# Inflation targeting: A supplement to "Open Economy Macroeconomics"

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**Preliminary and incomplete**



**Abstract**

The purpose of this compendium is to show how some of the models in Rødseth: *Open Economy Macroeconomics*, Cambridge University Press 2000 can be adapted and applied to discuss inflation targeting. All conclusions are contingent on the models presented.

# 1 Introduction

The purpose of this compendium is to show how some of the models in Rødseth (2000) can be adapted and applied to discuss the case of inflation targeting. Inflation targeting is discussed in Section 10.1 of the book. However, had the book been written today the widespread adoption of inflation targeting would have warranted an integration of inflation targeting in several of the chapters and in models that are richer than the one in Section 10.1. As in the book, focus will be on open economy issues, exchange rates, current accounts and capital movements.

Writing the supplement is challenging for a number of reasons:

1. Inflation targeting is not a single, precisely defined policy. In fact it is often defined as a framework for conducting a rather flexible monetary policy. Any framework that gives sufficient priority to meeting an explicit target for the inflation rate over some time horizon may qualify. Usually the interest rate is seen as the main or the only instrument to achieve the target.

2. Traditionally text-books (and economic research) concentrated on two main types of monetary policy, one where the central bank targeted the money supply and one where it targeted the exchange rate. Rødseth (2000) is no exception. Monetary policy has a more immediate effect on the exchange rate and the money supply than on the inflation rate. Hence, time lags become more prominent in discussions of inflation targeting. For technical reasons economists have preferred to handle these issues in discrete-time models, while the main parts of Rødseth (2000) uses continuous time. The complexity of the lag structure in commonly used models also means that numerical simulations often have to be used to get conclusions. This is less attractive in a text-book, where transparency of the models is paramount.

3. In the literature there are two different approaches to describing how central banks set interest rates under inflation targeting. One models central banks as maximizing a preference function over inflation and output (and possibly other variables) given the structure of the economy. The other starts directly with a relationship that purports to the describe how the interest rate setting depends on the state of the economy. The Taylor rule is a prominent example of the latter. The first approach has

an obvious advantage when it comes to producing good ideas for how to conduct policy. However, the second approach may sometimes be more illuminating in a pedagogical setting.

4. Model-consistent ("rational") expectations are always an important benchmark for assessing policies. The book shows in Sections 4.1 and 6.7 how one can form unique model-consistent expectations when the money supply is fixed, and how these expectations determine the future path of the price level. However, having an inflation target is not, by itself, sufficient to produce unique solutions for the price level. There may turn out to be a whole set of (non-explosive) rational expectations paths for the price level. This paradox is discussed further in Section 2 below.

In the present compendium we stick as close as possible to the book and take an ad hoc approach to expectations. Expectations display some degree of rationality but are not always fully consistent with the model we have in mind. We emphasize the consequences of pursuing the inflation target without regard for the other aims that often also play a role within actual inflation targeting frameworks and with the interest rate as the only instrument. We downplay the policy lags and the difficulties the central bank has with forecasting. This means that one should not jump to strong conclusion about how actual policies are or should be conducted. In actual policy making there are more variables to consider, more lags, more information problems, a more complicated structure of the economy etc. Remember that all conclusions are contingent on the models presented.

# 2 Targeting inflation in the simple monetary model of Chapter 4

Recall that in this model there is a single good which costs the same abroad and at home when prices are measured in the same currency. Prices are fully flexible. The output level is determined from the supply side. There is uncovered interest rate parity and the money supply is exogenous. Hence, money demand plays a crucial role in the determination of the price level.

With an inflation target the money supply become endogenous, and the model has to be supplemented with a new relation that describes how the interest rate is related to the inflation target, to the

state of the economy and to expectations of the future state. Suppose the inflation target is $\bar{\pi}$. Inflation-targeting central banks often claim to be forward looking, meaning that they are concentrating on hitting the target in the future and not just responding to past deviations in inflation. This is also often recommended in the theoretical literature. Inspired by Taylor-rules we may first try out the assumption that central bank behavior can be described by the function:

$$i = i_0 + \phi(\pi_e - \bar{\pi}) \tag{1}$$

where $i$ is the interest rate, $\pi_e$ is the expected inflation rate, $\phi$ a positive constant and $i_0$ the interest rate that will be set when expected inflation is equal to the target.

The rule for setting the interest rate has to be consistent with the interest rate parity condition

$$i = i_* + e_e \tag{2}$$

where $i_*$ is the foreign interest rate and $e_e$ is the expected rate of depreciation. Furthermore, it seems reasonable to require that the expectations of inflation and depreciation are consistent with each other, which, in view of that the model assumes purchasing power parity, means

$$\pi_e = e_e + \pi_{*e} \tag{3}$$

where $\pi_{*e}$ is the expected rate of inflation abroad. Combining the last two equation yields real interest rate parity:

$$i = i_* - \pi_{*e} + \pi_e \tag{4}$$

For arbitrary levels of $\pi_e$ equations (1) and (4) are inconsistent. The interest rate cannot both be determined by the central bank and by the expectations that prevail in the markets. This means that in the extremely open economy with perfect capital mobility the central bank is able to affect the nominal interest rate only if it can affect expectations. Expectations have to be endogenous and monetary policy is all about managing expectations.

Consistency between the two equations require that benchmark interest rate $i_0$ is set in accordance with the interest rate parity condition. Suppose $\pi_e - \bar{\pi}$. Then according to (1) $i = i_0$. However, for this to be consistent with equation (4), we have to have

$$i_0 = i_* - \pi_{*e} + \bar{\pi} \tag{5}$$

In words, the benchmark interest rate has to be equal to the foreign *real* interest rate plus the domestic inflation target. Hence, the interest setting rule can be reformulated as

$$i = i_* - \pi_{*e} + \bar{\pi} + \phi(\pi_e - \bar{\pi}) \tag{6}$$

Still this is not consistent with (4) except in the special case that $\pi_e = \bar{\pi}$. The implication is that the only inflation expectations that are consistent with the model are $\pi_e = \bar{\pi}$. Indeed, if we set $\pi_e = \pi$ ($\pi$ being the actual inflation rate) and $e_e = e$ the only solution to equations (2), (3) and (6) is $\pi = \bar{\pi}$, $i = i_* - \pi_{*e} + \bar{\pi}$ and $e = \bar{\pi} - \pi_{*e}$. Inflation targeting in this economy seems miraculously simple! Just set the domestic interest rate equal to the foreign interest rate plus the target inflation rate and inflation becomes equal to the target.

Alas, this is too good to bee true. The exchange rate is free to jump at any time, and, hence, the price level is free to jump too. The most we can get from the reasoning above is the expected future inflation rate. It tells us nothing about what the price level will be now. When the money supply was exogenous we could use this as a nominal anchor determining where the price level ends up in the long run. Then we could reason backwards to what the present price level should be. No such nominal anchor is available here. The absolute price level plays no role in the model above, and, hence, there is no way in which it can be used to determine the present price level.

The solution for the inflation rate is illusory. Future price levels are as indeterminate as the present. Given the model there is really no rational way to form expectations about the inflation rate. With fully flexible prices and perfect capital mobility a simple forward-looking rule for interest rate setting like (1) cannot provide a sufficient nominal anchor for the economy. This problem is not confined to extremely open economies.

Before we discuss ways to get around the problem, it is useful to take a look at price level targeting which is an alternative to inflation targeting. Suppose the target for the price level is $\bar{P}$. For simplicity assume that the foreign price level, $P_*$, is constant. Assume that the central bank raises the interest rate when the price level is above the target, lowers it when it is below, according to

$$i = i_* + \phi(P - \bar{P}) \tag{7}$$

Given that $P = EP_*$ this is the same as

$$i - i_* = \phi(EP_* - \bar{P})$$

Assuming interest rate parity and model consistent expectations the left hand side can be replaced by the rate of depreciation:

$$\frac{d\dot{E}}{E} = \phi(EP_* - \bar{P}) \tag{8}$$

This is a differential equation for $E$. It is unstable, but has a unique stable saddle path which is given by $EP_* = \bar{P}$ or $P = \bar{P}$. The solution method is the same as was used for the case with exogenous money supply in the book (and subject to the same criticism). Here, there is a nominal anchor that helps pin down the price level, provided that people believe in the long-run stability of the system. Note that targeting the price level in this case is similar to targeting the exchange rate. Differences appear only if the foreign price level is changing.

There are different ways of getting around the problem with the indeterminacy of the absolute price level with exchange rate targeting. One obvious way is to introduce a backward looking term in the interest setting rule. This is a bit like introducing a moving price-level target linked to the price level in the recent past. With the right parameters in the interest rate rule this can give a unique saddle path for prices. Another escape route is to drop the assumption of fully flexible prices. Price rigidities creates a tie between past and future prices. If this link is sufficiently strong, the future price level can be "anchored" by the present price level. This route is often taken in the literature. However, it may fail to work in highly open economies where the flexibility of the exchange rate weakens the anchoring effects of eventual price rigidities. In the literature one can also see cases where elements of exchange-rate targeting is brought in explicitly or implicitly. However, it should be obvious that if prices are fully flexible, a central bank with an inflation target cannot just look to future inflation. It must also to some degree respond to recently observed jumps in the levels of flexible prices unless these are expected to be temporary blips. The inflation target would loose credibility if big one-time jumps in the price level were allowed to happen without response. Further discussions of this matter can be technically demanding and is outside the scope of this compendium.

> *Technical note.* Some care is needed when defining the inflation rate in economies where the price level is free to jump. In the model above the price level, $P$, is the product of the exchange rate and the foreign price level, $P = EP_*$. All three variables in this equation are in principle free to

jump at any time. In continuous time models the inflation rate is defined as the, $\pi = (dP(t)/dt)/P$. The derivative $dP(t)/dt$ does not exist at points where there are jumps in the price level. However, as explained in Section 4.2 in the book, we cannot have expected jumps in the exchange rate. The expected future path of the exchange rate must be continuous, and the same argument can be made for expected future price levels. Hence, we can define $\pi_e(t)$ as the expected slope of $P(t)$ when we look towards the future.

# 3 Targeting inflation in the Mundell-Fleming-Tobin model of Chapter 6

In this section we will discuss inflation targeting within the framework with home and foreign goods from chapter 6 of Rødseth (2000). Measured in the currency of the country where they are produced goods prices change only gradually over time. Hence, at any moment of time their levels are predetermined. Short-run equilibrium in the goods market is described by an $IS$-equation:

$$Y = C\left(Y + \rho_* \frac{RF_{p0}}{P_*}, \frac{M_0 + B_0}{P} + \frac{RF_{p0}}{P_*}, i - p_e\right) + I(i - p_e) + X(R, Y, Y_*) \tag{1}$$

Symbols are the same as in Rødseth (2000). For simplicity we have dropped the fiscal variables and the foreign interest rate.

For our purpose here the $IS$- equation can be summarized as

$$Y = Y(R, i - p_e), \qquad Y_1' > 0, \;\; Y_2' < 0 \tag{2}$$

Here the equation is solved for $Y$ and we have suppressed predetermined variables. We make the assumption that a real depreciation always has a positive impact on output, while an increase in the real interest rate has a negative impact.

The exchange rate is floating freely. Perfect capital mobility is assumed. Hence, there is uncovered interest rate parity:

$$i = i_* + e_e \tag{3}$$

This does not prevent the central bank to set the interest rate freely as long as the expected rate of depreciation depends negatively on the level of the nominal exchange rate. In OEM 6.2-6.4 it is simply

assumed that $e_e = e_e(E)$ with $e_e'(E) < 0$. This seems to be a useful simplification for discussing the short-run impact of temporary shocks under the alternative monetary policies discussed there. In particular this is the case when the value of $E$ in long-run equilibrium can be expected to be unaffected by temporary shocks and independent of the monetary policies that are compared. Here we want to discuss also the effect of permanent shocks. Furthermore, inflation targeting opens for temporary shocks having permanent effects on the price level and the level of the exchange rate. Hence, we need to be more explicit about expectations[1]. The assumption we shall make is that:

$$e_e = p_e - p_* - \epsilon[(R - \bar{R})/\bar{R}], \qquad \epsilon + u_e > 0 \qquad \epsilon > 0 \qquad (4)$$

The expected real exchange rate in long run equilibrium, $\bar{R}$ is assumed to be independent of monetary policy and to provide an anchoring point for exchange rate expectations. If the actual real exchange rate, $R$, is depreciated relative to $\bar{R}$, the nominal exchange rate is expected to appreciate gradually, and thus help the economy to move towards the long-run equilibrium over time[2]. Hence, the expectations are regressive in the sense used in OEM. The $\epsilon$ determines with what speed the exchange rate is expected to move. It is a product of two factors. First, it depends on how much of the adjustment towards long-run equilibrium in $R$ that is going to take place through adjustment in the nominal exchange rate. As we shall see, this may depend on the way monetary policy is conducted. Second, it depends on the expected time remaining until the economy is in long-run equilibrium. This may depend on whether the shock is temporary or permanent. That the term $p_e - p_*$ is included in (4) means that if the real exchange rate is at its long-run equilibrium level, the nominal exchange rate is expected to move in such a way that the real exchange rate stays constant. This also means that differences in trend inflation will sooner of later be reflected in the expected depreciation rates. The depreciation shock $u_e$ in (4) represent exogenous shocks to expectations[3].

[1]Finding a good way of representing exchange rate expectations under inflation targeting in short-run models like those in OEM 6.2-6.4 has been a difficult problem and there may be better solutions than the one offered here. Purist would argue that one should only work with full dynamic models integrating the short and long run and having model-consistent expectations. However, there are insights to be gained also from focusing on the short run and from discussing the effects of exogenous variations in expectations.

[2]Empirical studies of exchange rate dynamics support that this should be expected, see ...

[3]Often a shock variable is added to (3) instead with the same effect. The shock may

Equations (3) and (4) can be solved to yield

$$R = \bar{R}[1 - \frac{1}{\epsilon}(i - p_e - i_* + p_* - u_e)] \tag{5}$$

This says that the real exchange rate will deviate from long-run equilibrium when the real interest rates at home and abroad are different. A high $\epsilon$ means that interest rates have a small effect on the real exchange rate.

Recall that the nominal exchange rate is by definition connected to the real exchange rate by $E = RP/P_*$. Since $P$ and $P_*$ are predetermined relative to the short run equilibrium, the real and nominal exchange rates move together. According to equation (5) a higher interest rate at home will as usual lead to an appreciation, a higher expected inflation to a depreciation.

If we insert for $R$ from (5) in (2) we get the $ISFX$-curve:

$$Y = Y(\bar{R}[1 - \frac{1}{\epsilon}(i - p_e - i_* + p_* - u_e)], i - p_e) \tag{6}$$

which tells us the combinations of output and interest rate which are compatible with a joint equilibrium in the markets for goods and for foreign exchange. As we can see an increase in $i$ affects output negatively through two channels, the interest rate channel ($Y_2'$) and the exchange rate channel ($Y_1'$).

## 3.1 Targeting the domestic component of inflation

The $ISFX$-curve describes the relationship between output and the interest rate given that there is equilibrium in the goods market and the foreign exchange market. In OEM monetary policy is described by an $LM$-curve, and the short-run equilibrium is found at the intersection between the $ISFX$- and the $LM$-curve. What we want to do here is to replace the $LM$-curve with an $IT$-curve ($IT$ for inflation target) that describes the relation between $i$ and $Y$ that follows from that the central bank is pursuing an inflation target.

Because this is the simplest case, we start by assuming that the target is for the rate of increase in the price of home goods, or, in

then be interpreted as a stochastic risk premium. However, we know from chapter 2 in OEM that risk premiums in the foreign exchange market depend on the level of the exchange rate, which is endogenous.

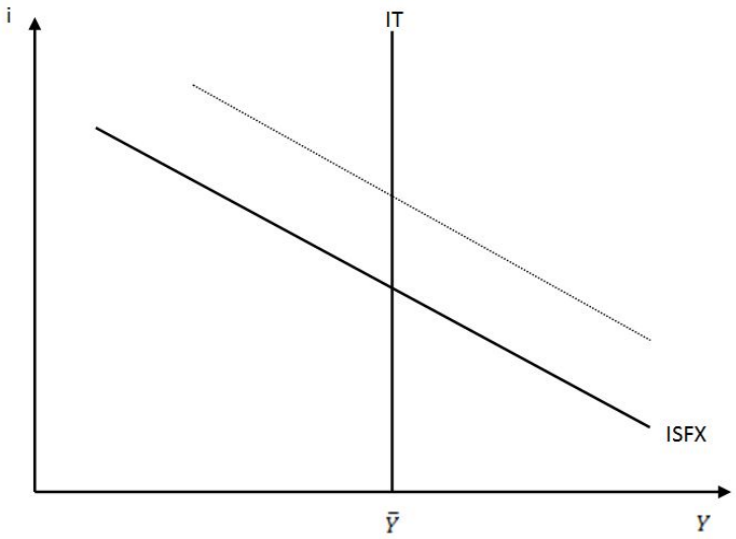


Figure 1: Short-run equilibrium

other words, for producer price inflation. Furthermore, producer price inflation is determined by a simple Phillips-curve:

$$p = p_e + \gamma \frac{Y - \bar{Y}}{\bar{Y}}, \qquad \gamma > 0. \tag{7}$$

Here $(Y - \bar{Y})/\bar{Y}$ is the output gap.

Suppose the inflation target is $\bar{\pi}$. With luck $p_e = \bar{\pi}$. Then all the central bank has to do is to set the interest rate $i$ at the level that makes $Y = \bar{Y}$. In figure 1 this monetary policy is represented by the vertical $IT$-curve. The equilibrium in the economy is where the $IT$-curve intersects with the $ISFX$-curve.

In practice keeping $Y = \bar{Y}$ is not an easy task. Unlike in the model, there are lags before the interests rate has any noticeable effect on output. When the central bank sets the interests rate, the present state of the economy is not fully known, and there is even more uncertainty about the the state at the time when today's interest rate has its maximum effect. The strength of the effects is also uncertain. Sometimes no interest rate exists that can make $Y$ equal to $\bar{Y}$ because even an interest rate at the lower bound of zero does not produce sufficient demand for goods. Here we abstract from all these issues.

If figure 1 gives the correct picture, the implication is that under inflation targeting shocks to aggregate demand and shocks to the foreign exchange market have no effect on output. Expansionary demand shocks shifts the $ISFX$-curve to the right, raises the interest rate and, thus, leads to an immediate appreciation of the currency. A depreciation shock (an increase in $u_e$) also shifts the $ISFX$-curve to the right and will be met by an increase in the central bank's interest rate. This will dampen the depreciation and neutralize the effect on aggregate demand. A positive shock to aggregate supply $\bar{Y}$ will be accommodated, meaning that the central bank will lower interest rates in order that aggregate demand can increase to the same level as supply. The result will be a depreciation that makes home goods relatively cheaper both at home and abroad.

Impulses from the business cycle abroad are transmitted through the two variables $Y_*$ and $i_*$. If foreign output is low due to low domestic demand there, it is likely that the foreign interest rate will also be relatively low. The $ISFX$-curve shifts left for two reasons. The response of the domestic central bank will be to lower the interest rate in order to raise the demand for home goods again. In principle $i$ should be lowered to the point where $Y = \bar{Y}$. In the new equilibrium the real interest rate is lower and, hence, domestic demand for consumption and investment should be higher. Since the output level is the same, this means that the trade balance has deteriorated. However, in general the effect on the exchange rate and the interest rate differential is ambiguous[4].

*Lack of credibility*

It may happen that $p_e > \bar{\pi}$, meaning that the inflation target does not have full credibility. Suppose the central bank still wants to meet the target immediately. It then has to aim for an output level that is below $\bar{Y}$. If it wants

$$p_e + \gamma(Y - \bar{Y})/\bar{Y}) = \bar{\pi},$$

it has to aim for the output level:

$$Y_A = \bar{Y} - \frac{1}{\gamma}(p_e - \bar{\pi})\bar{Y} \tag{8}$$

[4]The ease with which the effect of a foreign recession on domestic output can be neutralized raises a question about the realism of the model and the nature of world interactions. More on that in a later version.

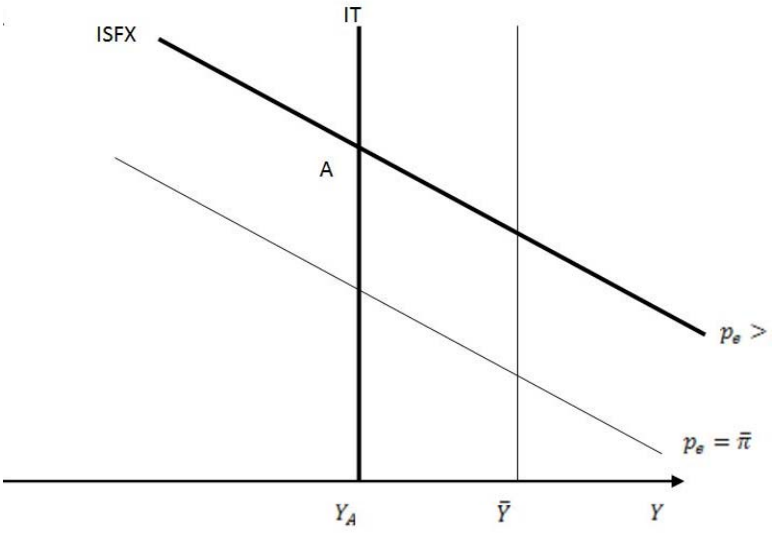


Figure 2: Equilibrium with lack of credibility

Thus, excessive inflation expectations $p_e > \bar{\pi}$ will result in output and employment below capacity. As illustrated in figure 2, the $IT$-curve is at $Y_A$ to the left of $\bar{Y}$. As also shown in the graph, a high expected inflation rate, $p_e$, raises aggregate demand by lowering the real interest rate and by raising expected depreciation. This means that the aggregate demand curve shifts to the right. The result is a higher interest rate and lower output than if inflation expectations had conformed to the target.

How, large will the necessary increase in the interest rate be? It is easy to see that raising $i$ by the same amount as $p_e$ is not sufficient. Inspecting the exchange rate equations (6) we see that this will leave the real (and nominal) exchange rate unaffected. The real interest rate will also be unaffected. Hence, raising $i$ by the same amount as $p_e$ would only move aggregate demand back to $\bar{Y}$. To get to $Y_A$ the central bank needs to increase the real interest rate [5]. Since the nominal interest rate is raised more than the expected rate of depreciation, the nominal exchange rate will appreciate. The direct depreciating effect of higher expected inflation in (6) is overcome by the response

[5]In the literature the idea that the central bank should raise the *real* interest rate when inflation goes up is known as the Taylor principle

of the central bank.

As we have seen, if the interest rate is increased sufficiently, actual inflation will stay on target. The fact that actual inflation is below expected inflation will over time bring down inflation expectations. Private agents will realize that the central bank is determined to keep inflation on target and has the power to do so. The interest rate can then gradually be reduced and the nominal exchange rate will depreciate gradually towards its old level.

As long as the central bank sticks to the inflation target, all adjustments in the real exchange rate have to come through changes in the nominal exchange rate. This supports the assumption we made about exchange rate expectations in (4).

*Stagflation*

If expected inflation is far above the target, the central bank may in practice be unwilling or unable to bring inflation down to the target at one stroke. There will then be a period of stagflation: high inflation combined with output below equilibrium. The interest rate is then set in order to achieve a level of aggregate demand somewhere between $Y_A$ and $\bar{Y}$.

The difference between the actual and the target inflation rate $p-\bar{\pi}$ is called the inflation gap. Often it is assumed that the central bank minimize a loss function that is a weighted sum of the squares of the output gap and the inflation gap:

$$L = \frac{1}{2}(p-\bar{\pi})^2 + \frac{\lambda}{2}\left(\frac{Y-\bar{Y}}{\bar{Y}}\right)^2, \qquad \lambda > 0 \tag{9}$$

Minimization of this with the Phillips-curve (7) as constraint yields a first order condition that can be written as

$$p - \bar{\pi} = -(\lambda/\gamma)\left(\frac{Y-\bar{Y}}{\bar{Y}}\right) \tag{10}$$

When it is not possible make both gaps equal to zero, a compromise has to be made. The first order condition implies that the two gaps should have opposite signs. A positive inflation gap can be accepted, but only if the output gap is negative. The more negative the output gap is, the larger the inflation gap that should be allowed. Stagflations should be accepted for a while if necessary, but not excessive inflation combined with a booming economy. Conversely, deflation in a stagnating economy should be avoided.

If we combine the first-order condition (10) with the Phillips-curve (7), we find that that the output level the central bank should aim for, $Y_B$, is given by

$$Y_B = \bar{Y} - \frac{1}{\gamma + \lambda/\gamma}(p_e - \bar{\pi})\bar{Y} \tag{11}$$

While the resulting inflation rate is

$$p = \frac{\bar{\pi} + (\lambda/\gamma)p_e}{1 + (\lambda/\gamma)} \tag{12}$$

$Y_B$ is between $\bar{Y}$ and the $Y_A$ that we found in (8). A high $\lambda$ means that the output gap should respond less to the gap between expected and target inflation. The higher the weight on output stabilization, $\lambda$, the less will the central bank raise the interest rate in response to expected inflation being above the target. However, it should always increase the real interest rate. The argument made above can be repeated. Keeping the real interest constant will keep aggregate demand at $\bar{Y}$. An increase in the real interest rate and a strong real exchange rate is needed to get any reduction in $Y$.

The optimization approach taken here is somewhat simplistic, because it ignores the benefits that will come in later periods if expected inflation is brought down quickly. Essentially the central bank will have to choose between a short and deep recession or a long and shallow one if the inflation rate is ultimately to be brought back to equality. Taking account of the future gains would imply a somewhat more aggressive anti-inflation policy, but not an immediate return to the inflation target.

Stagflation may result also from other reasons than excessive inflation expectations. Temporarily high upward pressure on wages ("union militancy") works in a way that is indistinguishable from high inflation expectations and pose the same policy dilemma. A gradual decline of competition in product markets has similar effects. These are examples of temporary *cost-push shocks*. While there is no conflict between stabilizing output and stabilizing inflation when there are temporary demand shocks, temporary cost-push shocks typically give rise to such a conflict.

*Permanent shocks*

So far we have considered only temporary shocks. When there is a permanent shock we need to consider also the effect it may have

through the expected equilibrium real exchange rate $\bar{R}$. Hence, a sketch of what a long-run equilibrium may look like is useful before we look at the effect of specific shocks. The sketch has borrowed some features from the long-run equilibriums in sections 6.6 and 6.8 of the book.

For simplicity, assume that there is no underlying productivity or population growth. Then it seems reasonable to expect that in the long-run there is equality between the real interest rates at home an abroad. The capital stock will end up at the level where the marginal productivity of capital is equal to the real return in the international capital markets. This will determine capacity output $\bar{Y}$. Actual output $Y$ will be equal to capacity output and, thus, determined from the supply side. The capital stock will be constant, which means investment will be zero (no depreciation). The current account should be balanced. With zero investment this will require that savings are also zero. Consumers will have accumulated wealth to the point where they do not find it worthwhile to save more. This implicitly determines the size of the foreign debt. The interest payments on the foreign debt needs to be financed by an equal trade surplus. The real exchange rate has to adjust to the level that creates the required trade surplus. If inflation at home and abroad stay at the same target rates, the only way the change in the real exchange rate can come about is through a change in the nominal exchange rate $\bar{E}$.

Our first example is a permanent shift in demand from foreign to home goods (a shift in the trade balance function). There will be no change in the value of the foreign debt in the long-run equilibrium. Hence, the trade surplus required to service the debt is unchanged. To keep trade balanced in spite of that demand has shifted towards home goods, a real appreciation is required. Home goods have to become more expensive relative to foreign goods. With strict adherence to the inflation target this will require a nominal appreciation of the same size as the real appreciation. However, if the agents in the foreign exchange market realize that $\bar{R}$ has to appreciate, equation (4) tells us that this appreciation will take place immediately through the nominal exchange rate. The short-run effect of the demand shift on the trade balance will be neutralized. This may be the end of the story. The only change is in the exchange rate, and the central bank can sit still.

However, if the foreign currency assets of the private sector differ from zero, we can get an additional effect from the change in their real value, as we see from the $IS$-equation (1). Suppose the private

sector has a net foreign debt. A real appreciation reduces the value of the foreign debt measured in home goods. In the short run this raises consumption demand. To keep inflation on target the central bank then has to increase the interest rate. This induces a further appreciation, beyond what is necessary in the long run. Paradoxically a shift of demand towards home goods then reduces the trade surplus. However, as the country gradually accumulates more foreign debt this will dampen aggregate demand, the central bank can reduce interest rates again and the currency depreciates towards its long-run equilibrium in accordance with what was assumed in equation (4).

As another example take a positive permanent shock to consumption demand. This means less saving and, hence, leads to lower private wealth in the long run. This creates a need for a real depreciation in order to produce a trade surplus big enough to pay the interest on the higher foreign debt. If this is expected at the time the shock occurs, the effect will be towards a depreciation now. This will require further increases in the interest rate in order to keep inflation on target. Whether the net effect now is an appreciation or a depreciation is ambiguous. Hence, we have the paradoxical result that an event that leads to depreciation in the long-run may induce an appreciation in the short run.

## 3.2 Targeting consumer price inflation

*This section is even more unfinished than the above.*

Actual inflation targets usually refer to consumer prices rather than producer prices. Within the model we have discussed the consumer price index can be defined as

$$\Pi = P^{1-\alpha}(EP_*)^{\alpha}, \qquad 0 < \alpha < 1 \tag{13}$$

Here $\alpha$ is the weight on foreign goods. Measured by this the rate of inflation is

$$\pi = \dot{\Pi}/\Pi = (1-\alpha)p + \alpha(e + p_*) \tag{14}$$

$p$ is called the domestic component of inflation while $(e + p_*)$ is called the imported or foreign component. While we have assumed that the prices $P$ and $P_*$ change only gradually, the model allows the exchange rate and, hence, the domestic currency price of foreign goods to jump instantaneously. The consumer price index will then jump too. This means that keeping the rate of increase in consumer prices continuously at the target is difficult if not impossible in the present model.

If the interest rate is used to avoid all jumps in the exchange rate, it cannot at the same time be used to keep output equal to capacity[6].

Technically the jumps in the exchange rate complicates the discussion. We shall take an indirect and informal approach. Based on the previous section, we first describe what happens to the consumer price index if the central bank targets the domestic component of inflation. Then, we discuss how concern for stability in the overall price index may lead to a different policy. As we shall see, it is not always obvious what that policy should be.

First of all we can note that whatever $p_*$ is, its effect on inflation can be neutralized by a corresponding change in the rate of depreciation $e$. This is already built into the model's exchange rate expectations and is consistent with our equation for the determination of the exchange rate. Hence, the main difference between targeting consumer and producer prices will be in how the central bank reacts to the exchange rate.

We need to distinguish between two types of changes in exchange rates, those due to temporary and those due to permanent shocks. With temporary demand shocks there is an argument for disregarding the direct effect on the consumer price index of the jump in the exchange rate and just focus on keeping internal balance. As argued above, it may then be legitimate to expect that the exchange rate will gradually return to its old level. Over time the average inflation rate will then be equal to the target. However, measured over short periods consumer price inflation will vary around the target.

Suppose there is a temporary increase in domestic demand. If the central bank targets the domestic component of inflation, it raises the interest rate to the level that is necessary to keep internal balance ($Y = \bar{Y}$). This leads to an immediate appreciation and a fall in the consumer price index. Since the shock is temporary, the real exchange rate should be expected to return quickly to its old level and the initial appreciation and fall in the price level effect will be small. After the initial jump the exchange rate will depreciate gradually until it reaches its old level when the shock ends. During this period the central bank has to raise the interest gradually in order to keep internal balance[7].

[6]In practice it takes some time before the full effect of a depreciation is transmitted to consumer prices. This may ease some of the problems discussed here, but does not remove them.

[7](Since the depreciation is driven by expectations, there is no inconsistency between the interest rate going up and the exchange rate depreciating.

After the shock everything will be back to the old order. This means that the average consumer price inflation when we look at the whole period is not affected by the shock.

The initial fall in the level of consumer prices can be reduced if the interest rate is increased less than what is needed to get internal balance. However, this will create excess demand and start a period of inflation in the prices of home goods in the following period. As $P$ goes up, the gradual depreciation of the exchange rate will be reinforced. (This requires higher interest rates in order to prevent the output gap from increasing). Hence, both the domestic and the imported component of inflation will be above target for a while. After the shock is over, the economy returns to the old real exchange rate, but with a higher price level on home goods. This means that the nominal exchange rate actually has to depreciate beyond the level that it had before the shock. Over the period as a whole there is then more inflation than if the central bank concentrated on internal balance. Hence, reducing the first spike in the inflation rate can make the average inflation rate over the longer period higher[8]. However, if we extend the horizon even further, including periods where there are shocks in both directions, the two policies may yield the same average inflation rate again. Hence, in this example there is an interval between the interest rate that avoids the initial jump in the exchange rate and the interest rate that keeps internal balance. Where in this interval the interest rate is set is important for the kind of deviations we get from the inflation target. Without specifying how different deviations from the target should be weighed against each other, we do not get any further.

Some economists argue that inflation targeting should be purely forward looking. In our context this may be interpreted as saying that the central bank should disregard the initial jump in the exchange rate. However, this requires an even more aggressive interest rate setting than the one which yields internal balance. As we saw, aiming for internal balance means that after the initial jump the imported component of inflation will be positive even if the domestic component is zero. To prevent this inflation it is necessary to create a negative output gap. A domestic component below the inflation target is needed to compensate for an imported component above target.

[8]If this is realized by the agents in the foreign exchange market, it may mean a higher *epsilon*, less effect of the interest rate on the exchange rate and possibly that the central bank sets an even higher interest rate.

When we look at the whole period, including the initial jump, the average inflation with this policy will be below target.

There are also economist who argue for concentrating on stabilizing the prices that are slow to adjust and for disregarding the direct effect on consumer prices of fully flexible prices like the exchange rate. [Reference to come].

Things are slightly different when a temporary shock emanates in the foreign exchange market. As discussed in section 3.1, if there is a depreciation shock (an increase in $u_e$) when the central bank targets the domestic component of inflation, the bank will respond by raising the interest rate enough to dampen, but not to prevent the depreciation. This means the conflict between stabilizing inflation over different horizons is less severe in this case.

A permanent positive shock to the trade balance leads, as shown above, to a one-time appreciation of the exchange rate and, hence, to a jump down in the consumer price index. Then nothing more happens unless the central bank takes action. When looking forward inflation will be on target. Measured over a period that includes the jump, consumer price inflation will have been below target. The initial jump in the price level may be avoided by lowering the interest rate sufficiently to keep the exchange rate constant[9]. This will create a positive output gap and and raise the domestic component of inflation above target. In the end the real exchange rate will appreciate by the same amount, but the appreciation will come about through a long period of inflation instead of by an instantaneous deflation.

Targeting of consumer price inflation may reduce $\epsilon$ in the expectations equation since it means that more of the adjustments in the real exchange rate will take place through prices on domestic goods and less through the exchange rate. A lower $\epsilon$ means that the exchange rates responds more to interest rates.

In principle it is possible to find an intermediate policy that makes the average consumer price inflation over the adjustment period equal to the inflation target. This means the real appreciation has to take place by a combination of an increase in $P$ and a decrease in $E$. This can only come about if there is an initial jump down in $E$ and $\Pi$ and it requires careful maneuvering of the interest rate throughout the adjustment period..

*Some further comments*

[9]If the shock is large, this may require a negative interest rate, which is impossible.

Given what we know about the costs of inflation it is not obvious that targeting consumer prices is intrinsically better than targeting producer prices. Hence, the degree of output stability which is achieved should be an important criterion when choosing between different inflation targets. However, one should be aware of some potential complicating factors that are not included in the discussion above.

- Throughout section 3.2 we have assumed that the expectations term in the Phillips-curve is equal to the inflation target. Actually it may matter whether these expectations relate to consumer or producer prices. If it is consumer prices, credibility may be in danger if consumer prices deviate too much or too long from target.
- If strong exchange rate movements threatens the credibility of the inflation target, then there may be more reasons to react to them.
- Wage and price setting may react not only to expected inflation but also to the levels of profits or prices.
- The model has only one production sector. When we have more sectors, it is difficult to move productive resources quickly and the sectors react differently to the exchange rate and the interest rate, large exchange rate jumps may be more of a nuisance.
- If we allow for imperfect capital mobility, this will normally reduce the effect of the interest rates and the expectations variables on the exchange rate.

When the exchange rate moves, it is often difficult to know why. Is it due to permanent or temporary shocks? How long can one expect the temporary shock to last? Is a depreciation a sign that the confidence in the inflation target is diminishing?