoretic approach illustrates the case of how speculative attacks might occur even in situations when the exchange rate peg is sustainable. The basis of the argument is that there is a
The role of large speculators

Of course, the investor never knows exactly what commitment the central bank is ready to offer. So the investor must first observe some signal that gives her an opinion about the economy. Then she makes up her mind about a speculation strategy. If she finds that she has positive expected returns, she will attack. If expected returns are negative, she will not attack. One question that has been asked is what role large speculators play in determining the fait of fixed exchange rate regimes. Above, I referred to the story of George Soros and the devaluation of the GBP in 1992. Soros is said to have made billions of USD during this attack.

What is a large speculator? There exist funds that control enormous amounts of money. Several American pension funds have resources in excess of the Norwegian GDP. However, when we talk about a “large player” in the FX-market, it is not necessarily market capitalisation that is interesting. Rather it is the ability to take high risk positions. Most banks and pensions funds have strong restrictions on the level of risk they can take. However, there exists a type of institutions that have no jurisdictional restrictions on their risk positions. These are the so-called hedge funds. Hedge funds are financial institutions that specialise in making money on potentially highly leveraged insinuation. Most hedge funds fall in this category. This is not attack.

An institution that bases its investment strategy on gearing is called a highly leveraged insinuation. Most hedge funds fall in this category. This implies that even a relatively small fund can take very large positions during e.g. a speculative attack. How can an American hedge fund with no NOK resources possibly attack a currency peg involving the NOK? It can do so by going short — i.e. sell currency in the forward market. When the hedge funds sells a forward contract on the delivery of NOK, the opposing party will be a bank. The contract implies that the bank must take a delivery of NOK sometime into the future. However, the bank does not want to expose itself to currency risk. So it will cover the contract by selling NOK today. If there is no market for NOK today, the central bank must intervene, and foreign reserves will be depleted. The hedge fund can force a spot sale of NOK today by intervening in the forward market. However, one should note that this strategy is not risk free. The cost of the forward contract is the same as the interest differential between the two currencies of the contract. To short sell NOK is equivalent to taking a loan in NOK. If Norges Bank increases its interest rates to stop the attack, the cost of such a contract can be high.

Hedge funds have been accused of trying to destabilise financial markets. The attackers are both politicians and economists, and they include, in a ran- dom order of importance, the former French president Francois Mitterrand, the Malaysian prime minister Dr. Mathahir and the head of Norges Bank Sven Gudnason. The central bank of Hong Kong and Australia have both issued reports where they accuse hedge funds of manipulating the local ex-change rates. In the case of Norway, it has been reported that the fund Manager has been actively involved in speculation against NOK. The same is the case of Chase Manhattan, although Chase is not a hedge fund.

In this situation we have possible instability—the peg might survive or it might not, depending on whether the traders are able to co-ordinate their attack or not.

The idea is that a “large player” could generate profits by secretly selling the currency forward and then deliberately trigger a crisis by making a large spot sale combined with some public statements of how weak the currency is. One example of manipulation might have taken place in Hong Kong in 1998. It is said that funds short sold both the HKD and the Hang Seng index at the same time. The idea was that by selling HKD they would force the Hong Kong Monetary authority to leave the currency peg. Then they would make money in on the currency contracts. Short selling the stock market would increase the pressure for a devaluation. However, if the authorities raised interest rates to defend the pegged rate one should expect the stock market would fall. Then the investors would make money on the stock contracts instead.

Was this a case of manipulation? “Fundamental analysis” probably could justify both going short in the currency, and short in the stock market. Of course by taking such positions, investors might contribute to making such events inevitable. But whether this is “manipulation” or not is hard to say. In fact the Hong Kong authorities pulled of a “double defence”. They increased interest rates to defend the peg. However, at the same time they intervened in the stock market to boost prices. This way investors lost money on both their contracts. Hong Kong authorities might have fooled potential speculators. The question is how this willingness to intervene in the markets affected the perception of other potential investors in Hong Kong.

How should we analyse the role of large investors? Take the example of speculation given above. Assume that the two traders have unequal size. E.g. let one investor control resources equal to 9 domestic currency units, and the small investor controls resources equal to 3 units. What would change? The “good state” remains as before. No devaluation would occur. In the bad state the small investor could no longer attack the currency alone. In fact, the “large player” gets a proportional share of the central bank reserves—i.e. 75 per cent of the reserves, as she has 75 per cent of the market, then the small investor would not care about the currency markets at all. The small investor would lose money by selling anyway, given the high costs of speculation. This is illustrated in figure 4.7.

Figure 4.7: Attack when fundamentals are weak. Committed reserves=6. Trader 1 controls 9 units, trader 2 3 units.

In the intermediate case however, there would be no real change. The large trader needs the support of the small trader to succeed. Only the payoffs would be different from the case where the traders were of equal size. If size is the only difference between two traders, this might affect who takes part in an attack when the central bank has only a low commitment in the fixed exchange rate. However in these cases an attack is probably due to happen anyway. In the cases when fundamentals are stronger, the whole market still needs to take part for an attack to succeed. If the large trader is different from the small trader on other conditions, the argument will of course change. However as the large player is perceived to have superior information, that might increase her ability to influence the behavior of the market. If the large player has less...
cost of speculating than the small investor, this might also affect the results. An extreme version of this case is reflected in figure 4.9.

Figure 4.9: Attack when fundamentals are intermediate and the large trader has no cost of speculation.

Committed reserves=10. Trader 1 controls 9 units, trader 2 3 units.

<table>
<thead>
<tr>
<th></th>
<th>Hold</th>
<th>Sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trader 1</td>
<td>0,0,</td>
<td>0,-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trader 2</td>
<td>0,0</td>
<td>15/4,1/4</td>
</tr>
</tbody>
</table>

Here we assume the large trader has no cost of speculating. In this case it would be optimal for the large trader to always speculate—and therefore for the small trader to speculate as well. If the costs of speculation is very small, the volatility of the exchange rate might increase.

A short note on the Tobin tax
A Tobin tax is a proposed tax on all transactions in the foreign exchange market. Intention: to reduce excess volatility caused by low costs of transaction. Will it work? Yes—and no. Hinder currency crises? If the cost is high relative to expected gains a tax will reduce the probability of crises. However, the tax necessary must probably be high. And there are possible problems, see example below.

A tax would make the markets less liquid. It is not perfectly clear how that will effect the price process. However, short term volatility might fall.

It has been argued that for a Tobin tax to be effective it must be implemented in all territories—if only a tiny bit of land is excluded one could move all FX transactions there to avoid the tax. However, a tax that covers the OECD countries will probably still have a substantial effect.

The real problem is financial derivatives. It is possible to speculate in the FX-market without being in the FX-market—one can create financial derivatives that reflect the risk in the FX market.

Contagion
Figure 4.11 depicts the development of Asian currencies over the period from 1996 to 1998. As we see, during 1997 there occurred a period of severe volatility that lead to a shift from fixed exchange rate regimes to floating exchange rate regimes. In figure 4.12 we take a closer look at the period from May 15 to December 31 1997. We observe that the crises did not occur simultaneously. Rather they occurred one after another. There is signs of some sort of regional “spread”. This phenomena is often referred to in the literature as “contagion”.

Figure 4.10: Example of how a Tobin tax can be destabilising (note that this is an extreme case).

Trader 1 controls 6 units, trader 2 6 units. Cost increases from 1 to 2.

<table>
<thead>
<tr>
<th></th>
<th>Hold</th>
<th>Sell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trader 1</td>
<td>0,0</td>
<td>0,2</td>
</tr>
<tr>
<td>Trader 2</td>
<td>2,0</td>
<td>1/2,1/2</td>
</tr>
</tbody>
</table>

Attack when fundamentals are weak. Committed reserves=6. In first case cost of speculation is set to -1. In second case cost of speculation is set to -2. In the first case we have one Nash equilibrium, in the lower, right corner. In the second case we have two Nash equilibria, in the upper right and lower left corner. This creates the possibility of a more unstable situation.

Why do contagion occur? Four reasons have been presented:

1. Several countries can be similarly affected by a common shock.
2. Trade linkages can imply that a crisis in one country weakens fundamentals in other countries.
3. Financial interdependence.
4. A currency crisis in one country can change market participants’ perceptions of other countries, resulting in the withdrawal of capital.

Argument one is providing a “fundamental” explanation of the spread of crises. Argument number four favour the perception of crisis as “self-fulfilling”. This argument does however depend on assumptions of limited rationality among market participants. It is no reason why a crisis in one country should affect rational expectations of other countries unless there are real links be- tween the two economies. Arguments two and three are therefore perhaps the more interesting, as they provide explanations of
Transmission of currency crisis via trade channels

It is important to point out that transmission via trade channels do not depend on the existence of trade channels between the countries affected. In fact, in the case of Asia one common feature is the relatively small trade flows between the countries affected by the speculative attacks. The important feature is to which degree the exports of two countries are competing in foreign markets. In table 4.3 we illustrate the case with countries A and B exporting to countries C and D. Country A sends most of her exports to country C, while country B sends most of her exports to country D.

Assume that country A devalues with 10 per cent. What is the effect on the exports of country B? To say something about this we must make some assumptions about how close substitutes the goods of A and B are in C and D. We assume that there is a one-to-one relationship between a devaluation and an increase in demand in the importing country. If the price of goods from country A falls with 10 per cent, the demand for goods from country B falls with 10 per cent. The relative price elasticity \( p \) is set equal to 1. The total effect of a devaluation in country A on the exports of country B will be given by

\[
\Delta \text{exports}_{B} = \sum_{k=0}^{\infty} (p_k \cdot \text{exports}_{B}(k) \cdot \text{marketshare}_{A}(k)) \cdot \text{dev}, \tag{4.12}
\]

where \( \text{exports}_{B}(k) \) is the export share of country B in market \( k \), \( k \in \{C, D\} \), and \( \text{dev} \) is the devaluation in per cent. If we substitute in from table 4.3 we obtain

\[
\Delta \text{exports}_{B} = \left[1 - 0.1 \cdot 0.9 + 0.1 \cdot [1 - 0.9 \cdot 0.1] \cdot 0.1 \right] = 1.8\% \tag{4.13}
\]

The exports of country B will fall by 1.8 per cent. However, assume that countries A and B are competing in the same market-kets. An example is given in table 4.2. In this case the effect of a 10 per cent devaluation in country A will be

\[
\Delta \text{exports}_{B} = \left[1 - 0.1 \cdot 0.5 + 0.1 \cdot [1 - 0.9 \cdot 0.5] \cdot 0.1 \right] = 5\% \tag{4.14}
\]

a 5 per cent fall in the exports of country B. In the case of South East Asia, these countries were all competing in foreign markets. They all specialised on electronics and computer compo-nents, sending their goods to Japan, the USA and Europe. The actual trade between these countries was of lesser importance. However, in this case the actual devaluations were not 10 per cent. Thailand, Malaysia and South Korea experienced devaluations of close to 50 per cent. If we assume a 50 per cent devaluation in country A, we get a 9 per cent fall in exports in country B in the "little competition case", and as much as 25 per cent fall in the exports of country B in the "strong competition case". Effects of that magnitude would certainly create a "fundamental" basis for a devaluation in country B as well.

Table 4.1: Non-competing trade flows

<table>
<thead>
<tr>
<th>Initial trade flows</th>
<th>Export share</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C 90 10 D</td>
<td>C 90 10 D</td>
</tr>
<tr>
<td>B</td>
<td>16 80 C</td>
<td>14 90 D</td>
</tr>
</tbody>
</table>

Table 4.2: Competing trade flows

<table>
<thead>
<tr>
<th>Initial trade flows</th>
<th>Export share</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C 16 80 D</td>
<td>C 14 90 D</td>
</tr>
<tr>
<td>B</td>
<td>50 50 C</td>
<td>50 50 C</td>
</tr>
</tbody>
</table>

Transmission via a credit crunch

We consider a case where two banks, bank 1 and 2, lend to three different countries, A, B and C. However, the dependence on the two banks differ between the three countries. This is not an unrealistic assumption. Often banks will specialise on lending to specific geographical regions. No assume that there is a speculative attack in country A, and that country A defaults on its foreign debt. Both bank 1 and 2 will lose all they have lent to country A. As a result both banks need to recall loans to satisfy the demands of their creditors. Bank 1 have total loans of 40 (20+20) after the default of A. It must recall a total of 20, which makes up 20/(20+20)=50 per cent of its loan portfolio. Bank 2 had an exposure of 10. It must no recall 10, which makes up 10/(10+40)=11.1 per cent of its portfolio. For country B this means that total loans are reduced from 30 to 20 + 0.5 * 10 + 0.899 = 18.9.

That implies a reduction in total loans of (30-18.9)/30=47 percent. For country C we find that total loans are reduced from 100 to 20 + 0.5 * 80 + 0.899 = 81.1. That reduces a reduction in total loans of (100-81.2)/100=18.9 percent. The point here is that a default in one country might have large effects on the financing of other countries if there are some kinds of concentration in lending. If credit channels and trade channels are both regions specific the transmission effects can be substantial. In other words, a shock to one country might have substantial implications for other countries, even though these countries before the crisis had "strong fundamentals", and even if we assume investors to be fully rational.

Through trade and credit channels economies can be interdependent despite no direct links between them.

Table 4.3: Bank dependence

<table>
<thead>
<tr>
<th>From</th>
<th>Initial portfolio</th>
<th>Exposure</th>
<th>Dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20 10</td>
<td>33 10</td>
<td>49 31 33 6</td>
</tr>
</tbody>
</table>

| Total | 100 |

CHAPTER 5

THE FOREIGN EXCHANGE MARKET

Some definitions

- **Spot market**: Spot transactions in the FX-market are transactions made today that shall be completed within two days, i.e. formal deliv- ery of the currency will take place in two days.
- **Outright forward**: transaction that contract delivery of the currency at some point beyond two days.
- **Option**: The right to buy (or sell) an asset at a predetermined value.
- **Swap**: Bundles two FX transactions that go in opposing directions. Usual to combine a spot transaction and an outright forward. Example: buy 100 million EUR today for USD at spot exchange rate. At the same time agree to sell EUR 100 million in one month. Purpose: Lock in interest rate differential. If I need EUR 100 million from now and one month into the future, I can reduce the cost of holding this sum to the interest differential between EUR and USD by doing a swap today. I will remove all exchange rate risk.

Swaps come in two types.

- **"Short swaps"** are contracts that give delivery today or tomorrow—i.e. before the delivery in a standard spot contract.
- **"Long swaps"** are swaps with spot contracts and future contracts with delivery beyond two days.

**Bid-ask**

All exchange rates are quoted as two prices—a bid and an ask. On the Reuters screens you will see quotes of the type:

USD/EUR  0.8810-0.8812

0.8810 will be the price where the bank is willing to buy EUR. This is the bid price for EUR. 0.8812 will be the price where the bank is willing to sell EUR. This is the ask price for EUR. The seller asks 0.8812 USD to give you one EUR. Note that the bid price for EUR will be the ask for USD—the price of one USD is after all only the inverse of the price of one EUR. This might be confusing...

Table 5.1: Example of bid-ask. Assume that CAD/USD=1.5858/1.5865

<table>
<thead>
<tr>
<th>Price of USD</th>
<th>Bid</th>
<th>Ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5858</td>
<td>0.8810</td>
<td>0.8812</td>
</tr>
<tr>
<td>Price of CAD</td>
<td>0.6303</td>
<td>0.6306</td>
</tr>
</tbody>
</table>

Trading in the market, dealers will only quote the last two numbers of the exchange rate. In the above transactions, dealers will say they have a bid of 10 and an ask of 12. The spread is measured in basis points. One basis point is one 1/10000 of the unit, that is one point in the fourth decimal of the quote. In the above example the spread is two basis points. The spread is the only ‘transaction cost’ in non-brokered interbank foreign exchange transactions. The spread is a ‘fee’ on the trading. Note that the spreads in the spot FX-market is much lower than what you will expect in most financial markets. E.g. a standard fee in equity trading can be 1 per cent of amount transacted—if the fee is symmetric (same for sell and purchase) that amounts to the the equivalent of 200 basis points. In the FX market spreads are seldom above 10 points in liquid markets.
What we know for certain about the FX-market

The FX-market is riddled with “puzzles”—things we do not understand. However, there are a few things we do know will hold for certain. In both examples below we will ignore the bid/ask spread. This simplifies things considerably. However, the logic still holds it we assume the existence of spreads.

Triangular arbitrage

Let us ignore the bid/ask spread. Assume that we have

- HKD/USD 7.70 (HKD-Hong Kong Dollar)
- ZAR/USD 11.9 (ZAR-South African Rand)

What is the HKD/ZAR rate?

\[\frac{HKD/USD}{ZAR/USD} = 7.70\]
\[\frac{ZAR/USD}{HKD/USD} = 11.9\]
\[\frac{HKD/USD}{ZAR/USD} = 0.6471\]

Suppose not. Suppose e.g. that HKD/ZAR = 0.75. This means that we can make a profit by arbitrage. How? Sell one ZAR and get 0.75 HKD. Sell 0.75 HKD and get 0.9794 USD. Sell 0.9794 USD and get 1.159 ZAR = you have made a profit of 16 per cent! Such profits can not exist for long in a free market. They will be traded away. In the end triangular arbitrage must hold.

Covered interest rate parity—CIP

Let F be the forward exchange rate. Consider two portfolios:

1. Invest 1 USD at the US 1 year interest rate of i. In one year you will have USD \(1 + (1 + i)\).
2. Convert 1 USD to GBP at the spot rate s today. This gives you a total of GBP=USD/s. Invest this at the UK 1 year interest rate of \(1 + i\). However, you may invest your money in USD, so you want to convert back to USD in the end of the year. To lock in the profit you buy a forward contract at the price F for delivery of USD in one year. The contract should cover an amount of GBP=USD/s \(1 + i\). The amount earned will then be (USD/s) \(1 + (1 + i)\) + F.

These two transactions are equivalent. If the UK and the US assets are similar, there is no risk difference involved by doing one transaction versus the other. So we should expect that:

\[
(1 + (1 + i)) = \frac{(1 + i)}{s} \cdot (1 + i^*) \cdot F.
\]

It follows that we must have:

\[
\frac{F}{i} = \frac{1 + i}{1 + i^*}.
\]

CIP should hold at every point of time unless there are restrictions on the trade in capital assets. To sum up: it should not be possible to lend riskless dollars at different rates in two different markets. A covered international investment is the same as a domestic investment: they both involve no currency risk. Ergo, the return should be the same. The forward rate should reflect this. In logarithmic terms the return of the covered international investment will be:

\[
i^* + f - e.
\]

The return on the domestic investment must be i. So we must have that:

\[
f - e = i - i^*.
\]

How the FX-market is organised

Assets are traded in three different types of markets:


   These can either be
   - market orders—buy or sell at the current market price, or
   - limit orders—buy or sell at a the in the contract predetermined price. When the market reaches the limit price, the order is executed. If the market never reaches the limit price, the order is never executed, or at least not at that price.

   There will be no dealers in this market, only a system for organisating the stream of orders. An example of an auction market is to be found at the Paris Stock Exchange.


   A single dealer will mostly specialise in only one currency cross. The dealer might take considerable positions in this currency intra-day. However, most dealers close their positions over night. Figure 5.2, illustrated observed dealer inventories for four different dealers in two different markets over one week, collected from a Norwegian bank. As we see, dealer strategies can be described as “individual”. In this sample we see that dealer might take intra-day positions of up to 20 million USD. It is not usual for dealers to trade for USD 1 billion a day. As a comparison US equity traders trade for an average of USD 10 million a day.

3. Multiple dealer market.

   - Centralised. Quotes from many dealers will be available at one screen at the same time. Example: NASDAQ.
   - Decentralised. Many dealers will offer quotes. However, there is no system to keep track of all offers in the market at the same time.

   The FX-market can best be described as a decentralised multiple dealer market. There exists no exchange and no common screen for all quotes. This means that trading will be partly fragmented—it is not possible to observe the price in all simultaneous transactions. Note that there are two types of traders that are active in the FX-market:

   1. brokers
   2. dealers.

   These groups offer slightly different services. Dealers will offer two-way prices (both bid and ask). Direct trade between dealers will be conducted over a computer system, or over the telephone. Mostly they will use something called Reuters D2000-1. An example of communication over Reuters D2000-1 is provided in figure 5.1. One dealer will contact another, and ask for a price quote. These quotes are considered to be binding. A market maker is a dealer that is supposed to always be able to give a quote. In direct interdealer contact the opposing party will be known.

   An example of a D2000-1 conversation when a trade takes place. The first word means that the call came “From” another dealer. There are information regarding the institution code and the name of the counterparty, and the time (Greenwich Mean), the date, and the number assigned to the communication. DEM 1 means that this is a request for a spot DEM/USD quote for up to USD 1 million, since it is implicitly understood that it is DEM against USD. At line 2, we find the quoted bid and ask price. Only the last two digits of the four decimals are quoted. In this case, the bid quote is 1.8145 and the ask quote is 1.8147. When confirming the transaction, the communication record provides the first three digits. In this case, the calling dealer buys USD 1 million at the price 1.8147. The record confirms the exact price and quantity. The transaction price always equals the bid or the ask. There is also information regarding the settlement bank. “My DEM to ’Full Name Here’” identifies the settlement bank of “our bank”, while “My USD to “Settlement bank” identifies the settlement bank of the other bank. It is usual to end a conversation with standard phrases, such as “thanks and bye,” “thanks for deals friends.”

In this market we have one dealer who offers a best bid and a best ask. The customer must accept the offer of the dealer. FX markets in some developing countries will work as single dealer markets, with the central bank acting as the single dealer.
a) Dealer 1: DEM/USD Market Maker
b) Dealer 2: DEM/USD "Nintendo-dealer"
c) Dealer 3: NOK/DEN Market Maker
d) Dealer 4: DEM/USD

The dealer consistently making most money of these four is supposed to have been the "Nintendo-dealer"—a guy who never held a position for more than two minutes. The evolution of dealers inventory over the week. Dealer 1 (panel a), 2 (panel b) and 4s (panel d) inventory are in USD million, while Dealer 3s inventory is in DEM million. The horizontal axis is in "transaction"-time. Vertical lines indicate end of day. The numbers are in USD million.

A broker is a pure matchmaker. Dealers will submit limit orders to the broker. The broker will post these orders on a screen. One such system is the Reuters D2000-2. In the broker system traders can observe the quotes available in the market on one screen. However, it is not revealed who has posted the quote. This is first revealed after the trade has been completed. A difference between the direct trade and the broker system is that the as the broker system is based on limit orders, one will post a maximum size of the order at a given price. Further, one needs not post limit orders on both sides of the market. A dealer can choose to post orders a bid or an ask.

The cost of trades will depend on the counterparty. Direct interdealer contact has the lowest spreads. Brokers take somewhat higher spreads, not least because brokers only make money through transaction costs. Customer get the highest spreads. The market is illustrated in figure 5.3

Three characteristics of the FX market:
1. A very high volume,
2. High intra-dealer volume, and
3. Low transparency.

In all these regards the FX-market is different from other multiple dealer asset markets. The daily volume in the FX spot market in April 1998 was 600 billion USD, of which about 2/3 is supposed to have been intradealer trade. As a comparison, the daily volume in the New York Stock Exchange in this period was 30 billion USD, and average daily world trade in goods and services was about 15 billion USD. One way to explain the high amount of trade in the FX-markets is the "hot-potato-hypothesis." Assume that a dealer gets an order from a customer and maturity. However, the dealer wants to keep his inventory as close to zero as possible. So the dealer makes a trade with another dealer. This dealer will keep a little, and trade the rest.

The FX-market has evolved almost with no government intervention. This might point to low transparency being in the interest of the dealers. Low transparency gives active dealers an advantage in the markets—and it might be an advantage for their customers as well, as they always get the best quotes. The smaller and less informed loose out however. In fact we have seen an increasing concentration in the FX-market over the last 10 years. The largest 10 firms did in 1998 control about 50 per cent of the market.

Data from the FX-market
In April every three years Bank of International Settlements, BIS, collect data on transactions in the FX-market from 48 national central banks. The total volume reported in the survey for 2001 is found in figure 5.4. As we can see, after years of increase in FX-volume, the volume has fallen considerably over the last three years. This is probably fairly simple to explain—with the introduction of the EUR, the number of heavily traded currencies fell dramatically.

Figure 5.5 summarises the types of instruments used in the market. We see that most deals are made with "reporting" dealers—dealers that are "reg-istered" by the central bank as reporters. We also see that most swaps are conducted as transactions with a life of less than 7 days—short swaps are the leading type of swap transactions in this market.

International currency
Just as domestic currency is the reference in the domestic economy, there needs to be a point of reference in the international currency markets as well. In a flexible currency system this point is not clear. However, at different times Greek coins, Roman coins, Florins, bills of credit on German banks or British pounds have worked as accepted means of payment in international transactions. Since the Second World War USD has filled this role, although some observers now predict a larger role for the EUR.

How do we define an international currency? What will determine which currencies are dominating the world markets?

Figure 5.5: Reported foreign exchange market turnover by instrument, counterparty and maturity. Daily averages in April, in billions of US dollars

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot transactions:</td>
<td>317</td>
<td>304</td>
<td>494</td>
<td>568</td>
<td>367</td>
</tr>
<tr>
<td>Outlook forwards</td>
<td>27</td>
<td>58</td>
<td>97</td>
<td>128</td>
<td>131</td>
</tr>
<tr>
<td>Foreign exchange swaps</td>
<td>190</td>
<td>224</td>
<td>256</td>
<td>378</td>
<td>650</td>
</tr>
<tr>
<td>Estimated gains in reporting</td>
<td>56</td>
<td>44</td>
<td>53</td>
<td>50</td>
<td>36</td>
</tr>
<tr>
<td>Total &quot;traditional&quot; turnover</td>
<td>590</td>
<td>620</td>
<td>1,196</td>
<td>1,459</td>
<td>1,210</td>
</tr>
<tr>
<td>Memorandum item:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Turnover at April 2001 exchange rate&quot;</td>
<td>570</td>
<td>750</td>
<td>100</td>
<td>1,100</td>
<td>1,210</td>
</tr>
</tbody>
</table>

Adjusted for local and cross-border double-counting. 2 Revised. 3 Non-US dollar legs of foreign currency transactions were converted into original currency amounts at average exchange rates for April of each survey year and then reconverted into US dollar amounts at average April 2001 exchange rates.

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Just as domestic currency is the reference in the domestic economy, there needs to be a point of reference in the international currency markets as well. In a flexible currency system this point is not clear. However, at different times Greek coins, Roman coins, Florins, bills of credit on German banks or British pounds have worked as accepted means of payment in international transactions. Since the Second World War USD has filled this role, although some observers now predict a larger role for the EUR.

How do we define an international currency? What will determine which currencies are dominating the world markets?
Factors that the determine the international use of a currency is
a. size of the economy,
b. importance in international trade,
c. size, depth, liquidity, and openness of domestic financial markets,
d. convertibility of currency, and
e. macroeconomic policies. Policies fostering low inflation (i.e. a stable value of money) are especially important.

So what currencies are actually used in international currency markets? As can be seen from tables 5.8 and 5.9 the most traded currency is the USD, and the most traded currency pair is the USD/EUR.

The roles of international money

Invoice currency

Rules for choice of invoice currency:
- Between industrialised countries: price the good in the currency of the exporter.
- Between industrialised countries and developing countries: price the good in the currency of the industrialised country, or in a third country currency (most likely the USD).

Because two currencies are involved in each transaction, the sum of the percentage shares of individual currencies totals 200% instead of 100%. The figures relate to reported net-net turnover, i.e. they are adjusted for both local and cross-border double-counting, except for 1989 data, which are available only on a “gross-gross” basis. 2 Revised. 3 Data for April 1989 exclude domestic trading involving the Deutsche mark in Germany. 4 For 1992-98, the data cover local home currency trading only.

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Figure 5.6: The roles of international money

Functions of an International Currency

Figure 5.7: Factors that determine the international use of a currency

Comparison of United States, Euro-Area, and Japanese Economies in 1999

NOTE: GDP is based on purchasing power parity equivalents. World exports excludes intra-euro-area trade.

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Functions of an International Currency

Figure 5.7: Factors that determine the international use of a currency

Comparison of United States, Euro-Area, and Japanese Economies in 1999

NOTE: GDP is based on purchasing power parity equivalents. World exports excludes intra-euro-area trade.
If you make two or three transactions instead of one, vehicle currency might well have the lowest transaction cost. If one makes two or three transactions instead of only one, a vehicle currency might have the lowest transaction cost if all currency trades included the USD. Most trades in NZD are probably conducted against USD. So it might only be possible to compete with USD as the currency of choice in international debt markets if the European financial markets get the same size and liquidity as the American markets. This will probably depend on the level of integration in the European financial markets.

Figure 5.12: Vehicle currency

<table>
<thead>
<tr>
<th>Category</th>
<th>U.S. dollar</th>
<th>Japanese yen</th>
<th>Deutsche mark</th>
<th>French franc</th>
<th>British pound</th>
<th>Italian lira</th>
<th>Swiss franc</th>
<th>Euros</th>
<th>Pound sterling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot</td>
<td>70.8</td>
<td>21.7</td>
<td>42.7</td>
<td>3.2</td>
<td>5.5</td>
<td>3.1</td>
<td>5.8</td>
<td>6.5</td>
<td>38.6</td>
</tr>
<tr>
<td>Forwards</td>
<td>81.4</td>
<td>26.7</td>
<td>28.0</td>
<td>5.1</td>
<td>6.0</td>
<td>3.3</td>
<td>6.0</td>
<td>6.5</td>
<td>48.8</td>
</tr>
</tbody>
</table>

Vehicle currency

When making a transaction between e.g. NOK and NZD one will have several choices available. One can:

- buy NZD against the delivery of NOK. This does however assume a coincidence of wants. The bank selling NZD should also want NOK.
- buy USD against the delivery of NOK, and then buy NZD against the delivery of USD.
- or even more intricate, buy EUR against the delivery of NOK, USD against the delivery of EUR and NZD against the delivery of USD.

Why should one choose a strategy involving more than one transaction? Because the transactions costs will depend on the liquidity in each bilateral currency market. E.g. 80 per cent of all spot trade (that is trades to be delivered within two working days) in the Norwegian market is conducted between NOK and USD. According to table 5.9 in April 2001 91 per cent of all currency trades included the USD. Most trades in NZD is probably conducted against USD. So it might well generate the lowest transaction costs if one makes two or three transactions instead of only one. A vehicle currency will emerge each time the indirect exchange costs through the exchange rate between USD and NOK. In the US one only has the oil price risk. In Norway (and other small European nations) EUR probably works as a vehicle currency. For most other transactions, the USD is probably the vehicle currency of choice.

Store of value — the choice of denomination of financial assets

Diversification is an important concept in finance. One wants to diversify one's portfolio across interest bearing paper and equity, between different issuers of bonds and equity and also between different currencies. However, the willingness to invest in a certain currency will depend on size, openness, and liquidity of financial markets and the stability of the currency. The EUR will only be able to compete with USD as the currency of choice in international debt markets if the European financial markets get the same size and liquidity as the American markets. This will probably depend on the level of integration in the European financial markets.

Figure 5.13: Denomination of international debt

<table>
<thead>
<tr>
<th>International Debt Securities by Currency of Issue (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------</td>
</tr>
<tr>
<td>U.S. dollar</td>
</tr>
<tr>
<td>Japanese yen</td>
</tr>
<tr>
<td>Swiss franc</td>
</tr>
<tr>
<td>Euro area</td>
</tr>
<tr>
<td>Other EUs</td>
</tr>
<tr>
<td>Pound sterling</td>
</tr>
</tbody>
</table>

Money Market

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. dollar</td>
<td>7.4</td>
<td>38.3</td>
<td>50.8</td>
<td>45.2</td>
</tr>
<tr>
<td>Japanese yen</td>
<td>14.6</td>
<td>17.7</td>
<td>16.6</td>
<td>18.1</td>
</tr>
<tr>
<td>Swiss franc</td>
<td>1.7</td>
<td>2.2</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Euro area</td>
<td>36.7</td>
<td>37.4</td>
<td>38.0</td>
<td>38.0</td>
</tr>
<tr>
<td>Other EUs</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Pound sterling</td>
<td>7.6</td>
<td>7.8</td>
<td>7.2</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Figure 5.14: US seignorage revenue. Seignorage Revenues from Foreign Holdings of U.S. Dollars

It is estimated that about 55 per cent (!) of the total U.S. currency held by the non-bank public was held outside the US in 1995. The same number would probably be held outside the US now.
for the DEM was 35 per cent. The seigniorage revenue from foreign holdings is estimated to an average of about 9 billion USD a year over the last decade. That is less than one per cent of US government expenditure. However, it would amount to between 5 and 7 per cent of Norwegian GDP—still a reasonably large sum of money.

CHAPTER 6
THE FLOATING EXCHANGE RATE

Introduction
Michael Mussa has summarised our understanding of flexible exchange rates in the following way:

The largely random character of exchange rate fluctuations under floating exchange rate regimes is explained by the preva- lence of “news” in inducing most exchange rate changes; the ten- dency for nominal and real exchange rates to move in together under a floating rate regime is explained by the contrast between the behavior of nominal exchange rates as randomly fluctuating asset prices and the behavior of national price levels as relatively sluggishly adjusting variables; and with respect to the influence of economic policies on exchange rates, what matters is not simply what policies governments pursue today, but also to an important extent, the policies they are expected to pursue in the future. Despite this progress made over the last 30 years, we still do not have a good understanding of the observed behavior of exchange rates. Jeffrey Frankel and Andrew Rose (1995) state that of all the research conducted in the area up to 1995, a remarkable little evidence that macroeconomic variables have consistent strong effects on floating exchange rates, except during extraordinary circum- stances such as hyperinflations. Such negative findings have led the profession to a certain degree of pessimism vis-à-vis exchange rate research.

High expectations
During the Bretton Woods era many economist argued in favour of floating exchange rates. Six main claims were made.

1. Real exchange rates would be more stable with floating than fixed exchange rates. The argument was that since the exchange rate could adjust faster than the price level, one should expect a floating exchange rate to allow faster adjustment than a fixed exchange rate, as in the last case all adjustment was left to the domestic price level. Outcome: in fact variability in the real exchange rate has increased considerably with floating exchange rates. Real and nominal exchange rates tend to move together, and nominal exchange rate changes tend to increase the variability in the real exchange rate, not alleviate vari- ability.

2. Adjustments in fixed exchange rates tend to be infrequent, but abrupt and large. They often take a form that can be described as “crises”. Floating exchange rates are supposed to change slowly, smoothly, and predictably. Outcome: Flexible exchange rates have been very volatile. Changes are abrupt and fast. Neither are they predictable, as we will see in the discussion of the UIP below.

3. Floating exchange rates were supposed to adjust to insulate the economy against shocks from abroad. Remember the n-1 problem: in a fixed exchange rate regime monetary policy had to be adjusted in all countries if adjusted in one country. Outcome: In fact, correlation between business cycles have tended to increase, not fall, over the last three decades. Even in a floating regime the n-1 problem can not be ignored. If interest rate differentials between economies are allowed to be too high, we experience changes in real exchange rates that are not easily accepted. The result is that real interest rates are highly correlated.

4. In a floating exchange rate the central bank gets complete control over the money supply. Outcome: Even in a floating regime the exchange rate can not be ig- nored. The exchange rate is probably the most important “price” in every moderately open economy. The stylised example of an indepen-dent monetary policy is an illusion.

5. With floating exchange rates, exchange rates would adjust faster to balance the current account, thereby decreasing the political pressure for e.g. tariffs an other measures to reduce trade imbalances. Outcome: if anything, current account imbalances have increased with floating exchange rates.

6. With a floating exchange rate one did no longer need a foreign exchange reserve. These money could be freed for other purposes. Outcome: Foreign exchange reserves are in real terms larger today than in the Bretton Woods era.

How come that we have missed the point so completely? Two possibilities: either our models have been just plain wrong, or we did not interpret them correctly. The main problem is probably that floating exchange rates are much more volatile than was expected. However, this is a feature the exchange rates share with all asset markets—asset prices tend to fluctuate much more than underlying “fundamentals” should presume.

Excess volatility and some ‘puzzles’ of exchange rate economics

In the beginning of this course we made two basic assumptions when we moved from the domestic relationship for money demand to a function for the exchange rate. We assumed that PPP and UIP would hold. PPP implies that given the function

\[ \frac{Q_t}{Q_t} = \frac{P_t^{*}}{P_t} \quad (6.1) \]

we assume Q to be one, or at least stable over time. The UIP states that

\[ E_t^{t+1} = \frac{1 + t}{1 + t^*} \quad (6.2) \]

According to the UIP E+1 should be our best guess of st at time t. Table 6.1 give the standard deviations of return for a number of variables. What we can see from this table is that from week to week one should expect very limited volatility in prices. The volatility in interest rates are 10 times the volatility in prices. The volatility in the exchange rate is a 100 times that of the interest rate. However, we can notice that exchange rate volatility can only be characterised as “excess” if compared with the volatility of prices and interest rates. Compared with return in the stock market or in a highly traded storable good like oil, volatility is in fact rather low.

Table 6.1: Standard deviation of weekly return (weekly change) for different markets. Sample cover 11.1992-03.2002

<table>
<thead>
<tr>
<th>Market</th>
<th>St. dev. in per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>0.003</td>
</tr>
<tr>
<td>Germany</td>
<td>0.002</td>
</tr>
<tr>
<td>10 year Gov. bond</td>
<td>0.003</td>
</tr>
<tr>
<td>Norway</td>
<td>0.008</td>
</tr>
<tr>
<td>Germany</td>
<td>0.003</td>
</tr>
<tr>
<td>3 month interbank</td>
<td>0.006</td>
</tr>
<tr>
<td>Norway</td>
<td>0.004</td>
</tr>
<tr>
<td>Germany</td>
<td>0.003</td>
</tr>
<tr>
<td>Spread (NOK-DEM)</td>
<td>0.005</td>
</tr>
<tr>
<td>Exchange rates</td>
<td></td>
</tr>
<tr>
<td>NOK/DEM</td>
<td>0.79</td>
</tr>
<tr>
<td>DEM/USD</td>
<td>1.37</td>
</tr>
<tr>
<td>Stockmarket index</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>2.79</td>
</tr>
<tr>
<td>Germany</td>
<td>3.44</td>
</tr>
<tr>
<td>Traded goods</td>
<td></td>
</tr>
<tr>
<td>Oil in USD</td>
<td>5.21</td>
</tr>
<tr>
<td>Volatility in 1 St. dev. in per cent</td>
<td></td>
</tr>
</tbody>
</table>

What conclusion can we draw if we combine our results from table 6.1 with the two parity conditions stated above? If price volatility is low, and the nominal exchange rate volatility is high, the volatility of the real exchange rate must be highly correlated with the volatility in the nominal exchange rate. Further, it the volatility in the differential between domestic and foreign interest rates is low, while the volatility of the current spot rate is high, then we should expect a very high correlation between the expected future exchange rate and the current exchange rate as well.

These are de facto puzzles. However, they are probably not puzzles only related to the market for foreign exchange. Rather they are related to all asset markets. In general changes in asset prices are not well explained by changes in fundamentals, at least not over a “short time horizon” of say, up to two years. The reason is that asset prices fluctuate so much more than other variables in the economy. This volatility can not be well explained with current economic models. One therefore often hear that asset markets show “excess volatility”.

We should add a third problem not reflected in the table above. The real exchange rate tends to fluctuate in long cycles, with a mean reversion time of between 2 and 6 years, depending on the country and the exchange rate regime. This implies that over time fundamentals do seem to explain exchange rates after all. Why is this a puzzle? Because we can not under- stand why fundamentals should only be reflected in asset prices over a time span of over two years. Most of the explanations given below for the high volatility in exchange rates might give a good explanation for a divergence between fundamentals and the exchange rate for a few months, or maybe a year. However none of the models can explain why exchange rates are mean reverting over 4-6 years...

The FX market vs. the stock market
Given the focus on excess volatility in the FX market it is reasonable to compare this market with the volatility of the stock market. Figure 6.1 depict the log of NOK/DEM exchange rate, indexed to 100 in week 47 1992. In the figure we have drawn a trend line over the period. Figure 6.2 depict similar figure for the Oslo Stock Exchange. In figure 6.3 we depict only the trend lines. We see that the the two graphs have many similar features. Both tend to move in long swings. However, as becomes very clear in figure 6.4, over time the underlying movements in the stock exchange are of much larger magnitude than the long term changes in the exchange rate.

Figure 6.1: The NOK/DEM exchange rate. Log of index=100 in week 47, 1992. Trend calculated with H-P filter.

Figure 6.2: Index of Oslo Stock Exchange. Log of index=100 in week 47, 1992. Trend calculated with H-P filter.

Figure 6.3: The H-P trend in NOK/DEM exchange rate and the Oslo Stock Exchange. Log of index=100 in week 47, 1992.

Figure 6.4: The H-P trend in NOK/DEM exchange rate and the Oslo Stock Exchange. Log of index=100 in week 47, 1992.

Figure 6.5: The difference from H-P trend for NOK/DEM exchange rate the Oslo Stock Exchange. Log of index=100 in week 47, 1992.
The stock market and the FX market reveal many of the same features. They both tend to move in long swings, with substantial volatility around these swings. However, both the movements in the trend and the volatility around the trend tend to be less for the FX market than for the stock market. This might indicate that the FX market is slightly more "efficient" than the stock market. If so, this is not a surprising conclusion. After all, as we discussed in Lecture 5, transaction costs are lower and volume is higher in the FX market than in the stock market. Both factors should contribute to a more efficient market.

Random walk—the Meese and Rogoff results

During the 1970's much work was done on econometric models for forecasting exchange rates. Some of these models showed promising results. However, in 1983 there was published a study by Meese and Rogoff that summarised the ability of such econometric models to forecast exchange rate changes out-of-sample. The results were devastating. To forecast something in-the-sample tells us about the ability of the model to explain the observations we use in the regression. In out-of-sample forecasts we use the model to forecast time periods that was not included in the actual regression analysis. Meese and Rogoff estimated four different models using monthly data. They had data from March 1973 to June 1981. First they estimated the models over the period from March 1973 to November 1976. Then they used the parameters estimated to forecast the changes in the exchange rate 1, 6 and 12 months into the future from November 1976. In this forecast they used actual realised values of the "fundamental variables"—taking a very strict assumption of perfect foresight. They then extended the regression with one month, to December 1976, and reported forecasts. They repeated this procedure for the whole period till June 1981. Having made these forecasts, they compared the forecasts with actual outcomes, and reported the squared errors of the forecasts. A summary of their findings is given in table 6.2.

Table 6.2: Out-of-sample forecasting performance of different exchange rate models—root of mean squared error of forecasts 1, 6 and 12 months ahead.

<table>
<thead>
<tr>
<th>Model</th>
<th>1 month</th>
<th>6 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random walk</td>
<td>3.7</td>
<td>9.7</td>
<td>18.9</td>
</tr>
<tr>
<td>Monetary</td>
<td>2.3</td>
<td>6.6</td>
<td>13.0</td>
</tr>
<tr>
<td>Dornbusch</td>
<td>2.7</td>
<td>9.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Portfolio balance</td>
<td>3.5</td>
<td>10.0</td>
<td>15.7</td>
</tr>
</tbody>
</table>

Meese and Rogoff had estimated three models with "economic contents" — a monetary equilibrium model, the Dornbusch model and a portfolio balance model. In addition they had estimated a "naive" model with no economic content—i.e. a random walk. A random walk is taking the very simple assumption that the current exchange rate is the best predictor of the future:

\[ e_{t+1} = a + e_t + u_t, \]

where \( a \) is a constant and \( u \) is the error term, with the expected normal distribution \( u \sim N(0, \sigma^2) \). As we can see from table 6.2 the random walk was the best predictor in eight out of nine cases. This is really equivalent to stating two things:

- Changes in the exchange rate are unpredictable, and
- The exchange rate is not mean reverting.

This has led to the idea that exchange rates are in fact following a random walk process. However, one needs to take this with some modifications.

- The result is only valid if we talk about purely floating exchange rate between industrialised countries in the short term.
- And even here the random walk is not completely satisfying. It shows up that exchange rate returns—an other word for the change in the exchange rate—have fat tails. In other words, returns are not normally distributed after all. What does fat tails mean? While most changes in the exchange rate are small, some changes are very large. We see more large changes than we should expect if the errors were drawn from a normal distribution.
- More specific, the exchange rate tends to follow an ARCH/GARCH process. This implies that a period of high volatility is usually followed by more periods of high volatility, and a period of low volatility is followed by periods of low volatility. Volatility in the exchange rate is to some degree predictable.

Equilibrium models

Ideally we want to build models that assume rational behavior and complete information. The rational behavior/perfect information case is in the end the only real benchmark we have. We need to gain full understanding of what this framework can tell us before we modify these basic assumptions. The rational behavior/perfect information was our starting point when we derived an exchange rate model in Lecture 2. We concluded that the exchange rate, \( e \), could be expressed as a function of money supply, real output, foreign interest rates and foreign prices, i.e. as:

\[ e_t = \frac{1}{1+\eta} \sum_{s=0}^{\infty} \left( \frac{\eta}{1+\eta} \right)^{s-t} (\rho u_{t-s} + \beta e_{t-s} + \nu_{t-s} - \mu_{t-s}). \]

The above framework is known as a "monetary equilibrium model". In this model all volatility should be a result of news information, "news". Such research tend to find that the exchange rate moves as much in periods with no "news" as it does in periods with "news". So "news" do not seem to explain the exchange rate very well. One should on the other hand not forget that the monetary equilibrium model does seem to have some explanatory power in the long run. The exchange rate is reverting to fundamentals. It only takes much longer than we are able to explain. We should ask why our model is no good in the short and medium term. Some arguments:

- The model specification might be no good. E.g. most tests of the above model are done assuming a linear framework. It is however an established fact that asset prices have a non-linear relationship to fundamentals. One result from research on "chaos models", as discussed in ch. 9 in De Grauwe, is that in a non-linear framework there might be a relationship between fundamentals and prices even in the short run. A problem has been that such non-linear models are very difficult to make intellectually tractable.
- Some of our basic assumptions, like the assumption that free trade and free capital mobility might not hold. There might also be public inter- ference not captured in the model.
- In equation (6.4) we have made the very convenient assumption of no bubbles. However, in the many cases bubbles might be a real problem, i.e. remember our discussion of rational bubbles.
- More problematic is the fact that we really do not understand how ex- pectations are formed. This is probably the best explanation of why the equilibrium models do not fit, because it is an explanation that helps us understand why we do not understand asset market in general—the FX market is nothing

Some tentative conclusions:

- The stock market and the FX market reveal many of the same features. They both tend to move in long swings, with substantial volatility around these swings.
- However, both the movements in the trend and the volatility around the trend tends to be less for the FX market than for the stock market.
- This might indicate that the FX market is slightly more "efficient" than the stock market. If so, this is not a surprising conclusion. After all, as we discussed in Lecture 5, transaction costs are lower and volume is higher in the FX market than in the stock market. Both factors should contribute to a more efficient market.

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special. What do we not understand? Perhaps markets are not as rational as this model assumes, or perhaps we do not fully understand what ‘rational behaviour’ really implies. The economic definition of rationality—to be a forward looking and maximise some simple utility function—might not be a good description of reality.

Other possibilities exist as well:

- In the above model we assume that all variables, i.e. the price level, as everything else is given exogenously will adjust instantaneously to clear all markets. However, we know that prices might be sticky, at least for periods of up to a year. If we assume that prices take time to adjust, we must take into regard that it takes time to move from one equilibrium to another. The economy will spend time "outside equilibrium"—i.e. the introduction of "disequilibrium models"—the main tool in the "New Keynesian economics"; dominating much of current research in macroeconomics.

- When we looked at the FX-market, we saw that different dealers seemed to follow different strategies. This will be the case for many agents in asset markets. E.g. we know for certain that many traders will buy assets based on so-called technical analysis. Technical analysis bases buy and sell recommendations on graphs of historic prices. Such traders will by definition be backward looking—they will not fit our forward looking framework.

- An other feature of the FX market was low transparency. This might indicate that we as researchers do not have full control over which information dealers actually use when they set their exchange rates. We might have a "missing variable" problem.

In the following sections we will investigate whether these three options can help us understand the "exchange rate puzzle".

**Disequilibrium models**

Disequilibrium models come in many forms. We will focus on the assumptions that prices are sticky. How will this affect our discussion of the exchange rate? When we derived the model in equation (6.6) we assumed both the PPP and the UIP to hold at the same time. However, if prices are sticky this can no longer be the case. In the short term either the UIP or the PPP will not hold. We will have a state that differs from the long term equilibrium stable condition—we will be out of equilibrium. In the model we will present, due to Rudi Dornbusch, we assume that while the UIP will hold at every point of time, although the PPP will not. Assume that there is an unexpected shock to the money supply. Money supply increases. According to the equilibrium model prices should immediately increase and the exchange rate should depreciate, leaving the real exchange rate unaffected. The interest rate would not change.

What happens if prices take time to adjust? The long term expectations will be the same as in the equilibrium model. When the price adjustment has taken place, the two models have the same implications. The price level will be higher, and the exchange rate will be higher. However, in the short term only the exchange rate will adjust. Prices do not change. Hence, domestic interest rates must fall. This is necessary to induce people to hold the higher money supply—remember that lower interest rates make people increase their holdings of currency. If prices had risen immediately people would have been be willing to hold more money just because prices were higher, and the interest rate would have been unaffected.

If the exchange rate immediately settles at its long term value, while interest rates for a period fall below the foreign interest rate, the UIP can not hold. But we have assumed the UIP to hold at every point of time. So what must happen? If the UIP shall hold when domestic interest rates are below foreign interest rates, we need to expect the exchange rate to appreciate—as Etet+1 must be smaller than et. This leads to overshooting—when the money shock occurs the exchange rate must change by more than its long term expectations. This is the only way the UIP can hold—because only if the exchange rate depreciates "too much" now, it can be expected to appreciate back to its long term value.

The Dornbusch model

Let us assume a real money demand function of the type we used in Lecture 2. We assume the real money demand, \( m \), is a function of the expected interest rate, \( i \), and real output, \( y \). If interest rates increase, you want to reduce your holdings of currency, so the sign of \( i \) is negative. If real output increases you want to increase your holdings of currency, so the sign of \( y \) is positive. Further, we assume perfect foresight. We then write real money demand as

\[
m - p = -\eta_i + \phi y. \tag{6.5}
\]

Assume that UIP holds, and that \( et+1 - e_t = \epsilon \) so that

\[
e = i - \epsilon^*.
\tag{6.6}
\]

Further, we assume that there are both traded and non-traded goods in the economy. The price of non-traded goods is \( p \). We can define the price level as a weighted average of traded and non-traded goods,

\[
p = \sigma p_d + (1 - \sigma)(e + p^*). \tag{6.7}
\]

You see that when \( \sigma = 0 \) the price level evolves according to the PPP. However, if \( \sigma > 0 \) prices will not adjust automatically to the PPP level. If we substitute for (6.6-6.7) into (6.5) we obtain

\[
m - (\sigma p_d + (1 - \sigma)(e + p^*)) = -\eta(e^* - \epsilon) + \phi y. \tag{6.8}
\]

Figure 6.7: The equilibrium model vs. the disequilibrium model

![Figure 6.7](image)

The whole lines give the solution to an unexpected positive monetary shock in the monetary model as discussed in lecture 1 and 2. The dashed lines give the movements of e, p and i as is expected in the Dornbusch model.

When we reorder we obtain
We concentrate about \( p \) and \( e \). All other variables are exogenous in this model. For simplicity we define a variable \( z \) that includes all exogenous variables:

\[
z = (1 - \sigma)p^* - \eta p + \eta y - m. \tag{6.10}
\]

We can then write \( e^* \) as

\[
e = \frac{\sigma}{\eta}p_d + \frac{1 - \sigma}{\eta}e + \frac{1}{\eta}z. \tag{6.11}
\]

This gives us a first order difference equation for the change in the exchange rate measured in \( e \) and \( p \). To complete the model we need a description of the movement in the price level. We can define the real exchange rate, \( q \), as

\[
q = p - p^* - e. \tag{6.12}
\]

We define the exchange rate that will assure that \( q = 0 \) as \( e^* \), i.e.

\[
\dot{e} = p - p^*. \tag{6.13}
\]

\( e^* \) the exchange rate is undervalued, if \( e < e^* \) the exchange rate is overvalued. We postulate that the price level will move up when the exchange rate is undervalued and that the price level will move down when the exchange rate is overvalued. The change in prices, \( p^* \), can be written as

\[
\dot{p} = \delta(e - \dot{e}), \tag{6.14}
\]

where \( \delta > 0 \). If we substitute (6.13) into (6.14) we obtain

\[
\dot{p} = \delta(e - p + p^*). \tag{6.15}
\]

Equation (6.5) describe the domestic price level as a weighted average of traded and non-traded goods. If we substitute (6.5) into (6.15) and rearrange we obtain

\[
\dot{p} = \sigma \delta (e - p_d + p^*). \tag{6.16}
\]

If \( \sigma \) is zero, there will be no over- or undervalued exchange rate, as the PPP will hold at all times. We have two first order difference equations, one for \( e^* \) and one for \( p^* \). We now set \( e^* = p^* = 0 \). From equation (6.11) we obtain

\[
p_d = -\frac{1 - \sigma}{\sigma} p + \frac{1}{\sigma} z. \tag{6.17}
\]

From equation (6.16) we obtain

\[
p_d = e + p^*. \tag{6.18}
\]

An equilibrium is a situation where variables are stable. Equation (6.17) defines under what conditions the financial markets are in equilibrium. Equation (6.18) defines under what conditions the goods markets are in equilibrium. The financial equilibrium is illustrated in figure 6.8. In the financial market equilibrium we adjust the exchange rate. Assume the price level of non-traded goods is “too high”—i.e. we are at a point above the line defined in equation (6.17). For the real exchange rate to adjust towards PPP the nominal exchange rate must depreciate—i.e. the direction of the arrow in the diagram. If prices are “too low”, the nominal exchange rate must appreciate. The goods market equilibrium is illustrated in figure 6.9. In this equilibrium we adjust the price level. If the exchange rate is “too high”—at a point to the right in the figure—the price level must fall for the real exchange rate to adjust. Together the financial market and the goods markets define the economy. If we bring the two equilibrium conditions into one diagram we can identify the equilibrium of the economy. However, outside this equilibrium we have possible unstable situations. How the market is expected to move in the different areas is described by the arrows in figure 6.10. The model has a “saddle point” where the two lines cross. There is only one stable line that leads from disequilibrium to the saddle point, and this path is defined by the “saddle path” in the figure. Every other path than the “saddle path” will lead to increasing deviations from fundamentals. However, as foresight is assumed to be perfect, it is reasonable to believe that the economy will be at the saddle path.

Now we can analyse shocks. A money shock is a shock to the financial market. An increase in the money supply will shift the line for \( e^* \) same time interest rates must fall to bring prices down.
In a phase diagram we will not expect an immediate shift to the new saddle point. Prices will be sticky in our model. So the price level will take time to adjust. In the short term only the exchange rate can move. It will do so by shifting to the right, to the new saddle path. However, this rate will be higher than the rate in the saddle point. Over time the exchange rate must appreciate as it moves towards the saddle point. In parallel interest rates will rise and prices will rise. A new equilibrium will be established with a higher price level and an interest rate equal to the foreign interest rate.

The weakness of the Dornbusch approach

What is the the problem of the Dornbusch model? The model gained attention because an overshooting result gave a possible explanation for the high volatility in the exchange rate. If the exchange rate tended to overshoot, we should expect exchange rate volatility to be substantially higher than the volatility in underlying fundamentals. Further, the model gives an explanation of why we should expect to see a high correlation between the nominal and the real exchange rate. After all, prices do not move here, while the nominal exchange rate overshoots. This should imply that even the real exchange rate will overshoot for a period of time. However, the model only gives this result in the case of monetary shocks. If there is a shock to demand, through e.g. public spending, this will shift the p = 0 equation. Such a shift does not lead to overshooting in this model.

Is it reasonable to assume that frequent monetary shocks are the main cause of the high volatility in the exchange rate? Empirically, monetary shock are very hard to distinguish, so this is not an easy question to answer. However, as we pointed out above, the high volatility in the FX market is a feature it shares with almost every other asset market. It is fairly certain that monetary shocks does not explain why other asset markets are so volatile. Probably the Dornbusch model is to specific to give any good understanding of the high volatility in exchange rates. It is however still important as a benchmark for much of the current literature in exchange rate economics.

Chartists and noise traders

The monetary equilibrium model assumes that all traders are using the same strategy. They have estimated a model for the exchange rate that they are continuously updating, based on expected fundamental underpinnings for the exchange rate. If the exchange rate is "overvalued" compared with their expectations they sell, it the exchange rate is "undervalued" they buy. However, different traders might be using different strategies. E.g. most surveys of traders active in the FX market reveal that at least 30 per cent tend to use chartist methods to forecast the exchange rate. A chartist will use historic values of the asset price to predict future movements in the asset price. They are assumed to use rules that are extrapolative, like "buy when the 1-week moving average crosses above the 2-week moving average."

Milton Friedman argued in 1953 that non-fundamental speculators would over time lose money. However, it has been shown by a number of studies that one can make money using a chartist strategy. Therefore it might be perfectly rational to be a chartist, although this implies a trading strategy that does not care about "fundamentals." If the exchange rate only reverts to fundamentals in the long term, much money can be made following the short term trends. Feedback trading can also be rationalised if one assumes that the chartist sees their order book. If we assume that traders have more information than others, the less informed will have to observe the trading process, as the actual trading is a source of how other agents are behaving. If many traders are operating as chartists, this might increase the probability for the exchange rate to move in long swings. If the value of a currency is appreciating, chartist strategies would probably indicate to buy the currency, thereby fuelling the trend. One the other hand, if this trend is moving away from fundamentals, should not "fundamental traders" force the rate back?

At some point they will. However, their total force might not be big enough to do so before the exchange rate has deviated quite substantially from the underlying rate. Some potential problems:

- There is actual uncertainty about the future. The discrepancy between the rate and fundamentals become "too large", there can always occur some unexpected "news" that would justify the current rate. The fear of such events might hinder a rational investor from short-selling to bring the exchange rate back.
- Even if the rate is currently overvalued, there is no guarantee for when the trend will turn. Hence, if you sell today, while the rate continues to move away from fundamentals, you will miss out on an even bigger profit opportunity tomorrow.
- Even if you base your predictions on fundamentals, you are never certain that your model is a 100 per cent correct.

The noise trader paradigm is a continuation of the chartist-fundamentalist approach. A noise trader is defined as someone who responds to random price movements. Experiments tend to show that investors are overconfident about their own predictable abilities. Other studies have shown that many traders believe a large change in the exchange rate to be the most important "news" over the course of a day—rather odd, given that "news" should be something generated outside the market. Such findings might indicate that actual behaviour does not follow the monetary equilibrium model's definition of "rational". Describing noise traders is hence difficult. Recent empirical studies link model noise trading by assuming that noise traders behave like chartists.

Microstructure theories

In Lecture 5 we discussed the institutional framework of the FX market. We saw, among other things, that the FX market tended to be distinguished by high liquidity and transparency compared with other markets. The microstructure theory is a sidetrack of exchange rate economics that investigate how institutional factors influence the pricing process in the market. There have been two lines in the literature. The traditional approach has been to see the traders, e.g. the exporter or different trading system, will have a price impact. These studies are generally restricted to looking at very short term price fluctuations, mainly basing their findings on tick-by-tick data, or the continuous flow of orders in the market.

A more recent strain of the literature focuses on the the lack of transparency. The argument is that different investors will have different information. This information will be reflected to the market through their trading. One measure of trading is "order flow." Order flow is defined as net initiated purchases of foreign currency. If a customer calls a dealer and asks for 10 EUR in the SEK/EUR market, this implies an order flow of 10. If the customer asks for 10 SEK, this implies an order flow of -10. Order flow reflects "excess demand" in the market. What is "excess demand"? Should not always demand equal supply? Well, the demand curve might shift. Excess demand reflects the direction of shifts in the demand curve. How does this differ from the equilibrium models? In the monetary equilibrium model demand is determined by the current value of a number of fundamental variables. The models assume that everyone has the same information, and that everyone uses the same model to interpret this information.

However, "fundamental variables" are mostly reported only with a lag. E.g. the inflation rate is reported only once a month, and with at least one month lag. Real output is reported at a quarterly basis, with several months lag. The numbers are often revised several times after that. At every given point of time there exists no consensus of what real output is in exactly this point. Further, it is no reason to believe that every investor uses the same model to evaluate the information available. It is however reasonable to assume that investors' beliefs about current fundamentals will be reflected in their trading. So if investors demands more of a currency, this might imply that there are reasons for the exchange rate to appreciate.

The main proponent of this approach, Richard Lyons, argues that actual dealers hardly care about "fundamentals," when about setting prices. He claims that dealers mainly observe the amount of incoming trade, and adjust prices as a result of this. If so, order flow will be the determinant of much of the price fluctuations we can observe in the market. Figure 6.12 depicts accumulated customer order flow in the Swedish krona and the SEK/Dem exchange rate. As the order flow has a negative number, we see that customers are not buying SEK. On the opposite side must be either the Sveriges Riksbank, or the reporting banks—the Riksbank or the dealers must be accumulating DEM if customers shall be able to acquire accumulated SEK.

As we see there is a fairly good correlation between accumulated order flow and the exchange rate. Table 6.3 reports regression results which include order flow in regressions on the exchange rate. As we see, including order flows in the regressions improve the R2 quite considerably compared with regressions only including "fundamental variables", like interest rates and the stock exchange.

Table 6.3: Estimating daily returns
Figure 6.12: Accumulated customer order flow in the SEK/DEM market and the SEK/DEM exchange rate, January 1, 1998, to June 30, 1998

The uncovered interest rate parity (UIP)

In Lecture 5 we discussed the covered return to investing one krone in the foreign money market. We argued that this return should equal the return of investing one krone in Norway. From this we derived the CIP, or

$$ F_t - c_t = E_t c_{t+1} - c_t, $$

or

$$ f_t = E_t c_{t+1}. $$

3. The international Fisher relationship. From previous courses you should be familiar with the term "real interest rate", i.e. The real interest rate is defined by the Fisher equation that states that the real interest rate is the differential between the nominal interest rate and expected inflation,

$$ i^r_t = i_t - E_t \pi_{t+1} \Rightarrow i_t = E_t \pi_{t+1} + i^r_t. $$

Similar, we must have

$$ i^r_t = E_t \pi^*_t + i^*_t. $$

If we substitute equations (6.27) and (6.28) into (6.24) we obtain

$$ E_t d_{t+1} = (E_t \pi_{t+1} + i^r_t) - (E_t \pi^*_t + i^*_t). $$

The PPP states that

$$ e_t = p_t - p^*_t. $$

We should also have that

$$ E_t e_{t+1} = E_t p_{t+1} - E_t p^*_{t+1}. $$

So the PPP implies that

$$ E_t e_{t+1} - e_t = E_t p_{t+1} - E_t p^*_{t+1} - (p_t - p^*_t). $$

This can be rewritten as

$$ E_t d_{t+1} = E_t \pi_{t+1} - E_t \pi^*_t. $$

So if the PPP holds we must have that

$$ E_t \pi_{t+1} = E_t \pi^*_t. $$

The real interest must be equal between countries.

Testing the UIP

The 'expectations hypothesis' or the 'efficient market hypothesis' is built on the idea that if there are free capital flows and rational expectations we should expect

$$ f_t = E_t e_{t+1}, $$

to hold if markets are efficient. It is reasonable to try to test whether this hypothesis holds in empirical data. To do so we define a forecast error, $u,$ as

$$ e_{t+1} = E_{t+1} \pi_{t+1} - \pi_{t+1}. $$

The forecast error is the difference between the realised exchange rate in period $t+1$ and the expected exchange rate. If we substitute (6.36) and the CIP into the UIP equation we obtain

$$ E_t e_{t+1} = E_t p_{t+1} - E_t p^*_{t+1}. $$

From (6.37) we can obtain the following testable equation

$$ d_{t+1} = a + b(f_t - c_t) + u_{t+1}, $$

where $a$ is a constant and $v$ is an error term. This is equivalent to testing the equation

$$ d_{t+1} = a + b(i_t - i^*_t) + u_{t+1}. $$

According to the UIP hypothesis we should expect $a$ to be zero and $b$ to be 1. Figure 6.13 reports the finding of this regression for five different markets. As we see $b$ is not close to one in any of the five reported regressions. In fact $b$ is significant and negative. This implies that the interest rate differential is negatively correlated with depreciation of the currency. An investor who holds funds in a high yield currency not only

$$ F_t = \frac{1 + i_t}{1 + i^*_t}. $$

In log form this can be written

$$ f_t - c_t = i_t - i^*_t. $$

The uncovered return to investing one krone in the foreign money market will be

$$ (1 + i^*_t) E_t c_{t+1} - c_t. $$

As described in Lecture 2 the UIP is the idea that if expectations are rational, then the the uncovered return is not equal to the return of investing one krone in Norway. Arbitrage should assure that the uncovered excess return should be zero on average. We should expect

$$ E_t (i_t^* + E_t c_{t+1} - c_t) = 0. $$

There are three interpretations of this equation.

1. The expected depreciation rate equals the interest rate differential. Let us define expected depreciation as $E_{t+1} = E_{t+1} - c_t.$ If we insert this into (6.23) we obtain

$$ E_t d_{t+1} = i_t - i^*_t. $$

2. Forward interest rates are unbiased predictors of future spot rates. If we insert (6.20) into (6.23) we obtain

$$ f_{t+1} = E_t e_{t+1} - E_t p_{t+1} - E_t p^*_{t+1}.$$
benefits form higher yields, but also tends to benefit from an appreciation in the long run. You simply get a double dividend. But how can such excess returns exist?

We should notice that although the UIP does not seem like a good idea, it is not certain that one can make money on doing the opposite of the UIP. Even if the t-ratios of the b-parameters are significant, the R2 of the equations are very low, indicating a poor fit of our model. It is reason to doubt whether one can make money on trading against the UIP in the long run. However, one certainly can make money trading against the UIP in the short run. Figure 6.14 depicts the interest differential between Norwegian and German three month interbank rates and the NOK/EUR exchange rate. In this case Norway has over 3 per cent higher interest rates than Germany. According to the UIP we should expect NOK to depreciate substantially vis-à-vis the EUR. However, during the last months NOK has appreciated. Lending in EUR, investing in NOK has given a double dividend—both a substantial interest differential and an appreciation of NOK. Such cases are difficult to explain using the UIP.

We are certainly missing out one something here. Notice that when we set the expected future exchange rate equal to the forward rate we leave out any discussion of risk. However, most investors are risk averse. We should probably take this into regard in our calculations. Fama decomposed the forward premium, ft – et into two parts:

\[ f_t - e_t = \left( \frac{E_t (r_{t+1})}{e_t} \right) + \left( \frac{E_t (e_{t+1}) - e_t}{e_t} \right) \]  

(6.40)

where \( r \) is the risk premium and \( d \) as before is expected depreciation. One implication of the above regression results is that \( r \) certainly must be different from zero. However, here, as in many other parts of the asset pricing litera ture, it is difficult to interpret the risk premium implicated by our findings. If the risk premium was constant this should have been reflected in the finding that a \( = 0 \), however that is not clear from the regressions in figure 6.13. If the UIP shall match the data, the risk premium must fluctuate extensively. This does not seem credible. Several explanations of the rejection of the UIP build on the presumption that expectations are not perfectly rational. The peso problem is the idea that investors expect a large correction of the exchange rate at some time, they are however not certain when the correction will take place. If this correction did not take place in the sample used to test the UIP, the UIP will not hold.

Figure 6.13: Regressions on the UIP

<table>
<thead>
<tr>
<th>Currency</th>
<th>a</th>
<th>b</th>
<th>Error</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Pound</td>
<td>-0.0057</td>
<td>-2.300</td>
<td>0.0332</td>
<td>0.0344</td>
</tr>
<tr>
<td>(0.0028)</td>
<td>(0.062)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canadian Dollar</td>
<td>-0.0027</td>
<td>-1.464</td>
<td>0.0120</td>
<td>0.0247</td>
</tr>
<tr>
<td>(0.0009)</td>
<td>(0.058)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>French Franc</td>
<td>-0.0026</td>
<td>-0.800</td>
<td>0.0326</td>
<td>0.0015</td>
</tr>
<tr>
<td>(0.0022)</td>
<td>(0.028)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German Mark</td>
<td>0.0032</td>
<td>-3.542</td>
<td>0.0333</td>
<td>0.0287</td>
</tr>
<tr>
<td>(0.0041)</td>
<td>(1.148)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japanese Yen</td>
<td>0.0054</td>
<td>-1.913</td>
<td>0.0344</td>
<td>0.0201</td>
</tr>
<tr>
<td>(0.0032)</td>
<td>(0.119)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.14: The interest differential between Norwegian and German three month interbank rates and the NOK/EUR exchange rate

In the regression \((i−i)\) is known today while the actual value of \( w \) will first be known in the future. The idea that expectations are an unbiased predictor of future exchange rates will just hold if the environment is stable. If the environment is unstable, one must expect investors to continuously update their expectations. This ongoing learning process will create problems if we try to test for the UIP. Researchers have substituted actual data with expected depreciation rates, as is reported in surveys from the financial markets. It shows up that if one uses survey data instead of actual data, \( b \) tends to be close to one, and \( a \) is significantly different from zero. This implies that on survey data the UIP holds if one takes into regard a constant risk premium. People might in addition act according to the UIP, however their expectations are not the best unbiased prediction of the future. In the stock market one has attempted to use risk premiums as an explanation for the high returns in equity compared with risk free assets. However, to make the model match the data one must assume an incredible degree of risk aversion. The data simply does not square at reasonable parameter assumptions.

CHAPTER 7
PORTFOLIO CHOICE, RISK PREMIA, AND CAPITAL MOBILITY

The first six lectures have focused on how we should understand the exchange rate from a macroeconomic point of view. If investors are rational and for- ward looking, the exchange rate is determined by the expectations of future values of certain economic variables, so-called funda- mentals. We have discussed how the government would want to influence the exchange rate from a macroeconomic point of view. If investors are rational and for- ward looking, we should expect the exchange rate to be an unbiased predictor of future exchange rates will just hold if the environment is stable. If the environment is unstable, one must expect investors to continuously update their expectations. This ongoing learning process will create problems if we try to test for the UIP. Researchers have substituted actual data with expected depreciation rates, as is reported in surveys from the financial markets. It shows up that if one uses survey data instead of actual data, \( b \) tends to be close to one, and \( a \) is significantly different from zero. This implies that on survey data the UIP holds if one takes into regard a constant risk premium. People might in addition act according to the UIP, however their expectations are not the best unbiased prediction of the future. In the stock market one has attempted to use risk premiums as an explanation for the high returns in equity compared with risk free assets. However, to make the model match the data one must assume an incredible degree of risk aversion. The data simply does not square at reasonable parameter assumptions.

Some notes on methodology

In economics one has tended to focus on utility maximisation when analysing decisions under uncertainty. An economist is expected to work with as gen- eral specifications of the utility function as possible. The set up is as follows: You control a number of variables, so-called choice variables. In addition there is a number of factors you can not control, so-called state variables. Let the choice variable be how much you will sow on a field. The state variable will be the amount of rain that falls in the following months.

The payoff in the next period will depend on both factors. The more you sow, the higher expected output. But output will be different for each different state—it will depend on how much rain that falls. When you decide how much to sow you must first make up your mind about the likelihood of different states, e.g. the possibility of much rain, little rain or no rain. Then you must calculate expected profits under each state. Having done this, you can make a decision about how much to sow. This set up is of course also applicable to financial decisions. The state- preference framework concludes that the fundamental object of choice in financial decisions are payoffs offered at different states of nature. However,
it is extremely difficult to list all payoffs offered at different states of nature. As a result, the state-preference theory is almost without empirical content—it is impossible to test it, as we can not characterise the objects of choice.

In finance this problem is solved by assuming that investors indifference curves are defined in terms of the means and variance of asset return. It is clear that this is only a very special case of the utility maximisation approach. However, in financial economics the possibility of empirical testing is seen as more important than the generalisation of the theory. In this lecture we will use the mean-variance analysis to derive demand functions for foreign currency. The main idea behind the portfolio approach to exchange rates is that assets in the home country and in the foreign country are not perfect substitutes. This is an important difference from the monetary approach analysed in the previous lectures. In the monetary approach, exchange rates are assets in the home country and therefore assets are perfect substitutes, and the uncovered interest parity test is seen as more important than the generalisation of the theory.

Demand for foreign currency
In the mean-variance analysis, the investor is assumed to maximise a utility function, \( U \), of the form

\[
U = E(\pi) - \frac{1}{2} \sigma^2(\pi),
\]

(7.1)

where \( \pi \) is real rate of return on the portfolio, \( E \) is an expectation operator, and \( \sigma \) is the coefficient of relative risk aversion. We assume \( R > 0 \). The higher \( R \), the higher the risk aversion. High risk aversion implies that the investor is willing to sacrifice more in the form of lower returns if she can reduce her risk. Risk is measured as the variance of return. In the currency market risk is a factor because of uncertainty about depreciation and inflation. The investor is assumed to hold two types of assets: domestic currency, \( D \), and foreign currency, \( F \). Total real wealth, \( W \), denominated in local currency will be

\[
W = B + \frac{F}{P},
\]

(7.2)

where \( s \) is the exchange rate. The share of total wealth the investor chooses to hold in foreign currency is

\[
f = \frac{sF}{PW},
\]

(7.3)

The model treats \( f \) as the the choice variable. Given \( f \), one can compute

\[
F = fPW \quad \text{and} \quad B = (1 - f)PW.
\]

Expected real return on the portfolio will be given by

\[
\pi = (1 - f)(i - \mu_p) + f(i^* + \mu_p - \mu_p) = (1 - f)i + f(i^* + \pi) - \mu_p,
\]

(7.4)

where \( i \) is the interest rate, \( i^* \) is the rate of inflation, \( \pi \) is the rate of depreciation and \( \mu_p \) denotes foreign values. We assume that \( \mu_p \) is a stochastic variable with the distribution

\[
p \sim N(\mu_p, \sigma_{pp}).
\]

\( \mu_p \) is the expected mean of a change in inflation, and \( \sigma_{pp} \) is the expected standard deviation around the mean. Similarly, we assume that

\[
\pi \sim N(\mu_p, \sigma_{pp}).
\]

(7.5)

The correlation between \( \mu_p \) and \( \pi \) is \( \sigma_{pp} \). There is no uncertainty about the interest rate, as it is observable today. Given this, and using the rules for expectations and variances of linear combinations of stochastic variables, we obtain

\[
E(\pi) = (1 - f)i + f(i^* + \mu_p) - \mu_p,
\]

(7.7)

and

\[
var(\pi) = f^2 \sigma_{pp} + \sigma_{pp} - 2f \sigma_{pp}.
\]

(7.8)

If we substitute into equation (7.1) we obtain

\[
U = (1 - f)i + f(i^* + \mu_p) - \mu_p - \frac{1}{2} R[f^2 \sigma_{pp} + \sigma_{pp} - 2f \sigma_{pp}],
\]

(7.9)

If we maximise with regard to \( f \) we obtain

\[
\frac{\delta U}{\delta f} = -i + (i^* + \mu_p) - \frac{1}{2} R[2 \sigma_{pp} - 2f \sigma_{pp}] = 0.
\]

(7.10)

Solving (11.84) for \( f \) leaves us with

\[
f = \frac{\sigma_{ep}}{\sigma_{ee}} + \frac{i}{R\sigma_{ee}}.
\]

We see that local investors demand for foreign currency increase as the foreign interest rate increases, and decrease as the domestic interest rates increases. Note that in the monetary model we assume the UIP to hold, which implies that \( \pi = -\mu_p \), as \( \mu_p \) is just expected depreciation, \( \pi = (et - 1 - et) \). In this model we assume that there is a risk premium on domestic currency, \( r \), that is given by

\[
r = i - i^* - \mu_p.
\]

(7.11)

\( r \) is the extra return needed to hold domestic currency. Note that \( r \) can be negative—it might be that the risk is on the foreign currency. Using the definition of \( r \) we can restate (11.48) as

\[
\frac{1 - f_M}{f_M} = \frac{\sigma_{pp}}{\sigma_{pp} + \sigma_{pp} \pi},
\]

and the share of domestic currency in the minimum-variance portfolio as

\[
1 - f_M = \frac{\sigma_{pp} \pi}{\sigma_{pp} + \sigma_{pp} \pi}.
\]

Note that if the variance of inflation in the home country goes to infinity, e.g. because of hyperinflation, it would be optimal to hold only foreign currency. If there is no inflation risk in one of the two countries, an investment in that country would be equal to a risk-free investment. The investor would minimise risk by only holding that currency. In general the investor should divide her portfolio in inverse proportion to the variance in inflation in the two countries. An implication is that we should expect currency substitution in high inflation countries. If inflation is spiralling out of control, domestic residents should shift their holdings to foreign currency. This is actually what we observe. In most high inflation countries people tend to prefer to hold USD. Domestic currency is only held in small amounts for transaction purposes. In some hyperinflation countries people have actually substituted the local currency with foreign currency as a means of payment.

If we instead assume that there is no correlation between prices and the exchange rate we have \( \pi = 0 \). In this case holding foreign currency would only add risk, and the minimum-variance portfolio will only contain domestic currency. In general deviations from PPP will create a preference for the domestic currency in the minimum-variance portfolio.

The speculative portfolio
The speculative portfolio, \( -r \), depends on three parameters: the risk premium, the risk aversion and the variance of the exchange rate. First, observe that the sign is negative. This is due to the fact that we define the risk premium as the risk premium of investing in domestic currency. Remember that the risk premium is defined as \( i^* - \mu_p = \mu_p \). If this risk premium is positive one would optimise the speculative portfolio by increasing the exposure in domestic currency. This can be done by borrowing in foreign currency and investing at home. We see that the exposure to foreign currency will decrease as the risk premium rises. Second, the effect on the speculative portfolio of a change in \( R \) or \( \pi \) will depend on the sign of \( r \). If risk aversion increases, the speculative port-
Capital mobility is the ability of capital to move freely across borders. A high degree of capital mobility means that differences in expected return have a strong effect on the supply of foreign currency. That should imply that the share of foreign holdings in the investor’s portfolio would increase if the risk premium decreases. The smaller the value of \( R \) and \( \sigma_{ee} \), the more does a change in \( r \) affect the optimal currency portfolio. There will be perfect capital mobility, \( F_* \to m_\ast \), if risk aversion is zero, or if there is no exchange rate risk (\( oee = 0 \)). In this case all capital will flow to the country with highest return. This should lead to the elimination of all risk premia, implying a speculative portfolio of zero.

**Empirical calculations**

Let us take a look at Norwegian data for the period from January 1993 to September 2001. Over this period we find

\[
\sigma_{ee} = 0.003850.
\]

\[
\sigma_{ee} = 0.0156
\]

Note that these are results on monthly data. For the exchange rate we use NOK/EUR (DEM before 1.1.99). This tells us that if \( R \) should be very small in the Norwegian market—there is no reason to hold foreign currency to hedge against inflation risk. It is a general finding that the minimum-variance holdings of foreign currency should be small for industrialised countries with stable inflation rates. However, for countries with high inflation, this changes radically. Over a high inflation period in Argentina it was found that the optimal holdings of USD in the minimum-variance portfolio of an Argentinean investor was 86 per cent. As a comparison, the optimal holdings of USD for a German investor was found to be 9 per cent. Calculating the speculative portfolio is more difficult, not least because we do not know the actual coefficient of the risk aversion. However, it is usual to assume this to be around 2. Note that if the risk aversion is very high, capital mobility becomes very low.

A simple estimate of the risk premium is to take realised interest rates and return in the exchange market over the period we investigate. This is obviously not the correct measure of the risk premium, as this depends on expected values. However it should be reasonably close if we assume rational expectations. I the case of Norway vs. Germany we find that over the period from 1993 to 2001 we have

\[
\rho = 0.0156
\]

\[
\rho = -0.00034
\]

The interest differential is the annualised value of the three month rates. We use the mean of \( e_* \) as a measure of the expected depreciation.\( ^4 \)

This leaves 4One should however be aware that the distribution of \( e_* \) is severely skewed (it is not normally distributed), so the mean might not be appropriate here. The median is as a us usual risk premium, measured as an annual return, of \( r = 0.0156 + \sigma_{ee} \approx 0.00034 \). Investing in NOK has over the last 9 years been a purely win-win situation—you have got a higher interest rate than abroad, and in addition the positive return from an appreciating currency.

The optimal speculative holdings of foreign currency by a Norwegian investor is found to be

\[
f_S = \frac{-0.0198}{2 \times 0.003855} \times 12 = -0.214.
\]

Norwegian investors should have negative holdings of EUR. Norwegians should borrow in foreign currency, and invest in Norway. In other words, they should go short in foreign currency. In fact this is what we see—Norwegian banks borrow extensively abroad to finance loans in NOK. And to a growing extent, Norwegian households do the same. Note that foreigners should choose to hold Norwegian currency.

**Heterogeneous agents**

Capital mobility depends not just on the risk aversion, but also on how much wealth, \( W_\ast \), is actually invested. Assume e.g. that wealth is held by two groups, households and professional investors. One would usually expect that a household has a much higher coefficient of risk aversion than a professional investor. Assume only professional investors are active in the market, and that these have a low \( R \). Then even a small change in \( r \) or \( e_* \) can lead to large movements in the portfolio holdings of a currency. This can explain the movements of currencies under speculative attacks. If a country has held a high interest rate to attract foreign investors, we can expect these investors to hold mainly short term, liquid funds. If expected exchange change, e.g. due to a change in inflational circumstances, large funds might be extracted over night.

One should also note that the proportion of investors that take active positions in the currency market might vary over time. If there is a cost of obtaining information about the risk of investing in foreign currency, small investors might prefer domestic currency. However, this will only be true up to a certain point. If expected return in foreign currency increases beyond the cost of investing, a large share of investors will shift from being "passive" to being "active". Such shift can be induced by dramatic movements in interest rates, exchange rates or reserves. This might be one explanation for contagion of currency crises, as we discussed in Lecture 4. One should also note that a the proportion of investors that take active positions in the currency market might vary over time. If there is a cost of obtaining information about the risk of investing in foreign currency, small investors might prefer domestic currency. However, this will only be true up to a certain point. If expected return in foreign currency increases beyond the cost of investing, a large share of investors will shift from being "passive" to being "active". Such shift can be induced by dramatic movements in interest rates, exchange rates or reserves. This might be one explanation for contagion of currency crises, as we discussed in Lecture 4.

We retain the assumption of only two assets; domestic currency, B, and foreign currency, F. We are only looking at financial assets. Net financial holdings of an asset summed over all sectors in the economy must be zero—investments made by one group must be reflected as loans taken up by another group. In other words: one agent’s assets are the liabilities of another agent. A currency is the liability of the government. Net outstanding liabilities on the government must equal total holdings of domestic currency by domestic private and foreign investors. We must have that

\[
F^g + B + P^* = 0.
\]

This must also hold for foreign currency. We must have that

\[
F^g + F + P^* = 0.
\]

Real financial wealth in for the private domestic sector, measured in domestic currency, will be

\[
W = B + \epsilon F_P.
\]

Likewise, the real financial wealth of the foreign sector, measured in foreign currency, will be

\[
W^* = \frac{B^*}{\epsilon} + F^* P^*.
\]

where \( P^* \) is the foreign price level.

\[
F = f \frac{PW}{\epsilon} = \left( \frac{\sigma_{ee}}{\sigma_{ee}} - \frac{\epsilon}{R \sigma_{ee}} \right) \frac{PW}{\epsilon}.
\]

If we use equation (11.53) and substitute that into (10.29) we obtain the demand for foreign currency by domestic private investors. Likewise we know that foreigner’s holdings of domestic currency, \( b^* \), which from the point of view of the foreigner will be holdings of foreign currency, will be

\[
b^* = \frac{\sigma_{ee}}{\sigma_{ee} + R \sigma_{ee}}.
\]

Note that we change signs, as the currency is defined as the price of foreign currency in domestic currency. From the point of view of the foreigner a depreciation of the domestic currency becomes an appreciation of the currency of his home currency, and vice versa. The demand for foreign currency by foreign residents will then be

\[
F^* = \frac{\sigma_{ee}}{\sigma_{ee} + R \sigma_{ee}} \left( \frac{B}{\epsilon} + F \right) \left( 1 + \frac{\sigma_{ee}}{\sigma_{ee} + R \sigma_{ee}} \right) \left( \frac{P}{\epsilon} + F^* \right).
\]

\[
F^* = \left( \frac{\sigma_{ee} - \frac{\epsilon}{P}}{\sigma_{ee} + \frac{\epsilon}{P}} \right) \left( \frac{B}{\epsilon} + F \right) \left( 1 + \frac{\sigma_{ee}}{\sigma_{ee} + R \sigma_{ee}} \right) \left( \frac{P}{\epsilon} + F^* \right).
\]
This gives us the supply of foreign currency to the domestic central bank. If we e.g., think about the NOK/EUR market, this will be the supply of EUR to Norges Bank. How Norges Bank reacts to a change in supply of foreign currency depends on the exchange rate regime. In a floating rate regime $F_g$ is given exogenously, and the right hand side of (7.25) will determine the exchange rate, as the exchange rate adjusts to clear the market. If the exchange rate is fixed, $F_g$ must be adjusted to clear the market. This will be done through interventions from the central bank. If we draw a diagram with $s$ on the y-axis, and foreign reserves on the x-axis, we tend to assume that supply of foreign currency to the central bank will increase if the domestic currency fall in value, as we have done in figure 7.1. In other words, we expect

$$
F_g = \left[ \frac{\sigma_{pe} c_{pe}}{\sigma_{pe}} \right] \left( \frac{B^*}{\sigma_e} + F^* \right) + \left[ 1 + \frac{\sigma_{pe} c_{pe}}{\sigma_{pe}} \right] \left( B^* \frac{\sigma_e}{\sigma_{pe}} + F^* \right) + \left[ 1 + \frac{\sigma_{pe} c_{pe}}{\sigma_{pe}} \right] \left( B^* \frac{\sigma_e}{\sigma_{pe}} + F^* \right).
$$

This follows from the asset sheet of the central bank. Foreigners will hold a positive amount of both currencies. We can bring our understanding a little further. Let us make the convenient assumption that $oep = oep^*$ = 0. That is similar to a statement that the PPP does not hold. We know that this implies that the minimum-variance portfolio should contain no foreign currency. This is not unreasonable as a short term description of a floating exchange rate. Given this, we have that $B^*$ = - $f$. We also know that $B^*$ = $B$ - $Bg$. If we substitute this into (11.59) we can solve for the condition of $Bg$ > 0 by solving

$$
f (-B^* - B^* f) + (1 + f) B^* f > 0.
$$

This is equivalent to assuming that demand for domestic currency rise as domestic currency get cheaper, an assumption we used when drawing demand and supply for foreign exchange in previous lectures. We also know that $B^* = f P^* W^*$, from which we obtain

$$
P^* W^* \frac{\epsilon}{B^*} < -1.
$$

Bg is domestic currency issued by the central bank. As money is a liability on the government, it must be assumed to be a negative number. (7.30) will be equivalent to

$$
P^* W^* \frac{\epsilon}{-B^*} > 1.
$$

P + W + $s$ is foreign wealth denominated in domestic currency. $B^*$ is domestic currency issued by the domestic central bank. This will be a proxy for the size of the domestic economy. The implication is as follows: as long as foreign wealth is larger than the domestic economy, $Bg$ > 0. In other words, if the foreign economy exceeds the local economy, a reasonable assumption for most countries, the foreign reserves will increase with a higher (weaker) exchange rate. However, note that the slope of the line will depend on the ratio of foreign wealth to the domestic economy. The smaller the domestic economy, the steeper the slope. The intuition might be as follows: if the foreign currency reserves of the domestic central bank increases, the holdings of domestic currency among private domestic and foreign residents must increase.

That follows from the asset sheet of the central bank. Foreigners will hold more domestic currency if this asset becomes cheaper—if it depreciates. Locals will retain more of their earnings in domestic currency if it becomes more valuable—if it appreciates. If both groups are equally large, the price of the currency need not adjust for the market to absorb the increased supply of domestic currency. However, if foreigners are the largest group, the price must depreciate. If locals are the largest group, the price must appreciate, and the line will have downward slope.

What can we bring of this? A reasonable question is how the holdings of $F_g$ is affected by a shift in $f$. If we retain the assumption of oep = oep^* = 0, we can rewrite equation (11.57) as

$$
F_g = -\frac{PW}{\epsilon} - (1 + f) P^* W^*.
$$

Maximising with regard to $f$ we then obtain that

$$
\frac{\delta F_g}{\delta f} = -\frac{PW}{\epsilon} - P^* W^* < 0.
$$

An increase in $f$ will shift $F_g$ inwards in the diagram in figure 7.1. A fall in $f$ will shift $F_g$ out in the diagram in figure 7.1. If the central bank holds the foreign currency reserves fixed, the central bank supply function is a vertical line. Note that this gives an interesting application if we compare a small country with a large country. In a small country the line is likely to be steep. In a large country is almost horizontal. An implication will be that a similar shift in $f$ will cause quite different effects depending on whether we are in a large country or a small country. In a small country the exchange rate must adjust much more to balance the market than what is the case in a large country. In previous lectures we have discussed the fact that small countries and developing countries have tended to be sceptical to a freely floating exchange rate. This might give an additional explanation of this fact. In a country with a small economy smaller shifts in investor sentiment might cause much larger impact on the exchange rate than what is the case in rich and large countries.

### A current account surplus

A current account surplus is the same as a shift in wealth from foreigners to domestic private residents. A transfer of wealth shall not affect the speculative portfolio, only the minimum-variance portfolio. A positive current account will increase the central banks holding of foreign currency if the share of foreign currency is higher in the minimum variance portfolio of foreigners than of domestic residents, i.e. that there is home bias in currency preferences.

Figure 7.2: Implications for how much the exchange rate much change to clear the market if $f$ change—small vs. large country

Mathematically speaking this can be expressed as
This seems like a fairly reasonable assumption, not least given the empirical numbers reported above. A country with a positive current account, like Norway, can accumulate foreign reserves. Countries with substantial negative current accounts shall, according to this rule, lose foreign reserves. In our figure a current account surplus should lead to a drain in p. In a floating exchange rate regime a current account surplus or deficit will presumably have less effect on the exchange rate in a large country like the US or Japan, than in small countries, like Norway or Sweden. One should note the following special case. If the PPP holds, we have that \( \sigma_{\text{pp}} = \sigma_{\text{pp}} + \sigma_{\text{pp}} \), \( \sigma_{\text{pp}} = \sigma_{\text{pp}} \), \( \sigma_{\text{pp}} = \sigma_{\text{pp}} \), and \( \sigma_{\text{pp}} = \sigma_{\text{pp}} \). This would imply that:

\[
1 + \sigma_{\text{pp}} > \sigma_{\text{pp}}.
\]

This is an equilibrium condition. We have previously defined \( f \) as:

\[
f = 1 - \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}}.
\]

When the PPP holds, the minimum-variance portfolio share should depend only on the difference in inflation volatility between the two countries. Developing countries need to create a preference for the domestic currency. Current account movements make no difference. To understand the full effect on the government’s position one needs to include government debt. If a country has a current account deficit there will be a drain of foreign reserves from the central bank. If it in addition has a fiscal deficit it needs to finance this by issuing new debt. However, there is no demand for domestic currency. So debt cannot be financed through domestic currency bonds.

The first possibility is a short term solution. The second option might be extremely expensive. A developing country with both substantial debts and a current account deficit is not seen as especially creditworthy. If foreigners doubt the long term prospects of the country, the demand for debt may dry up. Many developing countries are not able to finance their debt in long term contracts. Much of the debt is short term. This implies that developing countries are in the market for new loans not just to pay for a current deficit, but also to refinance previous debts. If the borrowing possibilities in world markets dry up, the country has to choose between depletion of the foreign reserves or asking for a moratorium, i.e. a default on the foreign debt. This is the story we see in countries like Russia in 1998, Brazil in 1999 and Argentina in 2002.

Equilibrium risk premium

Let us restate equation (7.21) as:

\[
F = fP_{\text{c}} - (1 - b^f)(PW^*) + \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}} = fP_{\text{c}} + \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}}.
\]

If we solve for the risk premium, \( r \), we obtain:

\[
r = \frac{fP_{\text{c}} + \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}} - (1 - b^f)(PW^*)}{(PW^*)}.
\]

Note that as \( F = fP_{\text{c}} \), the last term can be written as:

\[
f = \frac{1}{b^f}.
\]

The term

\[
\frac{fM}{PW} + \frac{1 - b^f}{PW} = \frac{fM}{PW} + \frac{1}{PW}.
\]

This is the share of foreign currency of total wealth held by private domestic and foreign residents. Let us define this as \( \Phi_{\text{M}} \). Using the same argument as above, we must have that

\[
\frac{fM}{PW} + \frac{1 - b^f}{PW} = \phi_{\text{M}}.
\]

The term

\[
fM = 1 - \frac{b^f}{b^f}.
\]

This implies that we can simplify equation (7.38) to:

\[
r = \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}} - \frac{\sigma_{\text{pp}}}{\sigma_{\text{pp}}}.
\]

We see that the risk premium is a product of three factors: \( R \), \( \sigma_{\text{pp}} \), and \( \sigma_{\text{pp}} + \sigma_{\text{pp}} \). Risk premium will be high if risk aversion or exchange rate volatility is high. This is a result of low capital mobility. \( b^f \), \( b^m \), tells us to which extent investors are taking more exchange rate risk in the domestic currency than in the foreign currency. If more domestic currency is held than what would be optimum, the risk premium increases. If “excessive risk” goes up, the risk premium increases. \( b^m \) implies that the market is over-supplied with domestic currency, so the risk premium must be positive to make supply meet demand. This is an equilibrium condition. We have previously defined \( f \) as:

\[
f = \frac{1 - b^m}{b^m}.
\]

Interest rates and the expected depreciation must adjust to assure that equation (7.43) holds.

The collapse of a currency board

In previous lectures we have discussed the role of currency boards. A currency board is an institution that guarantees to exchange the domestic currency in a foreign currency at a given parity. The board is supposed to control an amount of foreign currency that at least equals the amount of domestic currency in circulation. On paper a currency board should be a fully credible institution if the rules are followed. The risk of devaluation should in any event be zero. If the UIP holds, there should be no risk premium. If a country with the currency board. However, when we discussed the case of Argentina in Lecture 3 we found that \( i = 4 \times i \times 7 \) for the whole period since the currency board was imposed in 1991.

Risk premium and the need for capital

In Argentina the trust of the government has been low for a long time. Even with a currency board, it was reasonable to keep much of private holdings in foreign currency. Foreigners would probably only place their money in Argentina if it was for speculative purposes. So \( b^m \) was probably low. However, Argentina is a developing country with need for capital investments. There was need for \( b^m \) to fulfill these needs. If this conditions was to be satisfied, the equilibrium risk premium had to be positive. Both Argentineans and foreigners would take advantage of this risk premium. As a result Argentines held a negative speculative portfolio of foreign currency— they borrowed money abroad and invested them in ARP assets.

Risk premium and expected depreciation

We need to give a short comment on the risk premium at this point. Expected depreciation is not an easy term to handle. Even if domestic interest rates are higher than foreign interest rates, the risk premium might be zero or negative if expected depreciation exceeds the interest rate spread. This makes it important to distinguish between risk premium at different time horizons. In most fixed exchange rate regimes it is only a small probability that a devaluation will take place tomorrow. The probability of a devaluation over the time frame of one week, or even one month is still relatively small. However, the longer the time span, the higher the probability of an adjustment within that time span.

In the case of Argentina, it was clear that the commitment to the currency board was strong. The chance of a devaluation over night was considered small. So if \( i = 4 \times i \times 7 \) and we should expect the short term risk premium in Argentine pesos to be positive. However, few believed the currency board would exist for ever. So for long term investments the risk premium was probably much smaller. Note one implication for short term vs. long term capital flows: if we believe the above argument, the risk premium tend to be higher in the short run than in the long run in a fixed exchange rate regime. This encourages the stream of short term capital over long term capital. A floating exchange rate might increase the risk of adjustments in the exchange rate in the short term. This will discourage short term flows. One often assume that a country wants to attract long term capital. Long term capital flows are considered to be more accommodating if fundamentals are important in the long run, it probably should make no difference. However, fixed exchange rate regimes often break down during periods of speculative attacks. Speculative attacks tend to increase macroeconomic uncertainty for some period of time. It might actually be that a fixed exchange rate regime will discourage long term flows.

Effects of a fall in risk premiums

So what made the situation in Argentina unstable? Notice that if doubts are created about the currency board, two things happen simultaneously:

1. Expected \( r \) will fall as expected depreciation, \( e_i \) rises.
2. All above as uncertainty rises.

It was clear that the competitiveness of Argentina had been eroded over a long time. This was due to two factors:

1. The USD was appreciating compared to other currencies. As a result the ARP was
2. The fiscal deficit of Argentina created uncertainty about the long term viability of the regime.

One option was to change the parity of the board. But the Argentine government repeatedly stated that the currency board would not be fiddled with. However, in the middle of 2001 the Minister of Finance, Domingo Cavallo, openly suggested that leaving the currency board was an option. Over night, the argument for taking speculative positions in the ARP vanished. One held ARP because the risk premium was high. The risk premium was high because one believed the currency board to be credible.

In the new situation everyone wanted to re-balance their portfolios with less risk in ARP and more risk in USD. Everyone went to the banks to exchange their currency holdings of ARP into USD. At the same time they wanted to close their ARP deposits. Remember that people had loans denominated in USD and deposits denominated in ARP. According to the rules of a currency board, the board should be able to redeem every currency note in circulation at parity. However, in this case the currency in circulation was increasing fast, as everyone were withdrawing deposits in exchange for currency. So possible demands on the currency board far exceeded the amount of USD actually held by the board.

Further, the banking system was on the verge of collapse. The banks had most of their assets in the form of long term USD loans. They did not have sufficient reserves in ARP to cover all ARP deposits. The banks were not able to redeem their holdings of ARP since they did not have the money in their vaults. In this case the speculative attack on the currency was at the same time a speculative attack on the banking system.

The government had two choices:
1. They could devalue over night. However, as most Argentinians had loans in USD, and the cost of these loans would increase dramatically if the currency collapsed, this option would certainly lead to immediate social unrest. Indeed the government probably hoped they could retain the currency board.
2. They could restrict the currency in circulation. The way of doing so was to restrict the amount one could withdraw from the banks. The hope was that this could give the government time to restore credibility. If the amount of currency in circulation was restricted, it was possible to redeem the currency that was in circulation into USD, thereby showing that the system worked. At the same time one avoided a collapse of the banking system. The problem was that this system was both unfair and very problematic.

(a) It was unfair because they who had redeemed their money before the restrictions now seemed to get a better deal—they could ex-change their money at parity. Those who had trusted the system got screwed.
(b) As we all know, most of us depend on the possibility to take money out of our accounts every week if we shall be able to pay our bills. Over night this possibility was restricted. Many middle-class Argentinians found themselves in grave liquidity problems.

On top of this the Argentinean government needed to borrow money. Argentina had both a fiscal and a current account deficit. Foreigners were of course doubtful about the long term prospects of Argentinean debt, not least because the country was asking for a moratorium on existing debt. The Argentinean government had to borrow at home. But nobody wanted to hold domestic currency. The only way to solve the problem was to force people to hold government debt. State wages were paid in government bonds. State debts were paid in government bonds.

This further undermined the credibility of the system. On the one side the government tried to reduce the amount of ARB in circulation to strengthen the credibility of the currency board. On the other side they issued something looking very much like new money in everything but the name. Argentina became a country with many currencies. State bonds were used as means of payment, although people were accepted to much under their face value. The Argentinians fiddled with the system. The country could not work over time. People went on the streets demanding their money. The currency board was abolished, and the ARP depreciated with about 50 percent against the USD. To sweeten the pill people were allowed to exchange their USD loans in Argentinean banks into ARP loans at the old parity, at an unidentified cost to the government. Argentina declared that they were unable to repay foreign debts. The country went into a state of total disarray from which it has yet, as of May 2002, to emerge.

Empirical applications of the portfolio choice model
There are two main problems if we want to test the above theory.

1. We have made very simplistic assumptions of monetary policy. The most reasonable would be to assume a central bank reaction function that was neither horizontal nor vertical, but downward sloping. The actual slope is probably difficult to identify.

2. In practice we can observe the flow of private, government and domestic holdings of foreign currency. However, we can not observe the stocks involved. In the science of accounting it is by no means certain that flows and stocks are compatible. However, one can perhaps argue that observing flows might be sufficient if the focus of the analysis is on the change in the exchange rate—not the level of the exchange rate. One of the results above was that one should expect portfolio shifts to have more impact in small than in large countries. One implication might be that small floating currencies are more volatile than large floating currencies. That is not an obvious result from empirical data. Testing equality of variance in daily returns on EUR/USD, SEK/USD and NOK/USD from 01/01/1999 to 04/01/2002 we find that there is no difference in the variance when we compare EUR/USD and SEK/USD. However, the variance in NOK/USD is significantly lower than for the two other exchange rates.

It is very difficult to evaluate whether this is a result of our theory being wrong, or if the Norwegian and Swedish governments make a stronger effort to stabilise the effects of changes in currency flows on the currency than the Federal Reserve does. This might be the case even though both Norway and Sweden claim to have a freely floating exchange rate. Norway provides an interesting example. Although there has been no "intervention" since the beginning of 1999, Norges Bank is continuously active in the market, accumulating foreign exchange that is invested in the government controlled "Petroleum Fund". It is hard to identify the actual effects on the exchange rate from these activities. Likewise, we observe that Svenska Riksbanken is de facto accumulating reserves in periods of current account surplus. Is this just a random event, or the results of a conscious strategy?

Appendix

Mean-variance vs. state-preference
The mean-variance approach will match the state-preference utility maximisation if:

1. Preferences are time separable—the utility of consumption in the next period does not depend on the current level of consumption.
2. The relative risk aversion is constant over time.

Figure 7.3: ARP/USD exchange rate 1998-2002

3. Both the price level, , and the exchange rate, , follow Wiener processes, or Brownian motions. This implies that that level of return in the two variables, , over time. and , are normally distributed and independent.

4. Expectations, variances and covariances are constant over time.

The exchange rate
The most simplistic way to write equation (7.25) will be

If we solve this for the exchange rate we obtain

In previous lectures we have stated that in a floating exchange rate regime the central bank will hold no foreign reserves. We simplify by setting . We then obtain

Remember that the PPP states that the exchange rate is given as
In this framework one ratio will differentiate the exchange rate from the PPP rate: the ratio of nominal wealth held in the foreign currency unit. If this fraction is shifting over time, we should expect to see the nominal exchange rate changing, and we should also expect a correlation between the real and the nominal exchange rate.

**CHAPTER 8**

**THE REAL EXCHANGE RATE AND CAPITAL FLOWS**

Some notes on research strategy

Modern macroeconomics is built on analysing the maximising behavior of agents in a general equilibrium multi period setting. Although this research has been going on for some time—the book of Obstfeld and Rogoff from 1996 is probably the best summary of this kind of analysis in an open economy framework—many questions remain unsolved. However, interesting questions can now be analysed in such a framework. Not least, this framework allows to discuss questions in a more dynamic setting than what is possible in the traditional models, like the Swan diagram or the Mundell-Fleming model.

Some empirical observations

We remember that the real exchange rate, $Q$, is defined as

$$ Q = \frac{P^*}{P}. \quad (8.1) $$

Figure 8.1: The real exchange rate. DEM/USD

Real exchange rate calculated using CPI.

A central assumption in the monetary equilibrium model was the purchasing power parity—the belief that arbitrage would assure that the real exchange rate is constant over time. However, if we use the consumer price index as a proxy for the price level, and calculate the real exchange rate, we find that for most countries this is certainly not constant. Two examples are given in figures 8.1 and 8.2.

Using the CPI for such measurements is not unproblematic. The weights of goods in the CPI will differ between countries, and they will change over time. Relative prices will change with changes in tariffs or taxes. However, the findings illustrated in figures 8.1 and 8.2 are fairly representative for the results reported in numerous empirical studies of the PPP. For countries at about the same level of productivity, the PPP seems to hold over time, although the real exchange rate tends to move in long swings, with a mean reversion of about 3-4 years. The length of this cycle has been described as a “puzzle”, given that the most reasonable explanation for swings in the real exchange rate, sticky prices, should imply a mean reversion of about 1 year—in other words much faster than what is observed. For countries with more marked differences in technical development the PPP does not seem to hold. A general result is that countries with high economic growth tend to experience real appreciation over time. This is clearly illustrated in the case of Japan in figure 8.2.

Differences in the price level

Implicit in the assumption of purchasing power parity is the assumption that over time the ratio of price levels will be one if measured in the same currency, i.e. $s = P$. The implication is that the price level should be the same across countries. Price levels are very difficult to measure. The standard measure of prices published by statistical bureaus is the consumer price index, the CPI. However, the CPI does not measure the price level, only relative change in the cost of a basket of consumption goods. The best measure of actual price levels is provided in the Penn World Tables, where prominent economists have done empirical estimates of the relative price of comparable goods baskets for a number of countries. These tables are only available with a lag of many years—the most recent numbers are from the mid-1990s. However, what is clear from these data is that the price level is not the same across countries. In general one finds that the price level is much higher in countries with high income per capita. An interesting test of this result can be found if we compare the numbers in the renown “Big Mac index” published by The Economist in the end of April every year. The Economist collects the price of a Big Mac sold by MacDonalds in a number of countries. It calculates the price in USD at the current exchange rate. If absolute PPP holds, the price of one Big Mac should be the same as in the US.

Of course, there are a number of problems using a Big Mac as an indicator of the price level. This is one very specific good, not very representative of “normal” consumption. One the other hand it is a very standardised good. We are in fact pretty certain that we compare identical items across boards. The item contains both tradable parts, like beef and bread, and non-tradable parts, like labour input.

Table 8.1 gives the price of a Big Mac measured in USD for seven different countries. We can summarise some stylised facts from the table:

a. The price is clearly much higher in the five industrialised countries than in China and Russia. b. The prices are fluctuating over time. c. With the exception of Russia the price has moved towards the US price from 1995 to 2002. This might be an indication that price levels over time tend to converge.

Figure 8.2: The real exchange rate. JPY/USD

Real exchange rate calculated using CPI.

<table>
<thead>
<tr>
<th>Country</th>
<th>1995</th>
<th>2000</th>
<th>Ratio</th>
<th>CPI per capita</th>
<th>Ratio to USD</th>
<th>PPP adj. CPI per capita</th>
<th>Ratio to USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>5.59</td>
<td>5.28</td>
<td>1.00</td>
<td>31.70</td>
<td>1.00</td>
<td>31.70</td>
<td>1.00</td>
</tr>
<tr>
<td>Switzerland</td>
<td>5.28</td>
<td>5.81</td>
<td>1.11</td>
<td>35.30</td>
<td>1.11</td>
<td>35.30</td>
<td>1.11</td>
</tr>
<tr>
<td>France</td>
<td>2.32</td>
<td>2.49</td>
<td>1.00</td>
<td>32.59</td>
<td>1.00</td>
<td>32.59</td>
<td>1.00</td>
</tr>
<tr>
<td>Germany</td>
<td>3.48</td>
<td>3.79</td>
<td>1.00</td>
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<td>1.00</td>
<td>25.00</td>
<td>1.00</td>
</tr>
<tr>
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<td>5.29</td>
<td>1.14</td>
<td>32.410</td>
<td>1.00</td>
<td>32.410</td>
<td>1.00</td>
</tr>
<tr>
<td>China</td>
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<td>1.00</td>
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<td>1.03</td>
<td>33.07</td>
<td>1.00</td>
<td>33.07</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The first two columns give the the price of a Big Mac in seven different countries. Measured in USD at current market exchange rate. Ratio is the country price relative to the US. GNI per capita is numbers for 2000, measured at the “Atlas method”, a...