Chapter 5 – How does the exchange rate react to a cost-push shock?

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This article analyses how the nominal exchange rate reacts to cost-push shocks. Generally, the effect is uncertain as it depends on how the central bank reacts. The more weight the central bank places on price stability and the steeper prices are, the more likely it is that a cost-push shock will result in a nominal appreciation. With flexible inflation targeting, a cost-push shock is most likely to result in an appreciation in the short term, unless confidence in the central bank deteriorates at the same time.

1. Introduction

The exchange rate is an "asset price" and the price of currency in the market is based on supply and demand. Foreign exchange transactions may be the result of international trade in goods and services. However, the bulk of foreign exchange transactions occur as a result of adjustments in the currency composition of assets and liabilities.

The exchange rate is determined by a large number of factors. In this article we will look at a particular type of disturbance - or shock - that may be of importance to the exchange rate, cost-push shocks. A cost-push shock is defined as a change in inflation that is not a result of pressures in the economy.[1] The wage settlement in 2002 is an example of such a cost-push shock. The final wage settlement was far more expansive than estimated by most forecasters one year earlier.

[1]We focus on temporary changes in the economy that translate into temporary changes in the rate of inflation.

In order to analyse the effect of a cost-push shock on the exchange rate, we will differentiate between direct and indirect effects. The direct effect can be defined as the effect a cost-push shock would have if monetary policy had not reacted to the shock. The indirect effect comes via the central bank's response. To analyse these effects, we need a model. This model is presented in section 2, whereas in section 3 we discuss the effect of a cost-push shock both in general and with the help of simulations in our model.

2. A simple model

We have assumed that there is an inflation target for monetary policy and that the policy can be represented by the central bank minimising the following loss function:

$$(1) \qquad L_t = E_t \left\{ \sum_{k=0}^{\infty} \beta^k \left[\left(\pi_{t+k} - \pi^* \right)^2 + \lambda y_{t+k}^2 \right] \right\}$$

where π and π^* are the current rate of inflation and the inflation target, respectively, y is the output gap – discrepancy between actual production and production capacity, β is a discount factor and λ measures the importance the central bank attaches to stable production in relation to stable inflation.

Our starting point is a simple model for a small open economy developed by Laurence Ball.[2] It comprises three equations in addition to a measurement function for monetary policy:

$$(2) \qquad y_t = -\beta_r r_{t-1} + \beta_e e_{t-1} + \beta_y y_{t-1} + \varepsilon_t$$

$$(3) \qquad \pi_t = \pi_{t-1} + \alpha_y y_{t-1} + \alpha_e \left(e_{t-1} - e_{t-2} \right) + \eta_t$$

$$(4) \qquad e_t = -\theta_r \left(r_t - r_t^* \right) + \nu_t ,$$

where r and r^* denote domestic and foreign real interest rates, i.e. nominal interest rates minus

[2] Laurence Ball (1999), 'Policy Rules for Open Economies'. In John Taylor (ed.), *Monetary Policy Rules*

expected inflation and e is the logarithm for the real exchange rate, i.e. the price for foreign goods measured in NOK relative to the price of Norwegian goods. In addition, the variables ε, η and v are shocks (or disturbances) and the β-, α- and θ parameters are positive constants.

Equation (2) is an IS relationship for a small open economy and describes aggregate demand as a function of the real interest rate, the real exchange rate and of demand in the previous period. In addition, ε is a demand shock - that is a shock in demand in excess of that which is ascribable to the real interest rate and the real exchange rate. The period length is assumed to be one year so that a change in real interest rates or the real exchange rate translate into a change in demand with a one-year lag.

Equation (3) is a Phillips curve for an open economy. It is assumed that there is a considerable degree of persistence and that inflation will remain high unless the authorities cause it to fall. Furthermore, inflation depends on the level of activity – represented by the output gap, y. Pressure in the economy – a positive output gap – leads to higher inflation. In the first instance, high demand for goods and services results in firms increasing prices. And secondly, higher activity normally pushes up the cost level. This is because trade unions will demand higher wage increases and employers will outbid each other in the competition for labour.

Inflation is influenced by the exchange rate, as well as the level of activity. Consumer prices are a combination of prices for domestically produced and imported goods and services. Changes in the exchange rate will therefore affect consumer prices, in that prices for imported goods will change. This will in turn affect prices for domestically produced goods as a result of competition and changes in firms' costs - due to changes in prices for imported intermediate goods and changes in wages as a result of changes in consumption-based real wages.

The variable η is the cost-push shock in the model and shows the rise in inflation at a given level for the output gap and real exchange rate. This most obvious shock would be an increase in wages over and above that indicated by the activity level, but it could also be caused by an increase in international commodity prices that pushes up enterprises' production costs.

Equation (4) determines the real exchange rate. A higher real interest rate (differential) leads to a stronger real exchange rate, i.e. a real appreciation. The real exchange rate will also be affected by changes in the risk premium – which are represented by the variable v.[3]

We use the same calibration - i.e. the same values for the parameters - as Ball. The degree of persistence in the output gap (β_y) is assumed to be relatively high and is set at 0.8. This means that the half-life for a change in the output gap will be just over three years. The total effect of a 1 percentage point increase in interest rates is a 1 per cent fall in production. The effect via the real interest rate is greatest ($\beta_r = 0.6$) and the effect via the real exchange rate is somewhat weaker ($\beta_e\theta_r = 0.4$). The slope on the Phillips curve $\alpha_y = 0.4$ indicates that an increase in the output gap of one percentage point would give a 0.4 percentage point increase in inflation. It is further assumed that an appreciation of one per cent would result in a 0.2 percentage point reduction in inflation. A 1 percentage point increase in the interest rate differential is assumed to give an appreciation of $\theta_r = 2$ and thus $\beta_e = 0.2$.

We can now give the following stylised review of the effect of a 1 percentage point increase in real interest rates. Initially, the real exchange rate will appreciate by 2 per cent. One year after the rise in interest rates, production will fall by 1 per cent and inflation by 0.4 percentage point. Two years after the rise, the decline in production will result in a further fall in the rate of inflation so that the total effect after two years will be a 0.6 percentage point reduction in inflation.

3. The effect of a cost-push shock

We will now look at the effect of a cost-push shock on the exchange rate in a situation where the economy is in balance to start with. A robust result in many different models is that the central bank responds to a cost-push shock by raising real interest rates. This is also the case in the model above; the cost-push shock pushes up inflation for a given level of production. As

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[3] Strictly speaking, this representation is not consistent with uncovered interest parity. In the next section we will also discuss the effect of a cost-push shock when uncovered interest parity is maintained.

long as the central bank places importance on stability in both inflation and production, it will not allow the whole effect of a cost-push shock to translate into higher inflation. Therefore, it will dampen the effect on inflation by allowing a fall in production. And for production to fall, real interest rates must be increased – in other words, the *nominal* interest rate has to increase more than the isolated effect of the cost-push shock on inflation. The central bank will follow what is called the "Taylor principle". The optimal increase in real interest rates depends on how much importance the central bank places on production stability – described here by the weight λ. The higher the weight on inflation, the more real interest rates have to be increased. Under an inflation targeting regime we would get the following results:

Result 1: *A cost-push shock would lead to higher real interest rates*

When discussing the effect on the nominal exchange rate, it is appropriate to start by looking at the effect on the *real* exchange rate. In the model described above, a 1 percentage increase in real interest rates gives a real appreciation of θ per cent. An alternative to equation (4) is uncovered interest parity, which says that the expected return will be the same between different currencies. If uncovered interest parity applies in nominal terms, it can be proved that it also applies for real variables, that is, we have the following relationship:

(5) $$e_t = E_t e_{t+1} - \left(r_t - r_t^*\right) + \nu_t ,$$

where E is an expectations operator so that $E_t\, e_{t+1}$ is the expected real exchange rate in the period t+1, given the information in period t, and the variable υ is the risk premium. Because uncovered interest parity is included in many theoretical models, we will base the following discussion on equation (5). The qualitative results are, however, the same whether we use equation (4) or (5). Finally, model simulations will be based on the original Ball model, where equation (4) is included.

If we solve equation (5) successively and at the same time assume that purchasing power parity applies in the long run, we find that the real exchange rate today can also be written as

(6) $$e_t = -E_t \left\{ \sum_{k=0}^{\infty} \left(r_{t+k} - r_{t+k}^{*} \right) - \nu_{t+k} \right\}$$

i.e. the real exchange rate today depends on expectations regarding the future path for the real interest rate differential and risk premium. Let us assume that the cost-push shock does not affect the risk premium, real interest rates abroad or expectations regarding these variables. Then we can express the immediate change in the real exchange rate resulting from a cost-push shock as follows:

(7) $$\frac{\Delta e_t}{\Delta \eta_t} = -\frac{\Delta \sum_{k=0}^{\infty} r_{t+k}}{\Delta \eta_t} < 0$$

where the sign depends on result 1 above. We then have:

Result 2: *A cost-push shock gives an immediate real appreciation*

Now we will look at the effect on the *nominal* exchange rate. Note that $e = s + p^* - p$, where s is the nominal exchange rate and p and p^* are the domestic and foreign price levels, respectively. If we keep foreign prices constant, we arrive at $\Delta e = \Delta s - \Delta p$, which gives

(8) $$\frac{\Delta s_t}{\Delta \eta_t} = \frac{\Delta p_t}{\Delta \eta_t} - \frac{\Delta \sum_{k=0}^{\infty} r_{t+k}}{\Delta \eta_t}$$

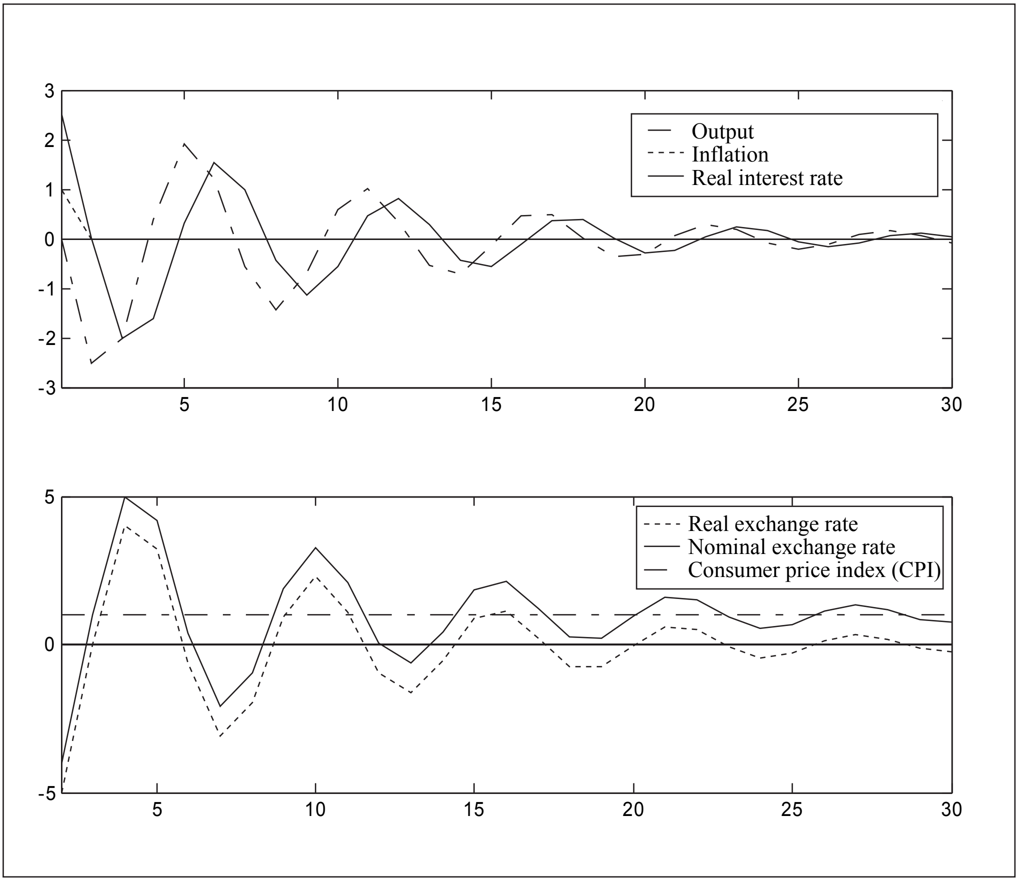
In the model in section 2, $\frac{\Delta p_t}{\Delta \eta_t} = 1$, as it takes one period before monetary policy affects inflation. If, for example, the exchange rate channel works faster, the effect will be less. It is, however, reasonable to assume that the term $\frac{\Delta p_t}{\Delta \eta_t}$ is positive, as the central bank allows a slight increase in inflation. The reason for this is partly that emphasis is placed on the real economy and partly that monetary policy influences prices with a time lag. Some of the shock therefore slips in as a change in the price level. There are thus two forces pulling in different directions. A higher price level, in isolation, results in a weaker nominal exchange rate, whereas higher real interest rates result in a stronger exchange rate.

Result 3: *The effect of a cost-push shock on the nominal exchange rate is uncertain*

In Charts 1 and 2, we have plotted the effect of a cost-push shock in the model with two different assumptions regarding the weight of the output gap (λ). Chart 1 shows the effect with strict inflation targeting (SIS), in other words, if $\lambda = 0$; whereas Chart 2 shows the effect with flexible inflation targeting (FIS) – where $\lambda = 1$. In the first case, we see that inflation rises initially, but then stabilises from and including period 2. The central bank achieves this by initiating a relatively sharp real appreciation so that inflation falls as a result of the decline in imported inflation. Parallel with the fall in inflation, the increase in real interest rates and the real appreciation lead to a fall in production. In order to avoid this in turn translating into even lower inflation, the interest rate hike must be reversed and real interest rates must be set at a lower level than normal. This will give a real depreciation that is just sufficient to offset the effect on inflation of a reduction in demand. The result of the strict inflation targeting is thus relatively substantial fluctuations in the other variables. As far as the exchange rate is concerned, we see that the long run effect is a nominal depreciation (equal to the increase in consumer prices) – whereas the real exchange rate reverts to its initial level. The immediate effect is, however, both a real and a nominal appreciation. In Chart 1 we can clearly see the two forces pulling in different directions. Consumer prices increase and there is a real appreciation.

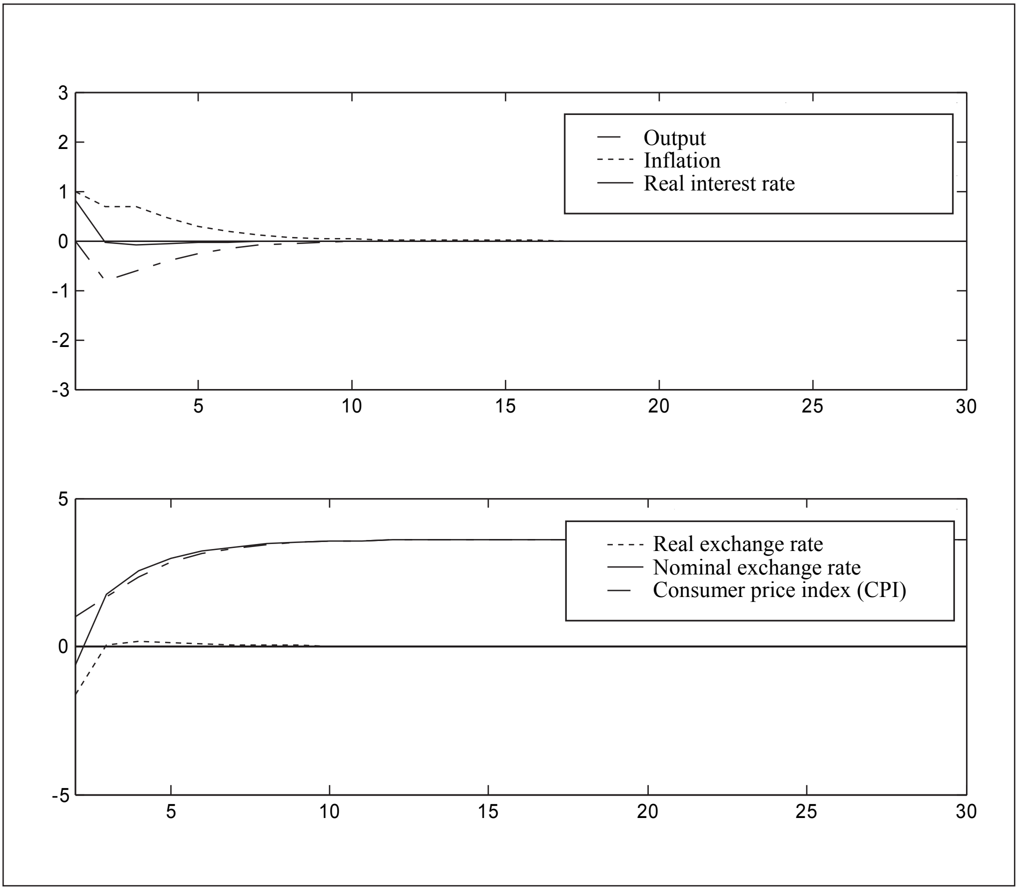
In the model above, it takes one period before monetary policy influences inflation. If the central bank is able to control inflation in the very short term, only the real interest rate effect has an impact on the exchange rate. In which case the effect is unambiguous: the nominal exchange rate will appreciate in the short term with flexible inflation targeting.

Chart 1: The effect of a cost-push shock (SIS - λ = 0)



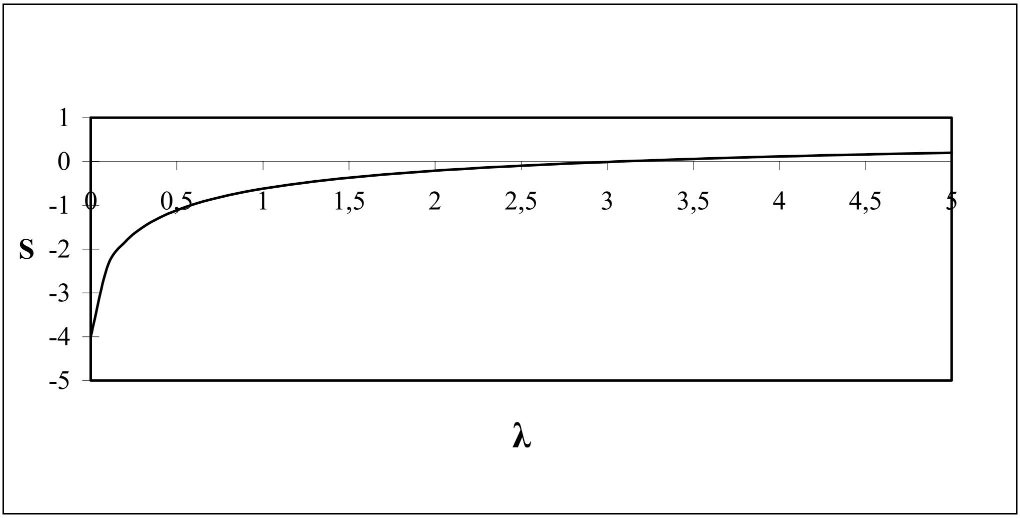
Let us now look at the effect of a cost-push shock with flexible inflation targeting. In Chart 2, we let the central bank place weight on variation in both production and inflation, thus λ = 1. Not surprisingly, it takes longer for inflation to return to the inflation target. The accumulated effect on the price level is thereby greater and the effect is a more marked nominal depreciation in the long term. We also see that there is less change in real interest rates, so that the real appreciation is smaller. The result is a smaller fall in production. And the immediate nominal appreciation is also less.

Chart 2: Effect of a cost-push shock (FIS - λ = 1)



In the long term, the cost-push shock does result in a nominal depreciation, given that the real equilibrium exchange rate does not change. The size of the nominal depreciation depends on how much emphasis monetary policy places on stabilising the output gap. In the short term, however, the effect on the nominal exchange rate is uncertain and will depend on two factors. First, the more importance the central bank attaches to the real economy, the more likely depreciation is. In Chart 3, we have plotted the relationship between the immediate effect on the nominal exchange rate and the weight of the output gap (λ). A higher weight on the output gap reduces the immediate nominal appreciation and if the weight on the output gap is sufficiently large, we will get a nominal depreciation. The reason for this is that the increase in the price level is greater and the rise in real interest rates is correspondingly lower.

Chart 3: Relationship between nominal exchange rate and λ



The more flexible prices are, the more likely an immediate nominal depreciation is. If prices are "completely" flexible, monetary policy will be neutral - so that real interest rates will remain unchanged - and the nominal depreciation will be immediate. In more realistic models, however, there is reason to believe that the real interest rate effect will dominate in the short term, causing the nominal exchange rate to appreciate. This is confirmed by the model analysed above. It is also the result presented in an article on inflation targeting in a small open economy by Lars Svensson. The nominal exchange rate will appreciate in the very short term with both flexible and strict inflation targeting, though the appreciation will be smaller with a flexible regime.[4]

If the central bank's target is to stabilise the price level rather than inflation, the likelihood of an immediate nominal appreciation increases. This also applies if there is a time lag in the effects of monetary policy - as in the model above. The reason for this is that the central bank in this case will steer the price level – and not inflation - back to its original level. Thus the change in real interest rates will be sharp.

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[4] See charts 2 and 3 p. 173-74 in Svensson (2000), "Open-economy inflation targeting", *Journal of International Economics 50*, 155-183.

Our focus is on temporary changes in the economy that translate into temporary changes in the rate of inflation. But the economy can also be exposed to permanent changes. An example of such a disturbance could be when real wage growth increases at a given level of unemployment. This will increase equilibrium unemployment so that wage growth in turn is linked to productivity growth in the economy. The central bank will then increase real interest rates in order to bring unemployment to the equilibrium level. Parts of the shock will still slip in as a change in the general price level, which, in isolation, gives a nominal depreciation. Contrary to temporary shocks, an increase in equilibrium unemployment may result in a real appreciation in the long run, as the supply of domestically produced goods and services, in isolation, will fall as a result of the rise in unemployment. Thus the relative price of the country's goods and services will rise, thereby leading to a real appreciation in the long run. As result, the nominal depreciation will be smaller in the long run. In the short term, however, in this scenario as well, two forces will pull the nominal exchange rate in different direction, which makes the total effect somewhat uncertain.

4. Conclusion

We have shown that the immediate effect of a cost-push shock on the nominal exchange rate is uncertain. A positive cost-push shock results in a higher price level, which pulls in the direction of depreciation. The monetary policy response implies (expectations of) higher real interest rates, which pulls in the direction of an appreciation. Even though the net effect is theoretically uncertain, the latter effect seems to dominate in realistic models. The stronger exchange rate resulting from the cost-push shock is, however, temporary. Gradually the exchange rate will fall and in the long run will move towards a level that is lower than that before the cost-push shock took effect.

In this article, a cost-push shock has been interpreted as a purely exogenous cost-push shock. If the cost-push shock is instead a result of improved productivity, the results will be modified. We have also assumed that purchasing power parity will be maintained in the long run, i.e. that the real exchange rate will move towards a constant equilibrium level. Differences in productivity trends between countries may, however, entail that this assumption does not hold. We have chosen not to include any such structural trends in this analysis.