Chapter 12

Monetary Policy

[This is a draft (December 2002) chapter of a new book - Carlin & Soskice (200x)[1]].

In this chapter, we investigate how the government or central bank makes its monetary policy choices. We take as the starting point an economy that is characterized by a vertical Phillips curve in the medium run and by a trade-off between inflation and unemployment in the short run. Economic agents react to new information but they cannot fully adjust to new information immediately. The presence of 'nominal stickiness' and / or inertia in expectations formation implies that shifts in aggregate demand including those induced by monetary policy can shift output and employment in the short run.

This chapter begins in section 1 with the question: what can monetary policy do? We show that monetary policy can affect the level of output in the short, but not in the medium, run and that monetary policy sets the inflation rate for the economy in the medium run. Two examples are used to highlight the role of monetary policy and the limits to its effectiveness. The first focuses on the attempt of the authorities to hold the level of output above the equilibrium level and contrasts a non-accommodating with an accommodating monetary policy. The second example takes the case of an economy with stable but high inflation and asks how monetary policy can help bring inflation down. A strategy of 'cold turkey' or shock therapy is compared with one of gradualism.

These examples lead directly to further questions:

[1] The working title of the book is *Macroeconomics: Theory and Analysis of Contemporary Market Economies.* We are grateful for comments on an earlier draft and / or discussions with Chris Allsopp, Andrew Glyn, Campbell Leith, Nicholas Rau, David Vines and Will Wachtmeister. We are responsible for all remaining errors.

1. What is wrong with inflation?

2. What is the 'ideal' rate of inflation — is it zero, positive or negative?

3. What is the government and/or the central bank trying to achieve by using monetary policy — i.e. what is the objective of the authorities?

In section 2 on the objectives and instruments of monetary policy, we bring the monetary side of the economy closer to the reality of a modern economy by taking into account two important facts: the demand for money may be unstable and the money supply may not be completely under the control of the authorities. Both of these features explain why modern central banks typically use the *interest rate* rather than the *growth of the money supply* as their monetary policy instrument. This issue was introduced in Chapter 8 (Money and Finance).

In section 3 we take the next step and set out how the government can use changes in the interest rate to steer the economy back toward a level of output close to the equilibrium and a level of inflation close to its target after the economy has been hit by a shock. We show how the government's objective function can be included in the Phillips Curve diagram. In the simplest case, we shall see that the government's indifference curves appear as a 'target' in which the 'bull's eye' is the desired inflation/output combination. The government aims to get as close as possible to its target subject to the constraint it faces in the form of inflation expectations. This constraint is the expectations augmented Phillips curve. By combining the expectations augmented Phillips curves with the indifference curves, we show how to derive the government's Output Reaction Function as a line in the diagram. This shows the level of output the government will choose by setting the interest rate so as to best meet its objectives.

In section 4, we fill in the link from the government's output reaction function to the interest rate it will set in order to achieve the desired output level. This requires bringing the IS curve into the story. The IS curve tells us the real interest rate that will deliver any given output level. This pins down the government's monetary policy reaction function. We can then summarize the model in three equations: the Expectations Augmented Phillips Curve, the IS curve and the Monetary Reaction Function and show how it can be used to analyze the reaction of the government to three kinds of shocks:

1. an inflation shock (i.e. a shift in the Expectations Augmented Phillips Curve);

2. an aggregate demand shock (e.g. a shift in consumption, investment or government spending, i.e. a shift in the IS curve);

3. an aggregate supply shock (i.e. a shift in the wage-setting or price-setting curves).

Section 4 then examines a famous monetary policy reaction function that is known as the Taylor Rule. The Taylor Rule states how the government (or central bank) should adjust the interest rate in response to any deviation of output from the equilibrium rate and of inflation from its target. It concludes by setting out the limits to the use of a monetary policy reaction function in dealing with macroeconomic problems.

Section 5 introduces the issue of the credibility of monetary policy and explains how the so-called time inconsistency problem arises. This is the problem of the government being unable to commit credibly to a target of low inflation: the result is that in equilibrium, inflation is higher than the government's target. This is referred to as the 'inflation bias'. We shall see that the origin of the inflation bias lies in the government's objective of a level of output higher than the equilibrium. The adoption of a monetary rule would only solve this problem to the extent that it shifted the government's target level of output back to the equilibrium. The delegation of monetary policy authority to an independent central bank is sometimes proposed as a method of achieving this. We also examine how a central bank may be able to develop a reputation for 'toughness' as a method of reducing the inflation bias.

In section 6, we show how to bring the analysis of monetary policy developed in this chapter together with the open economy analysis of Chapter 6. We shall see how to interpret a monetary policy reaction function in the open economy and how the way the adjusts to a demand or supply shock differs under such an inflation targeting regime from a regime of either fixed or floating exchange rates. Section 7 summarizes the key results of this chapter.

12.1 Monetary policy and inflation

We begin this section by summarizing the role of monetary policy in the basic model. In particular, we show that monetary policy

1. can affect output and employment in the short run;
2. cannot affect output in the medium run;
3. sets the rate of inflation in the medium run.

The role monetary policy can play in the short run and the medium run was explored in Chapters 2, 3 and Chapter 8 (Money and Finance). In the short run, monetary policy can be used to change the level of aggregate demand and therefore to affect the level of output and employment. We discussed how monetary policy can have a short-run impact on output if, for example, the central bank uses open market operations to influence the nominal interest rate. In the short run, when prices are sticky and inflation expectations are unchanged, a change in the nominal interest rate changes the real interest rate. When the real interest rate changes, there is a reaction from interest-sensitive components of spending in the economy such as investment. This influences the level of output and employment through the multiplier process. In the IS/LM diagram, this is reflected by a shift in the LM curve.

In the basic model presented in Chapter 3, we also saw that in a *medium-run equilibrium* characterized by constant inflation, the rate of inflation is determined by the growth rate of the money supply. This result relies on the key assumptions that the central bank is able to control the growth of the money supply and that the demand for money is stable. Under these assumptions, we can analyze the way the economy reacts when it is shifted away from the medium-run equilibrium. If we suppose that the economy is subjected to a shock that pushes output below the medium-run equilibrium, this will lead to a fall in inflation (as shown by a move down the relevant expectations-augmented Phillips curve). If the monetary authority keeps to a constant growth rate of the money supply, then lower inflation combined with unchanged money growth entails a rise in the real money supply and hence a loosening of monetary conditions in the economy. The LM curve shifts to the right pushing the interest rate down and the economy begins to recover. Alternatively, monetary policy could be used to speed up the return of the economy to the equilibrium: instead of waiting for the real money supply (M/P) to be boosted by a falling price level $(\downarrow P)$, the authorities could increase the real money supply by raising the nominal money supply, $(\uparrow M^S)$.

12.1.1 Accommodating and non-accommodating monetary policy

To highlight why monetary policy cannot affect the level of output in the medium run, we investigate the consequences when a government tries systematically to keep the level of output above and the rate of unemployment below the equilibrium. One explanation for such behaviour is that the government does not fully understand how the economy works and believes that it can sustain an unemployment rate below the equilibrium. Another explanation is that the government is trying to boost its support amongst the electorate and it believes that keeping unemployment low will increase its chances of re-election. If the election is due to take place in 'the short run', then this tactic may be successful.

We shall contrast the outcomes of two different monetary policies — one is called 'non-accommodating' and the other is 'accommodating'. Monetary policy is non-accommodating when the central bank cares only about hitting an inflation target. By contrast, monetary policy is accommodating when the government allows monetary policy to do whatever is necessary to ensure its unemployment target is maintained.

Non-accommodating monetary policy

We have examined the non-accommodating case in Chapter 3. We begin in equilibrium with $y = y_e$ and inflation constant at $\pi = 3\%$ (see Fig. 12.1). There is a rightward shift in the IS-curve (as a consequence of a rise in government spending, for example) and the authorities hold the growth rate of the money supply constant at $\gamma_M = 3\%$. In this case, we know that the new medium-run equilibrium will be characterized by an inflation rate of 3% with unemployment equal to the equilibrium rate. The government can only achieve a *temporary* reduction in unemployment as the economy moves from A to B along the IS-curve. Inflation rises as shown by the move from A to B along the expectations augmented Phillips Curve (i.e. $EAPC(\pi = 3\%)$), defined as:

$$\pi_t = \pi^E + g(E),$$

where $g(E)$ is the gap between the wage-setting and the price-setting curves at the existing employment level, E. In this chapter, it is more convenient to define the Phillips Curve diagram with output on the horizontal axis. We use the simple linear version of the expectations augmented Phillips curve:

$$\pi_t = \pi^E + \alpha(y - y_e). \qquad \text{(Expectations augmented Phillips Curve)}$$

If we assume that expected inflation is equal to last period's inflation ($\pi^E = \pi_{-1}$), then since inflation is now higher than the growth rate of the money supply, the real money supply shrinks, credit becomes more expensive and output falls. The economy traces out the spiral-shaped adjustment path to the new medium-run equilibrium at Z shown in the Phillips Curve diagram (Fig. 12.1). A similar protracted adjustment process would be expected if $\pi_t = \pi_{-1} + \alpha(y - y_e)$ not because of adaptive expectations but because of the sluggish adjustment of inflation as a consequence, for example, of the staggering of wage contracts.

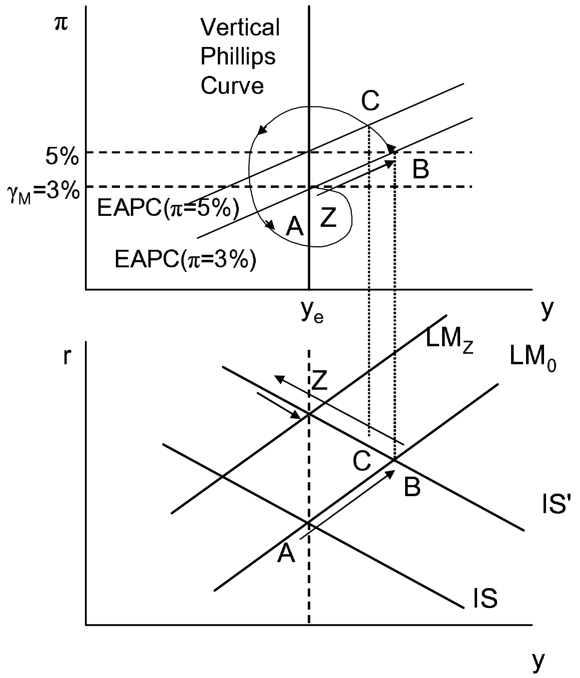


Figure 12.1: Aggregate demand shock and non-accommodating monetary policy

Accommodating monetary policy

In the accommodating case, the government allows monetary policy to do whatever is necessary to maintain employment at its target. This case is shown in Fig. 12.2, where the target output level is above y_e. The starting conditions for the economy are the same. But in this case, the authorities are obliged to allow the money supply to rise with inflation if they are to maintain unemployment below the equilibrium. Initially, inflation is equal to 3% and output is equal to the equilibrium level, y_e. The government then raises its spending so as to boost the level of output and to cut unemployment. This is shown by the shift in the IS curve to IS'. Unemployment falls to the target rate and inflation rises as the economy moves along the $EAPC(\pi^E = 3\%)$ from A to B. From this point on, performance differs from the non-accommodating case. To prevent the real money supply from contracting , the central bank allows the growth rate of the money supply to rise in line with the increase in inflation (since $\pi = 5\%$; the growth rate of the money supply, γ_M is allowed to rise to 5%). This means that output remains above the equilibrium level. Inflation rises each period as inflation expectations are updated and the $EAPC$ shifts upwards (see Fig. 12.2). The outcome when the government attempts to maintain unemployment below the equilibrium rate *and* directs the central bank to pursue an accommodating monetary policy is ever-increasing inflation (from B to C to D etc. in Fig.12.2).

It is obvious that such a situation cannot continue indefinitely. For as long as employment remains above the equilibrium, there is a mismatch between the real wage aspirations of employees (shown by the WS-curve) and the real wage consistent with equilibrium in price-setting for firms (shown by the PS-curve). In the simple model that we have been using, it is employees who are repeatedly faced with an ex post real wage below the expected real wage since the ex post real wage is equal to w^{PS}. In a richer model in which there are lags in price-setting as well as in wage-setting, the ex post real wage will lie between the wage- and price-setting real wages. In either case, the expectations of one or both parties — i.e. of wage-setters and/or price-setters are repeatedly unfulfilled.

12.1.2 The costs of inflation and deflation

This is a good moment at which to ask why rising inflation is a problem. Since there seem to be obvious benefits of having a higher level of output (i.e. above the equilibrium level set by the WS and PS curve and therefore closer to the competitive, full information market clearing levels), what are the costs to the economy of rising inflation? Indeed, we are invited to think

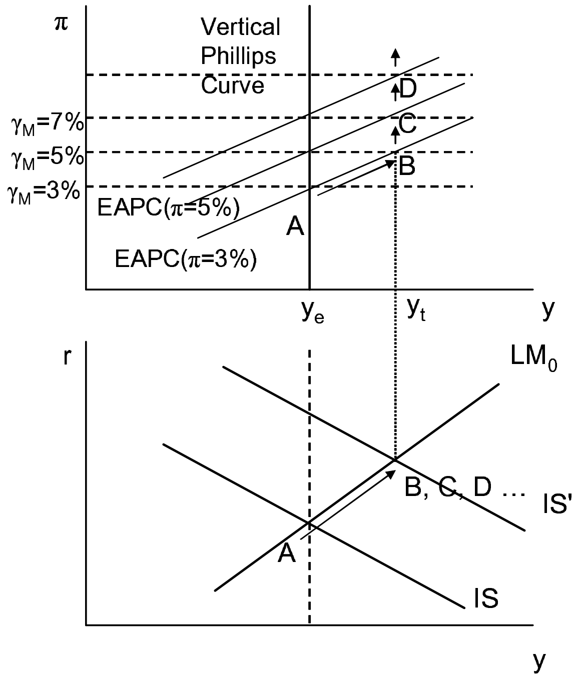


Figure 12.2: Aggregate demand shock and accommodating monetary policy

about the more general question: why might low and stable inflation be ideal? What problems arise when inflation is negative, i.e. when prices are falling. A situation in which the general price level is falling is referred to as 'deflation'. Some of the discussion about the appropriate inflation target is muddled by a confusion between the optimal medium run inflation rate and the costs of reducing inflation to the target. We discuss the latter below. First we shall identify the costs of inflation when it is: *rising, high, negative, volatile.*

Rising inflation In an economy in which social groups — such as unions — wield economic power, a situation of rising inflation reflects inconsistent claims on output per head in the economy. As we have seen in the example shown in Fig. 2, rising inflation reflects a situation in which workers' real wage aspirations are systematically frustrated. This reflects distributional conflict as different social groups (wage-setters/employees and price-setters/employers) seek to protect their interests. Social tension will rise as frustration mounts. It is clear that the phenomenon of rising inflation cannot continue indefinitely. Inflationary episodes of this kind in both advanced and developing countries have been followed by painful periods of disinflation. In extreme cases, rising inflation turns into hyperinflation, which is accompanied by extreme economic and social disruption. (For further discussion of hyperinflation, see Chapter 13 (Fiscal Policy).)

Constant inflation — what level is optimal? Assuming that constant inflation is needed for expectations to be fulfilled, we turn to the question of 'at what level'? We begin by noting that there are hypothetical circumstances under which the rate of inflation (i.e. high or low) should not matter much. Imagine that we move suddenly from a situation in which prices are rising at 3% per year to rate of 10% per year. We assume that this change is announced well in advance and that the tax system is indexed to inflation so that all the tax thresholds are raised by 10%. The same is assumed to be true of pensions and other benefits. The consequence of this change will be that all wages, benefits and prices will now rise at 10% p.a. and the nominal interest rate will be 10% higher. All real magnitudes in the economy remain unchanged. The economy moves from a constant inflation equilibrium with $\pi = 3\%$ to a constant inflation equilibrium with $\pi = 10\%$. The real interest rate and the levels of output and employment remain unchanged.

From our earlier analysis, we know that at the new equilibrium, the real money supply will be lower than initially. Why? At high inflation, people wish to hold lower money balances — they wish to economize on their holdings of money — so for equilibrium in the money market the real money supply must be lower than in the initial low inflation equilibrium. Since

$$\begin{aligned}\frac{M^S}{P} &= L(i, y) \\ &= L(r + \pi^E, y),\end{aligned}$$

at equilibrium output with low inflation, we have:

$$\frac{M^S}{P_L} = L((r_e + \pi_L), y_e)$$

and at equilibrium output with high inflation, we have:

$$\frac{M^S}{P_H} = L((r_e + \pi_H), y_e).$$

This highlights the fact that even in our simple example the shift from inflation of 3% to 10% is not quite as straightforward as it seems at first. After the move to 10% inflation, money wages, prices, the nominal money supply and nominal output will rise by 10% each year. But at the time of the shift, there has to be an additional upward jump in the price level to bring down the real money supply (M^S/P) to its new lower equilibrium level (M^S/P_H) consistent with the demand for lower real money balances when inflation is higher.

What are the real costs of people economizing on money balances when inflation is high? These costs are referred to as 'shoe-leather' costs because of the wear and tear associated with more frequent trips to the bank or the cash machine. Other costs (so-called menu costs) arise because of the time and effort involved in changing price lists frequently in an inflationary environment.

Once we relax our assumption that indexation to inflation is widespread in the economy and that adjustment to higher inflation is instantaneous because all parties are fully informed and can change their prices and wages at low cost, it is clear that the costs of maintaining a high inflation economy are likely to be more substantial. Distributional effects are also likely to occur. Unanticipated inflation shifts wealth from creditors to debtors. It is also likely to make the elderly poorer since they rely on imperfectly indexed pensions and on the interest income from savings. Recognition of such costs is consistent with survey evidence that shows the general public is more averse to inflation than would be expected if the costs were really as low as they seem in the example of full information, complete indexation and instantaneous adjustment.

Can we infer from this analysis that the optimal rate of inflation is zero or even negative? In thinking about the optimal inflation rate, we are led first of all to consider the following: the return on holding high-powered money (notes and coins) is zero so with any positive inflation rate, the real return turns negative. The negative real return leads people to waste effort economizing on their money holdings (shoe-leather again) and this is inefficient given that it is virtually costless to produce high-powered money. If we follow the logic of this argument then with a positive real rate of interest, for the nominal interest rate to be zero, inflation would have to be negative (i.e. prices falling). Is negative inflation or deflation as it is usually called optimal?

Deflation If inflation is negative (e.g. -2%) then prices and wages will be lower in a year's time than they are now. In a world of perfect information, there would only be benefits from this as we have already seen — shoe leather would be saved. The neatness of this argument is ruined however once we introduce real-world considerations. Why might a positive (though low and stable) rate of inflation be preferable to falling prices? One reason relates to the apparent difficulty in cutting nominal wages as discussed in Chapter (Nominal Rigidities). If money wages cannot be cut, then a positive rate of inflation creates the flexibility needed to achieve changes in *relative* wages. If a real wage cut is required due to a fall in demand for one kind of labour, it can be achieved with an inflation rate of, say, 2% with the money wage left unchanged in the sector where a real wage cut is necessary. This argument is referred to as inflation's role in 'greasing the wheels of the labour market'.

There is another reason why a zero nominal interest rate (combined with deflation) is unlikely to be viewed as ideal from a macroeconomic point of view. If the nominal interest rate is zero, then it will be impossible for the central bank to use monetary policy to boost activity. To boost activity, the central bank wishes to cut the real interest rate. If the nominal interest rate is already zero, a cut is impossible. In general, the constraint on expansionary monetary policy set by the zero floor to the nominal interest rate, provides a rationale for an inflation target that is mildly positive.

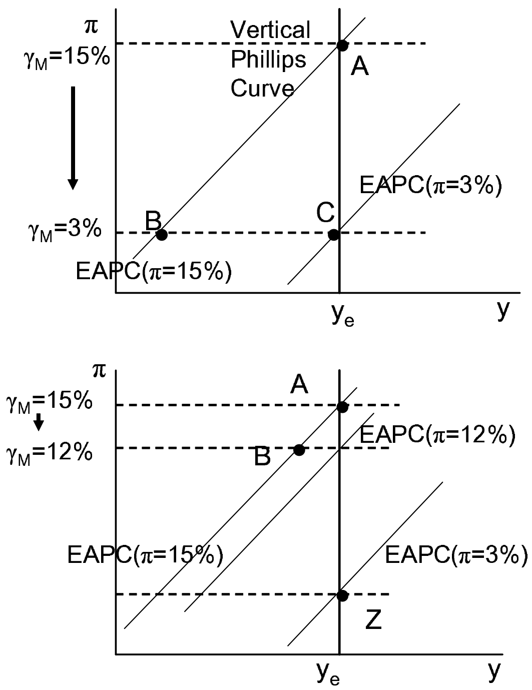
Volatile inflation Volatile inflation is costly because it creates uncertainty. As we have seen, if inflation is constant at 10% per year then the costs are relatively limited because contracts can incorporate this expected change in prices. Unexpected changes in inflation imply changes in real variables in the economy: if money wages and pensions are indexed by expected inflation of 10% and there is an unanticipated jump in inflation to 15%, real wages and pensions will drop. Equally, the real return on savings will fall because the nominal interest rate only incorporates expected inflation. Volatile inflation has real effects on the economy that are hard to avoid.

Summing up The conclusion to this discussion is that policy makers should aim for low and stable inflation. This raises a further question. Why do we observe economies with high, rising and volatile inflation? We have already noted that governments may be tempted to take advantage of the short run trade-off between inflation and unemployment. Since rising inflation reflects distributional conflict in the economy, one interpretation is that the political system is incapable of resolving these conflicts, which therefore come to be reflected in rising inflation. A variation on this theme is that the origin of situations of high and/or rising inflation lies with the financing of government spending. As we shall see in the next chapter when we discuss fiscal policy, there are situations in which the usual methods of financing government spending via taxation or borrowing are limited. Raising taxes may be politically unpopular and further borrowing may be prohibitively expensive because of the level of public debt that has already been built up. For example, if the government is intent on raising its spending in response to pressure from politically important groups in the economy, it may have to get hold of the necessary resources by increasing the money supply. The use of money to finance government spending is called seignorage. We examine the scope for and limits to seignorage in the fiscal policy chapter.

One explanation for the reluctance of governments to cut inflation is the cost in terms of higher unemployment in the short run, to which we now turn.

12.1.3 The costs of disinflation: 'cold turkey' versus 'gradualism'

So far in this section, we have seen how the attempt to keep unemployment below the equilibrium will result in ever-increasing inflation and will require the authorities to pursue an accommodating monetary policy. We have also seen the disadvantages associated with high and rising inflation. To complete the section, we take the situation of an economy with high and stable inflation (e.g. 15%) and ask how costly is a reduction in inflation to a low level (e.g. 3%). The answer to the question is simple if we were to assume that expectations are formed rationally and that there are no nominal rigidities or lags in adjustment in the economy. All that would be necessary in such a case is to announce that the growth rate of the money supply, γ_M will hence-



(a) 'Cold turkey'

(b) Gradualism

Figure 12.3: The costs of disinflation: 'cold turkey' versus gradualism

forth be equal to say, 3%. Inflation expectations will adjust immediately, all nominal contracts will be rewritten to incorporate an expected inflation rate of 3%, the price *level* will jump downwards so as to raise the level of real money balances to the new equilibrium level, and the economy will shift to the new equilibrium, without loss of output. The economy goes straight from point A to point C in Fig. 12.3(a).

In reality, such a costless disinflation is not normally observed. Instead, it is usually the case that before inflation falls and stabilizes at a lower level a period of unemployment *higher* than the equilibrium will be observed. The simplest way of seeing this is to assume that inflation expectations are entirely backward looking or alternatively that although agents are forward looking, nominal rigidities in the economy mean that the short-run Phillips curve is as follows:

$$\pi_t = \pi_{-1} + \alpha(y - y_e). \qquad \text{(Short-run Phillips Curve)}$$

When past inflation plays an important role as a determinant of current inflation, for inflation to fall, unemployment must rise above the equilibrium. When unemployment is above the equilibrium, there is downward pressure on inflation because the higher unemployment reduces the wage-setting real wage. With the wage-setting real wage below the existing real wage, money wages rise by less than π_{-1}. This is the information summarized in the short run Phillips curve.

When inflation expectations are backward looking or nominal inertia is important, disinflation takes time and the economy incurs costs in the form of lost output during the period that output is below equilibrium. Output falls below equilibrium because of the tight monetary policy ($\downarrow (M/P)$) imposed by the cut in the growth rate of the money supply from 15% to 3%: for as long as $\gamma_M < \pi$, the real money supply (M/P) is falling and the LM-curve is shifting to the left. The spiral shaped adjustment path to the new medium-run equilibrium at point Z is similar to the one traced in Fig. 12.1 above, when we looked at a non-accommodating monetary policy. The difference is that the economy ends up at a *lower* stable inflation rate because the growth rate of the money supply has been reduced.

The size of the unemployment bulge and the time taken before the low inflation equilibrium is reached will be affected by the extent of backward-looking behaviour in expectations formation and the extent to which the adjustment of prices, wages and nominal contracts is slow. The more backward are inflation expectations and the stronger are nominal rigidities in the economy, the higher will be the output cost of bringing down inflation.

For a given expectations formation process and given institutions, how should the authorities implement their disinflation policy? It is useful to note the contrast between what has been termed a 'cold turkey' or shock therapy strategy to reduce inflation and a 'gradualist' one. Under cold turkey, the authorities cut the growth rate of the money supply immediately from its existing growth rate of, say, 15% to the new target rate of 3%. This implies a dramatic contraction of the real money supply in the first period before any reduction in inflation has taken place. In Fig. 12.3(a), we show this as the move from point A to point B. The pronounced leftward shift in the LM curve implies a sharp rise in unemployment and a big fall in inflation. The short-run Phillips curve will therefore shift down sharply as shown in the diagram.

A more gradualist policy of disinflation would see a slower reduction in the growth rate of the money supply: instead of cutting monetary growth from 15% to 3% in one year, it is cut from 15% to say, 12% in the first year. Hence the leftward shift of the LM curve is less because the fall in the real money supply is more limited. As a consequence, unemployment rises by less: the economy moves from A to B in Fig.12.3(b). Although the rise in unemployment is less — which is good — the fall in inflation is also less — which is bad. In other words, this simple example helps to show that when reducing inflation there is a trade-off between the *speed* and the *annual cost in terms of high unemployment*. Cold turkey is fast but brutal; gradualism is slower and unemployment is higher for longer — but unemployment never rises as high.

Note that in both the cold turkey and gradualist cases, there is a period in the adjustment process to the new equilibrium during which inflation is below the growth rate of the money supply. This produces the rise in the real money supply that is consistent with the new lower inflation equilibrium. Nominal rigidities prevent the drop in the price level that brings about the rise in M/P in the example of costless adjustment ($A \rightarrow C$ in Fig. 12.3(a)). In theory, the government could speed up adjustment to the low inflation equilibrium by a one-off increase in the nominal money supply. Suppose the economy has moved from A to B in Fig.12.3(a). Inflation is now at the target rate: a one-off monetary boost would shift the economy to C. The level of real money balances would be appropriate to the new low inflation equilibrium and with inflation and the monetary growth rate at 3%, the equilibrium can be maintained. If a sense of unease on the part of the reader is generated by this example of combining a monetary growth rate rule with a one-off jump in the money supply it probably comes from concerns about how well such a policy would be understood by the public. We return to this issue in our discussion of monetary rules below.

12.2 Objectives and instruments

By an *objective* of monetary policy is meant an economic outcome that is valued by the policy maker. For the past two decades in many advanced countries and for longer in some others, this is thought to include a real variable such as output or employment and a nominal variable such as inflation or the price level. As we have already seen monetary policy cannot affect the level of output and employment in the medium run. This is the sense in which money is *neutral* in the medium run. But we have also seen in the comparison of the cold turkey and gradualist strategies that even a government seeking to reduce inflation to a low level has choices to make. It is therefore useful to identify two objectives of monetary policy: one is to establish a *nominal anchor* and the other is to provide *stabilization* for the economy.[2]

In Chapter 3, the 'nominal anchor' role of monetary policy was transparent. Monetary policy has a nominal anchor role when it is used deliberately to guide inflation back to the government's nominal target — in this case, an inflation target. We saw in Chapter 3 that in the medium run when inflation is constant and expectations are fulfilled, the growth rate of the money supply determines the rate of inflation. This suggests a very simple approach to monetary policy: set a constant growth rate of the money supply equal to the target rate of inflation. What is wrong with this approach?

Objection 1: A money supply rule can be costly. As we have already seen in the comparison of 'cold turkey' and 'gradualism', once we admit that there are nominal rigidities in the economy, the mechanical application of a monetary growth rate rule can lead to large fluctuations in output.

Objection 2: The demand for money may be unstable as explained in Chapter (Money and Finance). If the demand for money is volatile, then if the government sticks to a money supply rule, any shift in the demand for money will cause the LM curve to shift. This will take output away from equilibrium and will push inflation away from its target as the economy moves along the expectations augmented Phillips curve.

Objection 3: The money supply may not be under the control of the central bank. In a modern economy, as discussed in the money and finance chapter, the vast majority of money in the economy is 'inside money', i.e. money created by the private banking system. This means that there is no rigid link from the monetary base (notes and coins plus balances of commercial banks at the central bank) to the amount of loans made by commercial banks and therefore the amount of bank deposits, which are the core component of the money supply.

Objection 4: A money supply rule can be destabilizing. If the economy is at equilibrium employment with inflation equal to the target and is disturbed by a boost in aggregate demand (the IS shifts to the right), the stabilizing influence of the money supply rule works through the effect of the increase in inflation in cutting the real money supply and pushing up the nominal and real interest rates (as the LM curve shifts left). The implicit assumption here is that expected inflation remains constant — hence, a rise in the nominal interest rate pushes up the real

[2] For further discussion of these arguments see C. Allsopp and D. Vines (2000) 'The assessment: macroeconomic policy', Oxford Review of Economic Policy. Vol. 16, No. 4, pp. 1-32.

interest rate. However, it is possible that inflation expectations adjust very rapidly to the shock. If so, the real interest rate may actually *fall* (remember that $r = i - \pi^E$) and the LM curve will shift to the right, reinforcing the initial positive IS shock and taking the economy further from equilibrium.

In the light of these objections, monetary policy makers may choose to use the interest rate rather than the money supply as their 'intermediate target'. Before going further, there is one key clarification to make.

- Is the monetary policy instrument the real or the nominal interest rate?

The answer is that the authorities are only able to fix the nominal interest rate but their choice of the nominal rate must be dictated by their objective of influencing the real rate. It is easiest to see why this is so important by considering an example. Suppose that the economy is at the equilibrium level of output with inflation equal to the target: to be concrete, assume that inflation is 3%, the real interest rate is 2% and the nominal interest rate is 5%. Now assume that there is a shock to inflation. Suppose that inflation rises suddenly to 6%. If the central bank sticks to a nominal interest rate of 5%, then with inflation now of 6%, the real interest rate has fallen to -1%. A negative real interest rate will boost the interest-sensitive components of aggregate demand and output will expand (diagramatically what has happened is that the rise in inflation has shifted the LM curve to the right along the IS curve (in the IS/LM diagram drawn in $r - y$ space)). Higher output will in turn push inflation up further as the economy moves to the north-west along the expectations augmented Phillips curve. Sticking to a constant nominal interest rate is clearly the wrong response to an inflation shock.

What should the government do? Since inflation is now higher than the target, the authorities will seek to *raise* the real interest rate so as to reduce the level of activity and push the economy to the south west along the expectations augmented Phillips curve. Hence they will push the nominal interest rate up by *more than* the increase in inflation.

12.3 Reaction Functions

We have introduced the idea of the government's objectives and its policy instruments. The term 'monetary policy reaction function' can be used to describe how the government uses monetary policy to react systematically to different kinds of shock so as to stabilize the economy with inflation close to its target. Although this does not provide a good description of how all governments operate monetary policy, it will provide us with a useful benchmark against which to examine the implementation of monetary policy in different contexts. We begin by asking:

1. What is the government's utility function?
2. What constraints does it perceive itself as subject to?
3. What policy instruments does it have available?

In order to make the discussion of monetary policy reaction functions concrete, we shall use specific examples of the government's utility function, policy instrument and constraints. The method for deriving a monetary policy reaction function will be the same if different variants are chosen.

12.3.1 The government's utility function

We shall assume that the government has two concerns: the rate of inflation, π, and the level of output, y. Looking first at inflation, we shall assume first that it has a target rate of inflation π^T and that it wants to minimise fluctuations around π^T. A simple way of writing this is to assume that it wants to minimize the loss function:

$$(\pi - \pi^T)^2.$$

Rather than having the government maximize a utility function, we have it minimize a loss function. A loss function is just like a utility function except that the higher the loss, the worse it is for the government. This particular loss function has two implications. First, the government is as concerned to avoid inflation below its target as it is inflation above π^T. If $\pi^T = 2\%$, the loss from $\pi = 4\%$ is the same as the loss from $\pi = 0\%$ — in both cases $(\pi - \pi^T)^2 = 4$. Second, it attaches increased importance to bringing inflation back to its target the further it is away from π^T; the loss from $\pi = 6\%$ is 16, compared to the loss of 4 from $\pi = 4\%$.

We turn now to the government's second concern — about output and employment.[3] We assume the government's target level of output is the equilibrium level y_e and it seeks to minimize the gap between y and y_e. At this point it is useful to draw attention to the fact that we have assumed

[3] We shall use output rather than employment in what follows simply because this is common in the literature.

that the equilibrium output level y_e is known, that the government's target output level is y_e and that it is able to stick to this target. As we shall see in section 5, even if y_e is known, the government may target a higher level of output. Output (or employment) targets are likely to arise from the interplay of interest groups in the economy mediated by political institutions, and governments may be unable or unwilling to go against these pressures at particular times. Concrete instances of such problems and their consequences are discussed in Chapter (Booms and Slumps).

The government's loss from output different from its target of y_e is

$$(y - y_e)^2.$$

Note that this loss function again suggests a symmetrical attitude to positive and negative deviations — in this case, from the equilibrium level of output. The most straightforward way of thinking about our central case in which the government's target is an output level of y_e is that it understands the model and realizes that inflation is only constant at $y = y_e$. Whenever the economy is disturbed, the government sees its task as steering the economy back to this constant inflation output level.

If the two loss functions are added together, we have the government's objective function:

$$L = (y - y_e)^2 + \beta.(\pi - \pi^T)^2, \qquad \text{(Government loss function)}$$

where β is the relative weight attached to the loss from inflation. This is a critical parameter: a $\beta > 1$ will characterize a government that places less weight on deviations in employment from its target than on deviations in inflation, and vice versa.

Let us first look at the geometry of the loss function in the Phillips curve diagram, on the assumption that $\beta = 1$. With $\beta = 1$, the government is equally concerned about inflation and output deviations from its targets.

The loss function is simple to draw: with $\beta = 1$, each indifference curve is a circle with (y_e, π^T) at its centre (see Fig.12.4(a)). The bigger the circle the bigger the loss. The loss declines as the circle gets smaller. When $\pi = \pi^T$ and $y = y_e$, the circle shrinks to a single point and the loss is zero. The diagram is easy to remember if you think of it as a target (as for archery) with the government's objective to get as close to the bull's eye as possible. With $\beta = 1$, the government is indifferent between inflation 1% above (or below) π^T and output 1% above (or below) y_e. They are on the same loss circle.

Only when $\beta = 1$, do we have indifference *circles*. If $\beta > 1$, the government is indifferent between (say) inflation 1% above (or below) π^T and

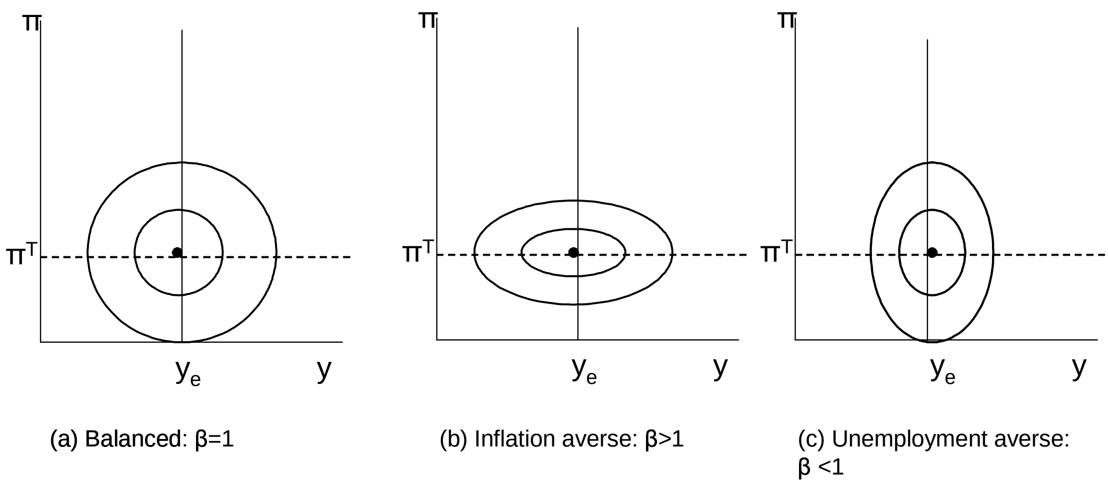


Figure 12.4: Government loss functions: utility declines with distance from 'bull's eye'

output 2% above (or below) y_e. They are on the same loss 'curve'. This makes the indifference curves ellipsoid as in Fig.12.4(b). A government with less aversion to inflation ($\beta < 1$) will have ellipsoid indifference curves with a vertical rather than a horizontal orientation (Fig. 12.4(c)). In that case, the indifference curves are steep reflecting that the government is only willing to trade off a given fall in inflation for a smaller fall in output than in the other two cases.

12.3.2 The Phillips curve constraint

Next, we shall assume that the government can control the level of output via its ability to use monetary policy (by setting the interest rate) to control aggregate demand, y^D. However, it cannot control inflation directly — only indirectly via y. As we have already discussed, output affects inflation via the expectations augmented Phillips curve:

$$\pi = \pi^E + \alpha.(y - y_e) \tag{12.1}$$

This is shown in Fig. 12.5, where the upwards sloping lines are expectations augmented Phillips curves. For simplicity it is assumed that $\alpha = 1$, so that each $EAPC$ has a slope of 45°. Each expectations augmented Phillips curve is labelled by expected inflation. Assume that $\pi^E = \pi^T = 2$ (remember that this $EAPC$ must go through point b at which $y = y_e$ and $\pi = 2$). The government is in the happy position of being able to choose the bull's eye point b or (π^T, y_e) at which its loss is zero.

What happens if expected inflation is not equal to target inflation? Suppose, for example, that expected inflation is 4%. This means that the government can only choose points along $EAPC(\pi^E = 4)$. The bull's eye is no longer obtainable. The government faces a trade-off: if the government wants $y = y_e$ then it has to accept $\pi = \pi^E = 4 \neq \pi^T$ (i.e. point a) and vice versa if it wishes to hit the inflation target (point c). Point a corresponds to our earlier discussion of a fully accommodating monetary policy in which the objective is purely to hit the output target, and point c corresponds to the non-accommodating case, in which the objective is purely to hit the inflation target.

In fact, as will be evident from Fig.12.5, if the government is faced by $\pi^E = 4$, it can do better than either point a or point c. It minimises its loss function by choosing point d, where the $EAPC(\pi^E = 4)$ line is tangential to the indifference curve of the loss function closest to the bull's eye. Thus if $\pi^E = 4$ it will choose an output level y_1 which will in turn imply an inflation rate of 3%.

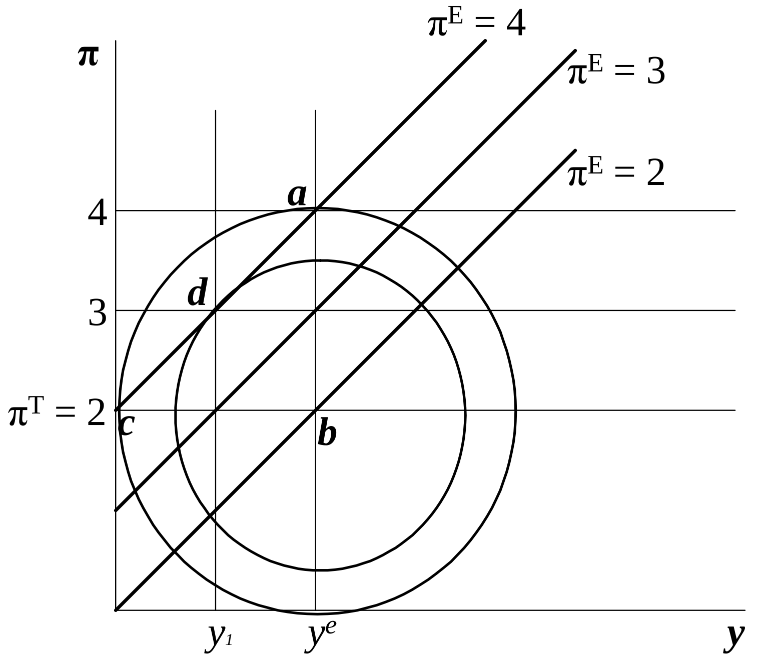


Figure 12.5: Loss circles and Phillips curves

12.3.3 Deriving the output reaction function

The timing of moves

The choice of point d in Fig. 12.5 provides us with a point on the government's output reaction function. We can generalise this result quite easily, and this will be a major step towards deriving the *monetary policy reaction function*, to which we return in section 12.4. But first we need to provide some background on timing and on who does what. Expected inflation, π^E, is not under the government's control. We assume that wage-setters start with the belief that this is what the rate of inflation will be, and they therefore set money wage inflation from the formula:

$$\Delta W/W = \pi^E + \alpha.(y - y_e)$$

Price setters then set price inflation

$$\pi = \Delta W/W - \Delta\lambda/\lambda,$$

where λ is labour productivity. For simplicity we shall assume that productivity growth is zero. The $EAPC$ comes from putting these two equations together to get $\pi = \pi^E + \alpha.(y - y_e)$.

It is useful to be a bit more explicit about the timing: in particular, it will be assumed that:

First, wage-setters have in mind and act according to expected inflation of π^E. If inflation expectations are adaptive, e.g. $\pi^E = \pi_{-1}$, or if so-called core inflation depends on past inflation, then π^E can be thought of as given exogenously by history. In the case of rational expectations, wage-setters use the available information to work out their best estimate of π^E.

Second, given π^E, the government chooses the level of output, y. The government sets the interest rate so as to choose y (via the IS/LM diagram) thereby giving the government's desired combination of output and inflation, for different values of π^E.

Third, wage-setters then set $\Delta W/W$, and price setters in turn set π.

Given this timing of moves, deriving the government's monetary policy reaction function consists of two steps. The first step is to find out what level of output the government will choose given any π^E and the second step is to see how the government will achieve this level of output by choosing its monetary policy.

The output reaction function: choosing y, given π^E

For simplicity, we use the form of the loss function in which $\beta = 1$ — so that we have loss circles as in Fig. 12.5 above. This implies:

$$L = (y - y_e)^2 + (\pi - \pi^T)^2$$

And using the simplest version of the $EAPC$ in which $\alpha = 1$ so that each $EAPC$ has a 45° slope as in Fig. 12.5:

$$\pi = \pi^E + y - y_e$$

The geometry can be seen as follows: in Fig. 12.6, the points of tangency between successive EAPCs and the loss circles show the level of output that the government needs to choose so as to minimise its loss at any given level of π^E. Thus when $\pi^E = 3$, its loss is minimised at c; or when $\pi^E = 4$ at d. Joining these points (e, d, c, b) together produces the equation labelled OR for 'output reaction function'. We can see from Fig.12.6 that a one unit rise in π^E implies a half unit fall in y, as implied by the equation; for example an increase in π^E from 3% to 4% implies a fall in y from y_2 to y_1.

We can derive the output reaction function explicitly as follows. By choosing y to minimise L we can derive the optimal value of y for each value of π^E. Substituting the Phillips curve into L and minimising with respect to y :

$$\begin{aligned}\frac{\partial L}{\partial y} &= 2(y - y_e) + 2(\pi^E + (y - y_e) - \pi^T) = 0 \\ &= (y - y_e) + (\pi^E + (y - y_e) - \pi^T) = 0\end{aligned}$$

Thus the optimal value of y for any given π^E is:

$$(y - y_e) = -\frac{1}{2}.(\pi^E - \pi^T). \tag{12.2}$$

This says that the greater the gap between expected inflation and the target rate of inflation, the more will the government have to deflate the level of output below the equilibrium level. For example, if $\pi^E - \pi^T = 3\%$, the government will have (to use monetary policy) to deflate y by 1.5% below y_e.

As we have derived it so far, the output reaction function is expressed in terms of expected inflation. We can reformulate it as a trade-off relationship between inflation and output by using the Phillips curve equation to eliminate

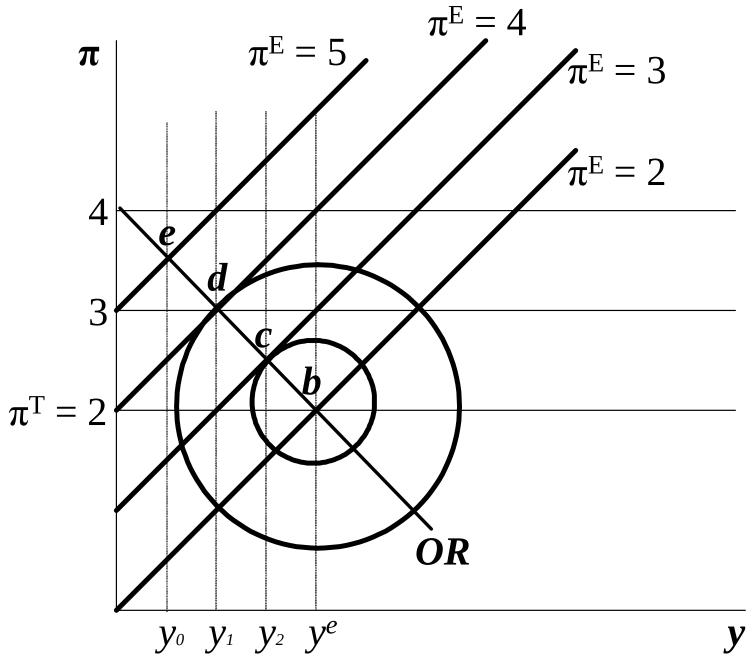


Figure 12.6: Deriving the output reaction function

expected inflation from equation (12.2):

$$\begin{aligned}(y - y_e) &= -\frac{1}{2}.(\pi^E - \pi^T) \\ &= -\frac{1}{2}.(\pi - (y - y_e) - \pi^T) \\ &\Rightarrow \frac{1}{2}.(y - y_e) = -\frac{1}{2}.(\pi - \pi^T).\end{aligned}$$

This implies:

$$(y - y_e) = -(\pi - \pi^T) \qquad \text{(Output reaction function (example))}$$

This shows the output reaction function as a inverse relation between π and y with a negative 45° slope (Fig.12.6). Specifically, it shows that y is reduced below y_e so as to reduce π below π^T by the same percentage. We are interpreting the difference between y and y_e as the percentage gap (which is equivalent to defining y as the log of output). Thus this could be thought of as a reaction function half way between: (i) a completely non-accommodating monetary policy — when the government cuts output sufficiently to bring inflation directly back to π^T; and (ii) a completely accommodating monetary policy, which leaves π equal to π_1^E — leaving $y = y_e$. If the output reaction function was flat at π^T we would have a completely non-accommodating monetary policy; if it was vertical at y_e, we would have a completely accommodating monetary policy.

It is because of two simplifying assumptions that the output reaction function ends up exactly halfway between an accommodating and a non-accommodating policy and by relaxing these, we can learn what it is that determines the slope of the output reaction function. We shall see that the more responsive are wages to employment (the steeper are the Phillips curves) and the more inflation averse is the government (the flatter are the loss ellipses), the closer is the output reaction function to a non-accommodating policy.

The first factor is the degree of inflation aversion of the government as captured by β. In our example, we have assumed that $\beta = 1$, implying the government is equally balanced in its inflation and output goals. If $\beta > 1$, the government attaches more importance to the inflation target than to the output target. This results in a flatter output reaction function as shown in Fig.12.7. Given these preferences, any given π^E shock implies a more significant output deflation and hence a sharper cut in inflation than in the neutral case. Using the same reasoning, $\beta < 1$ implies that the output reaction function is steeper than the 45° line.

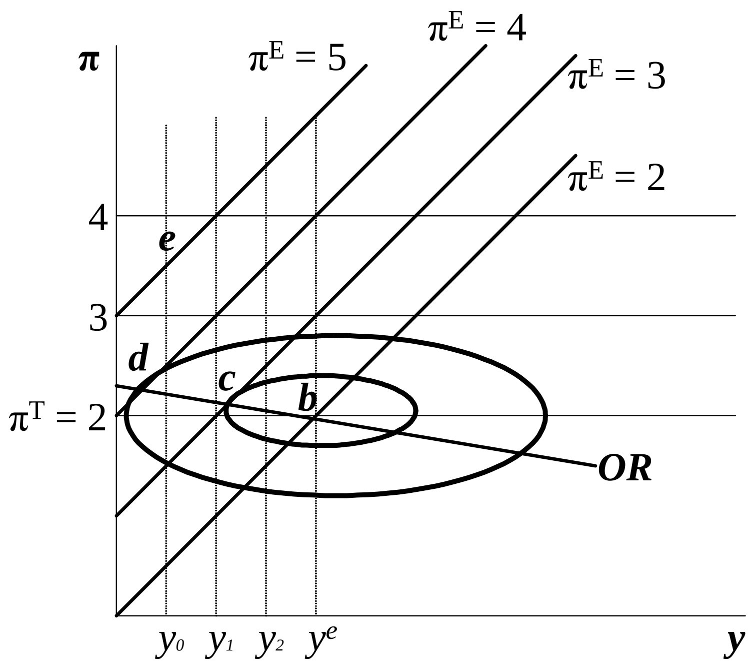


Figure 12.7: Inflation-averse government: flat output reaction function

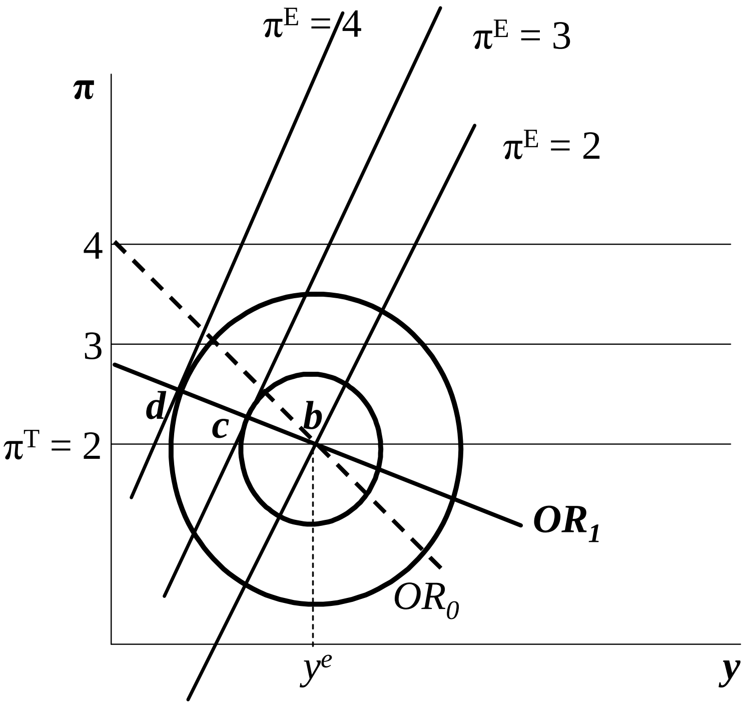


Figure 12.8: High responsiveness of inflation to output: flat output reaction function

The second factor that determines the slope of the output reaction function is the responsiveness of inflation to output (i.e. the slope of the expectations augmented Phillips curve): $\pi - \pi^E = \alpha.(y - y_e)$. In our example, we have assumed $\alpha = 1$. Intuitively if $\alpha > 1$, so that any given cut in y has a greater effect in reducing inflation than when $\alpha = 1$, we should expect that if the government is balanced in its inflation and output goals ($\beta = 1$) it would reduce y more than before. This is clear geometrically in Fig.12.8, in which OR_0 is the old and OR_1 the new output reaction function.

We can derive the more general form of the government's reaction function as follows. If we let β and α take any values, the government chooses y to minimise

$$L = (y - y_e)^2 + \beta.(\pi - \pi^T)^2 \tag{12.3}$$

subject to

$$\pi = \pi^E + \alpha.(y - y_e). \tag{12.4}$$

By substituting (12.4) into (12.3) and differentiating, we have:

$$\frac{\partial L}{\partial y} = (y - y_e) + \alpha\beta.(\pi^E + \alpha.(y - y_e) - \pi^T) = 0 \tag{12.5}$$

Substituting equation (12.4) back into equation (12.5) gives:

$$(y - y_e) = -\alpha\beta.(\pi - \pi^T) \qquad \text{(Output reaction function)}$$

Now it can be seen directly that the larger is α (i.e. the more responsive are wages to employment) and the larger is β (i.e. the more inflation-averse is the government), the flatter will be the slope of the output reaction function and the closer is the monetary rule to a purely non-accommodating one.

12.3.4 The mechanics of the output reaction function — an example

If we take the case of adaptive expectations, we can examine how the output reaction function operates if the economy is subjected to an inflation shock. Let us first define an inflation shock. Assuming we have adaptive expectations, two equations determine the inflation rate, the $EAPC$:

$$\pi = \pi^E + \alpha.(y - y_e)$$

and the equation determining π^E

$$\pi^E = \pi_{-1} + \varepsilon_{\pi^E},$$

where ε_{π^E} is the random or shock term in the π^E equation. We will refer to an *inflation* shock if $\varepsilon_{\pi^E} \neq 0$.

Suppose we are initially in period 0, at point b or $(\pi^T,\ y_e)$ in Fig.12.9, with $\pi_0^E = \pi^T = 2$. Then in period 1 there is an inflation shock, with $\varepsilon_{\pi^E} = +2$. This shock only lasts for the one period, and then drops back to zero, so $\varepsilon_{\pi^E,1} = +2$ while $\varepsilon_{\pi^E,0} = 0 = \varepsilon_{\pi^E,2} = \varepsilon_{\pi^E,3} = ...$ Thus in period 1 the economy moves to point d or (4, y^e). The $EAPC$ schedule moves up from $\pi^E = 2$ to $\pi^E = 4$. What now happens?

Given that the government is constrained to be on the $EAPC(\pi^E = 4)$ in period 1, the OR line shows the optimal level of output and hence inflation for the government to choose: it therefore chooses $y = y_1$ so that $\pi = \pi_1 = 3$: this is point e. In the next period, period 2, $\pi_2^E = \pi_{t-1} = 3$. The new

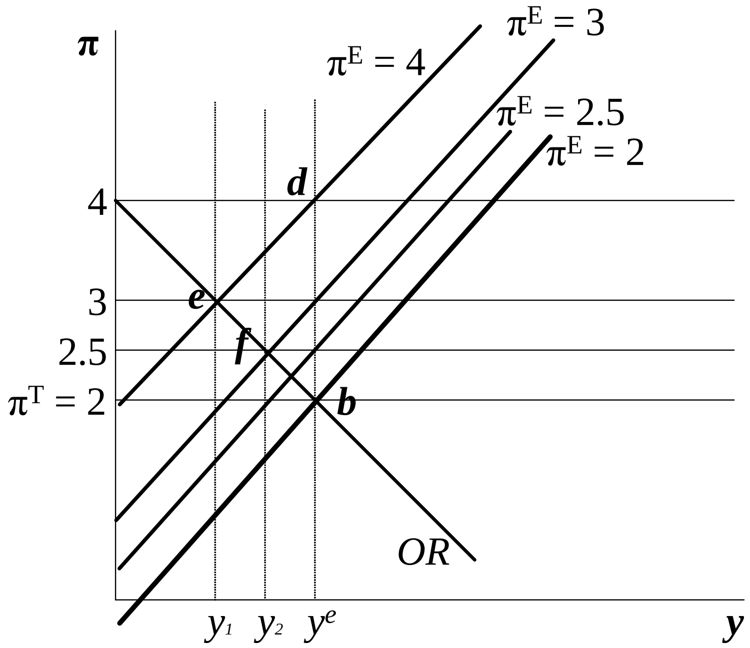


Figure 12.9: Adjustment to an inflation shock: the output reaction function

constraint faced by the government is the $EAPC(\pi^E = 3)$ and its optimal output response is y_2 . Inflation therefore falls to $\pi_2 = 2.5$ (point f). In period 3, π^E falls to $\pi_3^E = 2.5$. This process carries on until the economy returns to equibrium at point b. A government that adopts this output reaction function will move the economy down the OR line to point b.

12.4 Monetary policy reaction functions & the 3-equation model

12.4.1 The monetary policy reaction function

We have already seen how the government chooses its output level so as to maximize its utility whenever inflation deviates from its target. We maintain our assumption that it can adjust output immediately. This is summarized in the OR line in the Phillips curve diagram:

$$y - y_e = -\alpha\beta.(\pi - \pi^T).$$

From the OR, we know the government's optimal output response to a given deviation of π from π^T. We can now move to the second step that will take us from the output reaction function to the monetary policy reaction function. If we assume the government uses the interest rate as its instrument of monetary policy, then the monetary policy reaction function specifies how the interest rate should respond to produce the output required to meet the government's output objective given π^E. This information is provided by the IS curve.

The IS curve at its most basic says that output is the multiplied up value of autonomous demand (autonomous consumer demand, investment and government expenditure), i.e. $y = k.(c_0 + I + g)$, where k is the multiplier. We assume throughout this chapter that g is constant. Investment and possibly consumption will depend inversely on the real rate of interest r. In order to make the discussion as clear as possible, we shall not for the moment distinguish between real and nominal interest rates or between long and short term rates. In line with the discussion in section 12.2, we simply assume that the government can control r. So let us write

$$\begin{aligned} y &= k.(c_0(r) + I(r) + g) \\ &= k.[A(r) + g] \\ &= \bar{A} - a.r \end{aligned} \tag{12.6}$$

Thus the IS curve tells us what rate of interest r is needed to produce the optimal output level implied by any given deviation of π from π^T. We now combine the output reaction function, OR with the IS to deduce the interest rate the government will choose:

$$\bar{A} - a.r = y_e - \alpha\beta.(\pi - \pi^T)$$
$$\Rightarrow r = \frac{(\bar{A} - y_e)}{a} + \frac{\alpha\beta}{a}.(\pi - \pi^T)$$
(Monetary policy reaction function, MR)

Thus the required interest rate, r, for the monetary policy reaction function (MR) has two elements. The second element, $\frac{\alpha\beta}{a}.(\pi - \pi^T)$, comes into operation when inflation is not at its target level, i.e. $\pi \neq \pi^T$. This is sometimes referred to as the *nominal anchor* component of the monetary policy reaction function: it pins down the rate of inflation to π^T. The first element, $\frac{(\bar{A}-y_e)}{a}$, is the *aggregate demand stabilisation* component of the monetary policy reaction function. If $\pi = \pi^T$, it ensures that $y = y_e$ because it fixes the interest rate at the level that the IS shows is consistent with output at equilibrium.

We define r^S (where s stands for 'stabilization') as the interest rate that makes $\bar{A} - a.r$ equal to y_e: thus

$$y_e = \bar{A} - a.r^S \tag{12.7}$$

and r^S therefore changes whenever $\bar{A}$ changes. Turning this around, we have

$$r^S = \frac{(\bar{A} - y_e)}{a} \tag{12.8}$$

So we can write MR as

$$r = r^S + \frac{\alpha\beta}{a}.(\pi - \pi^T) \tag{12.9}$$

r is the sum of the aggregate demand stabiliser, r^S, and the nominal anchor $\frac{\alpha\beta}{a}.(\pi - \pi^T)$.

We can interpret $\frac{\alpha\beta}{a}$ easily. The more inflation-averse is the government (high β), the more sharply will interest rates be raised in response to an inflation shock above π^T: an inflation shock will lead to a bigger deflationary policy response. The more responsive is inflation to output (high α), again the more will interest rates be raised, because inflation will fall faster. But if a is high (IS is flat — e.g. investment is very interest-sensitive), a smaller interest rate increase is needed to produce a given cut in demand and output.

12.4.2 The 3-equation model

We shall return to the interpretation of r^S after we develop the 3-equation model. Each of the equations has been discussed already in this section. The first equation is the IS equation, linking r to y:

$$\begin{aligned} IS : \quad & r \rightarrow y \\ y \quad = \quad & \bar{A} - ar \end{aligned} \tag{12.10}$$

The second equation is the $EAPC$ linking y to π :

$$\begin{aligned} EAPC \quad : \quad & y \rightarrow \pi \\ \pi - \pi_{-1} \quad = \quad & \alpha.(y - y_e) \end{aligned} \tag{12.11}$$

The third equation is the monetary policy reaction function MR, linking π to r :

$$\begin{aligned} MR \quad : \quad & \pi \rightarrow r \\ r - r^S \quad = \quad & a^{-1}\alpha\beta.(\pi - \pi^T) \end{aligned} \tag{12.12}$$

These three equations can be seen as the key building blocks of the medium-run macroeconomic model.[4] The IS equation describes, when fully set out, how aggregate demand is generated, and for our purposes how the rate of interest influences aggregate demand. The $EAPC$ equation sets out how inflation is determined: it is the aggregation of a price inflation equation ($\pi = \Delta W/W$), a wage inflation equation ($\Delta W/W = \pi^E + \alpha.(y - y_e)$) and a price expectations equation ($\pi^E = \pi_{-1}$). The MR shows how government policy responds to deviations from target as a result of shocks in the other two systems (the inflation system and the demand system).

In the examples below we show the three equations in action in a familiar setting, with one difference. The familiar setting shows the IS/LM diagram above and the Phillips Curve diagram below. But note that there is no LM curve. Indeed David Romer has christened the 3-equation model, macroeconomics without the LM curve.[5] The place of the LM curve has been taken by the monetary policy reaction function. This appears indirectly in the Phillips curve diagram as the OR line, which pins down the government's choice of output level. The interest rate that will deliver this output level can then be read off from the IS curve. For clarity, the MR lines can be shown

[4]The output reaction function collapses the IS and MR equations into one: $\pi \rightarrow y$ leaving us with a two-equation system.

[5]'Keynesian Macroeconomics without the LM Curve.' Journal of Economic Perspectives 14 (Spring 2000): 149-169.

explicitly as horizontal in the IS/LM quadrant: since at a given chosen output level, there is one corresponding interest rate, this fixes the horizontal MR.

12.4.3 Three types of shock

To analyze a shock we begin in equilibrium at $\pi = \pi^T$ and $y = y_e$. Note that in the IS diagram, the interest rate $r = r^s$ is just such as to equate y to y_e; this is how r^S in the monetary policy reaction function is defined — r^S is the interest rate at the intersection of the vertical $y = y_e$ line and the IS curve. r^S, the aggregate demand stabiliser in the monetary policy reaction function, therefore changes whenever either the IS curve shifts or $y = y_e$ shifts.

(i) inflation shock We have already analyzed an inflation shock using the output reaction function using the Phillips Curve diagram. We now show the analysis when the IS/LM diagram is included so that the monetary policy reaction via the interest rate can be shown explicitly (see Fig.12.10).

The analysis of the inflation shock begins in the Phillips curve diagram because it takes the form of an upward shift in the $EAPC$ curve from $\pi^E = \pi^T$ to $\pi^E = \pi_1$. From the output reaction function, OR, we can see that the optimal new level of output in response to the inflationary shock is y_1. If we now move up to the IS diagram, we can see that the rate of interest necessary to reduce the level of output to y_1 is r_1. So r is increased from r^S to r_1.

It is useful to recall that the monetary reaction function, MR, is given by $r = r^S + \frac{\alpha\beta}{a}.(\pi - \pi^T)$. The aggregate demand stabiliser, r^S, remains unchanged. We shall see below that since $r^S \equiv \left(\bar{A} - y_e\right)/a$, r^S changes if $\bar{A}$ changes (a demand shock) or if y_e changes (a supply shock). The rise in the interest rate to r_1 represents solely a "dragging" of the nominal anchor, which has come into operation because inflation has risen above the target, i.e. $\pi > \pi^T$. This is shown by the upward shift in the MR line from MR_0 to MR_1.

As Fig. 12.10 shows, the increase in r to r_1 and the consequent reduction of output (movement up the IS curve) to y_1 leads to a fall of inflation from $\pi^E = \pi_1$ to $\pi^E = \pi_2$. The OR now indicates an increase in output to y_2 is needed, since inflation is now closer to π^T. Hence the interest rate is required to fall to r_2 to allow output to recover (MR shifts down to MR_2). This process continues until equilibrium is restored. It is clear from the diagram that if the IS curve is much flatter (because the components of aggregate demand are much more sensitive to the interest rate) then the monetary reaction function will call for a much smaller initial rise in the interest rate.

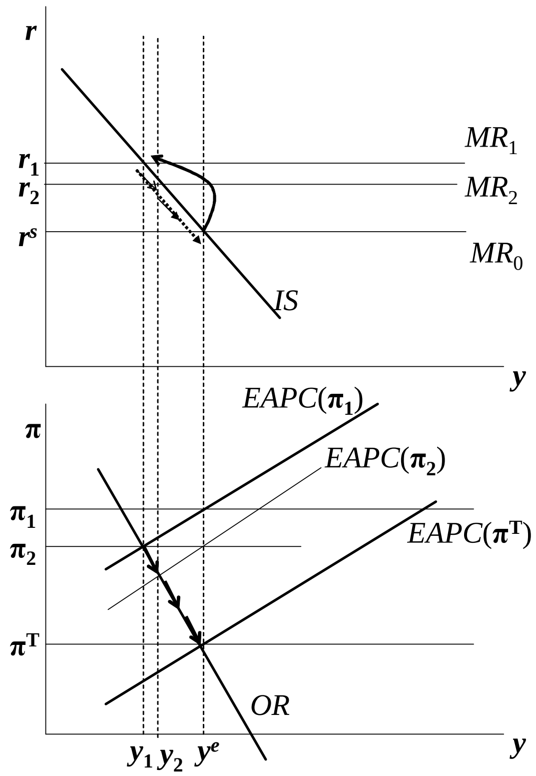


Figure 12.10: Inflation shock and monetary policy reaction function

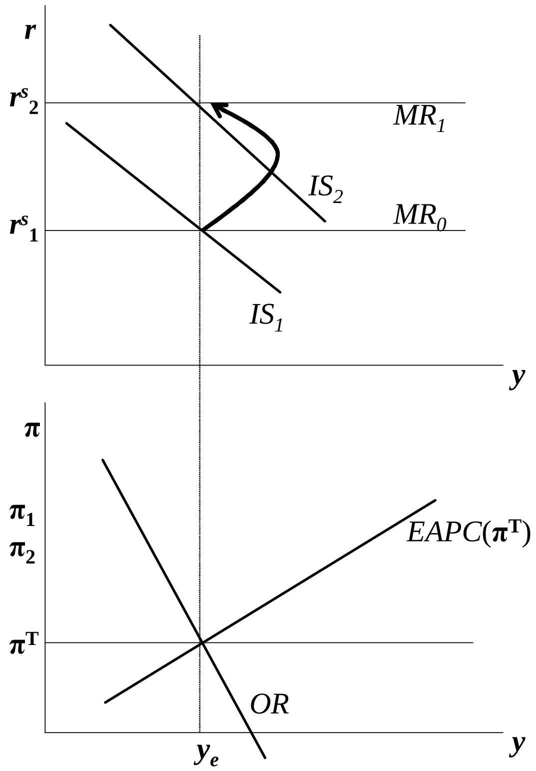


Figure 12.11: Aggregate demand shock and monetary reaction function

A smaller rise in the interest rate would deliver the required reduction in output to y_1.

Summary: Inflation rises; government cuts aggregate demand by raising the interest rate; output falls (economy moves northwest along IS); inflation falls; government boosts aggregate demand a bit by reducing the interest rate; output rises (economy begins to move south-west along IS); inflation falls; ... until r, π and y are back to their original levels.

(ii) demand shock A demand shock is easy to deal with in this model, given the simple (and unrealistic) assumption that the government can immediately change y with an appropriate choice of r. We relax this assumption in the next subsection where the so-called Taylor rule is discussed.

A demand shock is a shift in the IS curve. Fig. 12.11 illustrates. The economy starts in equilibrium with IS_1 and $r = r_1^S$, $\pi = \pi^T$ and $y = y_e$. The IS curve is then shocked upwards to IS_2. Given the government's objectives and its ability — by assumption — to choose the level of output immediately, the monetary policy reaction function dictates an immediate increase in the interest rate sufficient to exactly extinguish the aggregate demand stimulus. This requires an upward shift in MR to MR_1 in Fig.12.11.

To follow through the detail of this argument, let us write the original IS curve as $y = \bar{A}_1 - ar$ and the new curve as $y = \bar{A}_2 - ar$. The MR requires that $r = r^S + a^{-1}\alpha\beta.(\pi - \pi^T)$, where $r^S \equiv a^{-1}.(\bar{A} - y_e)$. Thus, if r_1 is the initial interest rate

$$\begin{aligned} r_1 &= a^{-1}.(\bar{A}_1 - y_e) + a^{-1}\alpha\beta.(\pi - \pi^T) \\ &= a^{-1}.(\bar{A}_1 - y_e) \end{aligned}$$

since at equilibrium, $\pi = \pi^T$. Thus the interest rate is simply equal to the stabiliser component, $a^{-1}.(\bar{A}_1 - y_e)$. The demand shock does not change inflation expectations (nor hence the rate of inflation), so the nominal anchor role of the interest rate remains zero. But the stabiliser component has to increase to ensure that aggregate demand remains equal to y_e. The new stabiliser component is $a^{-1}.(\bar{A}_2 - y_e)$ because this ensures $y_2 = y_1 = y_e$:

$$\begin{aligned} y_2 &= \bar{A}_2 - a.r_2^S \\ &= \bar{A}_2 - a.\left(a^{-1}.(\bar{A}_2 - y_e)\right) \\ &= y_e \end{aligned}$$

Summary: Aggregate demand rises; government cuts aggregate demand by raising the interest rate. y remains at y_e and inflation at $\pi = \pi^T$. The interest rate jumps to the new $r^s = r_2$ and remains there.

(iii) supply shock Fig.12.12 illustrates a supply shock. A supply shock is reflected in a shift in y_e. This may be caused by shifts in the wage-setting or price-setting equations. Here we just focus on the shift in y_e and its consequences for monetary policy.

Equilibrium output shifts from y_{e1} to y_{e2}. This means that the vertical Phillips curve and the expectations augmented Phillips curves shift to the right as well to reflect the fact that target inflation is now consistent with a higher level of output. The output reaction function will also shift to the right: the government now seeks to keep the economy close to π^T and to $y = y_{e2}$. All that remains is for the government to adjust the interest rate downwards to generate sufficient aggregate demand such that $y = y_{e2}$. The monetary policy reaction function shifts down from MR_1 to MR_2.

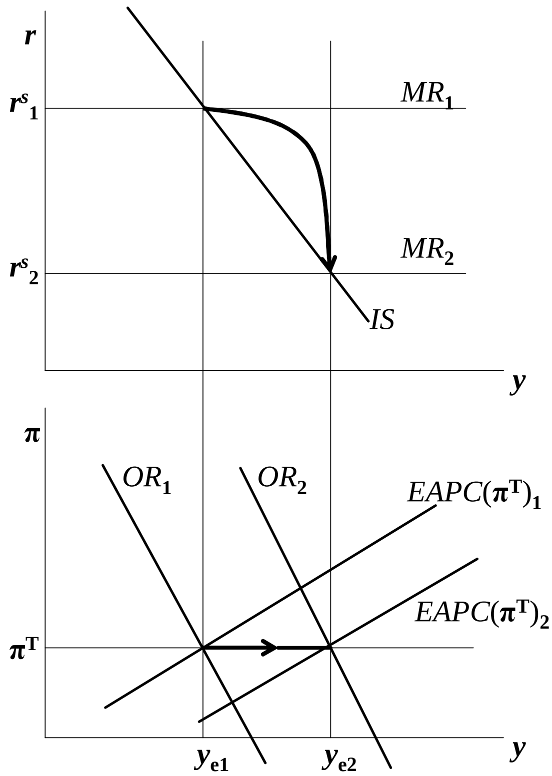


Figure 12.12: Supply shock and monetary policy reaction function

As before, we can go through this in more detail. Since there is no simultaneous demand shock, the IS curve does not shift. However the increase in y_e implies that aggregate demand is now less than equilibrium output, i.e. $\bar{A} - ar_1^S = y_{e1} < y_{e2}$. As a consequence the stabiliser component of the monetary policy reaction function has to fall from r_1^S to r_2^S to reequilibrate aggregate demand with the new higher equilibrium output. So r_2^S is given by $\bar{A} - ar_2^S = y_e$, which implies that $r_2^S = a^{-1}.(\bar{A} - y_e)$. Since we are assuming that there is no inflation shock, the expected rate of inflation remains the same. We therefore move horizontally right along the $\pi = \pi^T$ line to y_e. Since we are now at equilibrium output, inflation remains equal to expected inflation, which in turn is at the target level. The nominal anchor function of the interest rate does not therefore change. It follows that:

$$\begin{aligned} r_2 &= a^{-1}.(\bar{A} - y_e) + a^{-1}\alpha\beta.\left(\pi - \pi^T\right) \\ &= a^{-1}.(\bar{A} - y_e) \\ &= r_2^S. \end{aligned}$$

Summary: Equilibrium output rises; the government cuts the interest rate to raise aggregate demand so that output is equal to the new equilibrium level. Inflation remains unchanged.

12.4.4 The Taylor rule: a famous monetary reaction function

A very widely discussed monetary policy reaction function is known as the 'Taylor Rule'. This takes the form:

$$r - r^S = 0.5(y_{-1} - y_e) + 0.5(\pi - \pi^T) \qquad \text{(Taylor Rule)}$$

and can be compared with the monetary policy rule derived above:

$$r - r^S = a^{-1}\alpha\beta.(\pi - \pi^T). \qquad \text{(Monetary Policy Reaction Function)}$$

We can see immediately that there is a key difference. The Taylor Rule includes a term in the deviation of output from equilibrium as well as in the deviation of inflation from its target. What explains this? It is very important to emphasize that in deriving the monetary policy reaction function, we have used a government utility (or loss) function that includes both output and inflation: the government was assumed to experience a loss of utility *both* when output deviated from equilibrium and when inflation deviated from the target. The reason that only the deviation in inflation from target appears in the monetary policy reaction function is that we have assumed so far that the government can set the interest rate to choose exactly the level of output it wants. This is not true in practice of course: if the Federal Reserve changes the interest rate now, the full effects on output only show up between six months and a year later. When the US economy swung into recession in late 2000, the dramatic cuts in interest rates by the Fed in early 2001 were forecast to have their full effect on output by the end of 2001. Once a lag in the response of output to a change in the interest rate is introduced into the model, the monetary reaction function will take a form similar to that of the Taylor Rule.

To see why this is the case, we make the following assumption about how a change in the interest rate changes output cumulatively over time. First, the level of output in the long-run in response to the interest rate is the same as before: $y = \bar{A} - ar$. Call this level of y, $\tilde{y}$, so that $\tilde{y}(r) = \bar{A} - ar$. Now suppose we start in equilibrium with $\tilde{y}(r_0) = y_0 = \bar{A} - ar_0$, and that the government increases r to r_1. We explicitly assume that

$$y_1 - y_0 = b.[\tilde{y}(r_1) - y_0], \; 0 < b \leq 1 \tag{12.13}$$

where y_1 is output in period one. Thus if $b = .5$ one half of the adjustment takes place in the first period; half of the remaining discrepancy takes place in the next period and so on. If $\tilde{y}(r_1) - y_0 = 10$, y_1 will be 5 above y_0, y_2 will be 2.5 above y_1 and so on.

How might we expect the interest rate rule to change if output takes time to adjust? As long as a change in the interest rate, r^S, could bring y immediately into line with y^T, the authorities never needed to worry in period t about y_{t-1} being different from y_e, which is target output. But now the authorities do need to take this into account. Thus we would expect that the modified rule would add in this term, as follows:

$$r - r^S = \gamma.(y_{-1} - y_e) + a^{-1}\alpha\beta.(\pi - \pi^T) \tag{12.14}$$

with γ proportional to $(1 - b)$ so that instantaneous adjustment of output $(b = 1)$ would lead the $(y_{-1} - y_e)$ term to drop out.

We now step back and derive this result by minimising the loss function over r as before

$$\min_r L = (y - y_e)^2 + \beta.(\pi - \pi^T)^2$$

subject to the Phillips curve constraint:

$$\pi = \pi_{-1} + \alpha.(y - y_e)$$

and the new 'lagged adjustment' constraint (from equation (12.13)):

$$\begin{aligned} y &= y_{-1} + b.(\bar{A} - ar - y_{-1}) \\ &= (1 - b)y_{-1} + b(\bar{A} - ar). \end{aligned}$$

A simple way of writing the loss function incorporating both constraints is

$$\begin{aligned} L &= (y - y_e)^2 + \beta.(\pi - \pi^T)^2 \\ &= (y(r) - y_e)^2 + \beta.(\pi(y(r)) - \pi^T)^2. \end{aligned}$$

Differentiating this with respect to r implies:

$$(y(r) - y_e).y'(r) + \beta.(\pi(y(r)) - \pi^T).\pi'(y).y'(r) = 0.$$

We can divide through by $y'(r)$, and note that $\pi'(y) = \alpha$, so that we get

$$(y(r) - y_e) = -\alpha\beta.(\pi(y(r)) - \pi^T). \tag{12.15}$$

We now need to bring r and r^S into this equation to get the modified monetary policy reaction function. Remember that

$$y = (1 - b)y_{-1} + b(\bar{A} - ar) \tag{12.16}$$

Since $y_e \equiv \bar{A} - ar^S$, we can write equation (12.16) for $y = y_e$ as:

$$y_e = (1 - b).y_e + b.\left(\bar{A} - ar^S\right) \tag{12.17}$$

Subtracting equation (12.17) from (12.16) we get:

$$y - y_e = (1 - b).(y_{-1} - y_e) - ab.(r - r^S). \tag{12.18}$$

We replace the left hand side of equation (12.15) with this formula and rearrange (12.18) as follows:

$$\begin{aligned} (1 - b).(y_{-1} - y_e) - ab.(r - r^S) &= -\alpha\beta.(\pi(y(r)) - \pi^T) \\ ab.(r - r^S) &= (1 - b).(y_{-1} - y_e) + -\alpha\beta.(\pi(y(r)) - \pi^T) \\ (r - r^S) &= \frac{(1 - b)}{ab}.(y_{-1} - y_e) + \frac{\alpha\beta}{ab}.(\pi - \pi^T). \end{aligned}$$

(The Taylor Rule)

This is our modified monetary policy reaction function. We will refer to it as the Taylor rule, since Taylor first formulated the argument that interest rates should respond to divergences of output from target as well as inflation from target.

The modified monetary policy reaction function (Taylor Rule) has three components:

long-run stabiliser: $r^S = a^{-1}.\left(\bar{A} - y_e\right)$

short-run stabiliser: $\frac{(1-b)}{ab}.(y_{-1} - y_e)$

nominal anchor: $\frac{\alpha\beta}{ab}.(\pi - \pi^T)$.

The nominal anchor and long-run stabilizer are exactly as they were in the simpler monetary reaction function but the introduction of lags in the response of output to changes in the interest rate results in the new component: the *short-run stabilizer.*

We can briefly consider how the Taylor Rule modifies our analysis of the three kinds of shock. In the case of an *inflation shock*, just as before, there is no role for the long-run stabilizer. The rise in inflation calls for the use of the nominal anchor component of the reaction function (exactly as before). Output falls. The short-run stabiliser will now come in to play to reinforce the nominal anchor in guiding the economy back to the equilibrium.

In the case of an *aggregate demand shock*, the simple monetary policy reaction function worked directly via the long run stabilizer (see Fig.12.11): the required change in $r = r^s$ was implemented immediately with the result that there was no change in inflation. The introduction of lags in output adjustment means that the government cannot simply cancel the effect of a shift in the IS curve on output by raising the interest rate. It will take time for a change in the interest rate to influence output. Meanwhile, output will have risen above the equilibrium.

One can think of the Taylor Rule working in the following way. The IS curve shifts to the right, output begins to rise. The long-run stabilizer component is identical to that in Fig.12.11 and this is shown in Fig.12.13. However, monetary policy will now be implemented in a more complex way: the interest rate will not be raised immediately in line with the long-run stabilizer. Rather, the rise in output prompts the use of the short-run stabilizer component of the reaction function so the interest rate is increased. An upward-sloping MR line in the IS/LM diagram depicts this (see Fig.12.13). Meanwhile, the rise in output pushes up inflation (see the Phillips Curve diagram), calling in the nominal anchor component of the reaction function: the interest rate is increased further (the MR line is shifted up from MR_0 to MR_1). Both the short run stabilizer and the nominal anchor components serve to raise the interest rate in the direction required by the long run stabilizer. The economy will move north-west along the new IS curve. The nominal anchor component shows that output has to fall below the equilibrium in order to squeeze the increased inflation out of the economy. Adjustment down the IS to the new long run equilibrium (y_e, π^T at r_2^s) occurs in the same way as has been described for an inflation shock (along the OR line).

In the case of a *supply shock*, the simple monetary policy reaction function operated to shift the economy immediately to the new higher equilibrium

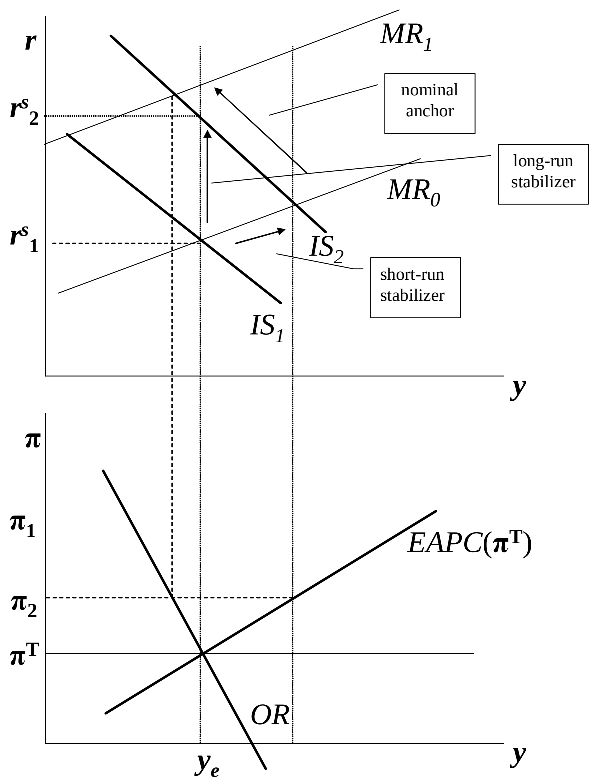


Figure 12.13: Aggregate demand shock and Taylor Rule

output level by cutting the interest rate (according to the long run stabilizer). No change in inflation occured. Lags in adjustment mean that before any cut in the interest rate has an effect on output, inflation begins to fall (since the $EAPC$ has shifted downwards). This will call in the nominal anchor component to reduce the interest rate. This reinforces the message from the long-run and short-run stabilizers. The interest rate will be cut and the economy will move toward a higher level of output. To get inflation back to the target, output will have to rise above the new equilibrium (as shown by the nominal anchor component). The economy will then be guided back to equilibrium through the operation of the nominal anchor.

Taylor presented his monetary rule with equal weights on the $(y_{-1} - y_e)$ term and the $(\pi - \pi^T)$ terms. If this were the case, then if output were 1% above equilibrium and inflation were at the target, the central bank should raise the nominal interest rate by 0.5 percentage points (i.e. by 50 basis points). As noted earlier, we are interpreting the difference between y and y_e as the percentage gap; this is the equivalent of defining y as the log of output. Alternatively, if inflation was 1% point above the target but output was at the equilibrium level, then the rule would suggest that the real interest rate needs to be 0.5 percentage points higher. Since expected inflation will rise by 1% point, the nominal interest rate must be raised by $1 + 0.5$, i.e. by 1.5 percentage points in order to secure a rise in the real interest rate of 0.5 percentage points. As this example shows, an important point to notice about an interest rate based monetary policy reaction function is that it requires the central bank to be active. Frequent adjustments have to be made to the interest rate in order to achieve the central bank's objective. This highlights the fact that it is quite consistent to think of a central bank as following a 'rules-based' approach to monetary policy yet having to be very active. We return to the issue of 'rules' versus 'discretion' in monetary policy in the next section.

12.4.5 Problems with using a monetary policy reaction function

The central bank may sometimes be thwarted in its attempt to use a monetary policy reaction function to stabilize the economy. One reason would be if investment or other components of aggregate demand failed to respond or to respond enough to the change in the interest rate. As discussed in Chapter (Consumption and Investment), empirical evidence for the impact of changes in the cost of capital (of which the interest rate is a key component) relative to the expected rate of return (measured for example by a change in Tobin's

q) is rather weak.

Another reason why the interest rate may fail to affect output in the desired manner arises from the fact that the interest rate that is relevant to investment decisions is the *long term real* interest rate (as discussed in Chapter (Consumption and Investment)). The central bank can affect the *short term nominal* interest rate. As we know, the real and the nominal interest rates differ by the expected rate of inflation. It remains to explain how the short and long-term interest rates are related. The relationship is referred to as the *term structure of interest rates*. The long term interest rate refers to the interest rate now (i.e. at time t) on an n-year bond. We can express the long term interest rate as follows:

$$i_t^n = 1/n \cdot [i_t^1 + E_t i_{t+1}^1 + E_t i_{t+2}^1 + ... + E_t i_{t+n-1}^1] + \phi_{nt} \tag{12.19}$$

In words, this means the long term interest rate (say, the interest rate on 20-year bonds) is equal to the average of the expected interest rate on one-year bonds for the next twenty years plus the term ϕ_{nt}, which is called the 'uncertainty premium'. In tranquil times, we would expect the long-term interest rate to exceed the short-term rate by the uncertainty premium and we would expect short and long-term interest rates to move in the same direction. Monetary policy will then have the desired effect. As a counter-example, consider the situation in which the central bank cuts the short-term interest rate to stimulate the economy because it fears a recession is imminent. If the financial markets believe that the underlying cause of the recessionary threat is likely to produce higher inflation in the long run, then the long-term interest rate will rise. Higher long-term interest rates are likely to dampen investment-sensitive spending at a time when the authorities are trying to stimulate the economy.

A third example of the limits to the use of monetary policy as a stabilization tool comes from the fact that the nominal interest rate cannot be negative. The reason for this — as we have seen — is that there is always the choice to hold cash with a zero nominal return. Zero places a floor on the cuts in the nominal interest rate that are available. Hence a problem can arise if the real interest rate required to stimulate activity in the economy were negative. For the nominal interest rate to be positive, then if the real interest rate that is required in order to generate sufficient aggregate demand is negative, its absolute value must be less than expected inflation. In a very low inflation economy, there is therefore limited scope to use monetary policy to stimulate aggregate demand if the required real interest rate is negative. This is rather ironical — the successful implementation of a stability-oriented monetary policy along the lines outlined in this chapter may have the effect of producing an economy with low inflation in which the scope of monetary policy to stimulate the economy if it is hit by a negative shock is limited.

To summarize, the reasons that monetary policy can fail to have its desired effect on output include the following:

- investment is insensitive to the real interest rate.
- the long run real interest rate does not move in line with changes in the short term nominal interest rate.
- the central bank wishes to stimulate demand but the nominal interest rate is close to zero.

For the monetary policy reaction function to be used, the government needs to know the equilibrium level of output, or the gap between current and equilibrium output, the 'output gap'. In the real world, this is difficult to estimate. Nevertheless, setting out the reaction function helps to pin down the inputs of information and judgement that the government will need to make use of in fixing the interest rate.

12.5 Monetary policy rules & credibility

The analysis of the monetary policy reaction function set out how the government should use its monetary policy instrument in order to steer the economy back toward its goals of $y = y^T$ and $\pi = \pi^T$. This is known as an inflation targeting regime. Is there any gain from formalizing this reaction function as a 'rule' that the government is obliged to implement? We shall examine this question in two stages. It has been suggested that one reason for tying down the government to a rule is that this is necessary in order for the inflation target be achieved. A rule is suggested as a method of making monetary policy more 'credible'. We shall see that this argument is really about the objectives of the government or the monetary authority. If the government's objective is a level of output higher than y_e, we shall see that it will not be able to stick to its inflation target of π^T. There will be a so-called inflation bias. The bias arises because the target output level is above the equilibrium. A monetary policy rule would only be effective in delivering target inflation to the extent that it had the effect of shifting the target output level back to $y = y_e$. In the second stage, we assume that the monetary authority's targets are indeed $y = y_e$ and $\pi = \pi^T$ and ask whether a formal rule is preferable to allowing the monetary authority to operate with discretion. Here the key arguments relate to the usefulness of a rule in guiding how expectations are formed in the economy.

12.5.1 Credibility and the time-inconsistency problem

We have assumed so far that the government's target output level is y_e, the equilibrium level of output. But the government might well have a higher target. We have already seen that imperfect competition in product and labour markets implies that y_e is less than full-employment output. So how do things change if the government's target is full-employment output, or more generally a level of output above y_e?

A starting point is to look at the government's new objective function. It now wants to minimise

$$L = (y - y^T)^2 + \beta.(\pi - \pi^T)^2, \tag{12.20}$$

where $y^T > y_e$. This is subject as before to the Expectations Augmented Phillips curve,

$$\pi - \pi^E = \alpha.(y - y_e). \tag{12.21}$$

In Fig. 12.14 below the new indifference curves are shown.

The government's ideal point is now point a (where $y = y^T$ and $\pi = \pi^T$) rather than point b (where $y = y_e$ and $\pi = \pi^T$). If we assume that $\beta = 1$ (for simplicity), then each indifference circle has its centre at a. The whole set of loss circles have shifted to the right.

To work out the government's reaction function for any given expected rate of inflation, consider the level of output it chooses if $\pi^E = 2\%$. Fig.12.14 shows the $EAPC$ corresponding to $\pi^E = 2\%$. d is the point on $\pi^E = 2\%$ that minimises the government's loss. Since the government's output reaction function must pass through a, it is the downwards sloping line in Fig.12.14. Another way of putting this is to highlight the fact that the government's target, point a does not lie on the $EAPC$ for an expected inflation rate equal to the target rate of $\pi^T = 2\%$.

Starting with $\pi^E = 2\%$ where do we end up in equilibrium if the output target y^T is above y_e? From Fig.12.14 we can see that the economy will only be in equilibrium in the sense that inflation expectations are fulfilled at point g. This is where the output reaction function (OR) intersects the vertical Phillips curve at $y = y_e$. At point g, inflation is above the target: the target rate is 2% but inflation is 4%. The gap between inflation in the equilibrium and the target rate of inflation is called the inflation bias. We shall now work more slowly through the details to pin down the source of the inflation bias and the determinants of its size. We begin by showing why the equilibrium is at point g — first by assuming adaptive expectations and then by assuming rational expectations.

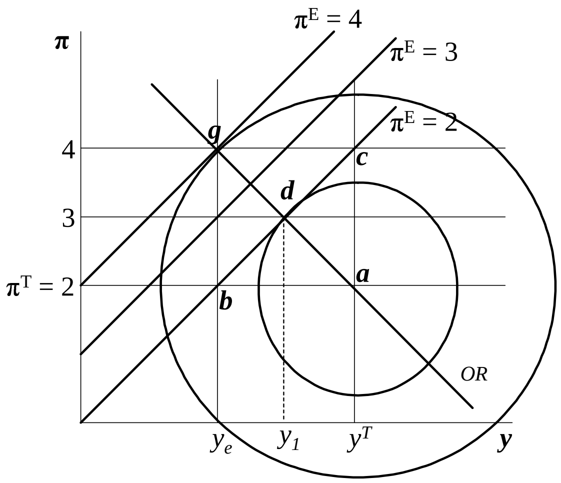


Figure 12.14: Output reaction function: $y^T > y_e$

Adaptive expectations

If we assume adaptive expectations, we have $\pi_t^E = \pi_{t-1}$. With inflation initially at its target rate of 2% we begin at point d in Fig.12.15, where the initial time period is $t = 1$. The government chooses its preferred point on the $\pi_t^E = 2\%$ expectations augmented Phillips curve. Thus the government minimizes its loss by setting $y = y_1$ (the tangency between the loss function and the constraint $EAPC\left(\pi^E = 2\%\right)$). But at $y = y_1$, the actual rate of inflation, π_1 is 3%. Since $\pi_2^E = \pi_1$, π_2^E rises to 3% (see Fig.12.15). The point on the output reaction function corresponding to $\pi^E = 3\%$ is e; so in period 2 the government reduces output from y_1 to y_2. But y_2 is still above equilibrium (or stable inflation) output, and it can be seen that at y_2 inflation rises from $\pi_1 = 3\%$ to $\pi_2 = 3.5\%$.The process of the adjustment of expectations and the subsequent response by the government to the rise in inflation according to its output reaction function continues until point g. At g, output is at the equilibrium and inflation is equal to its expected level. Since the government is on its reaction function, it has no incentive to change its policy and since the wage-setters' inflation expectations are fulfilled, they have no incentive to update them. The economy is in equilibrium. But neither inflation nor output are at the government's target levels (see Fig.12.15).

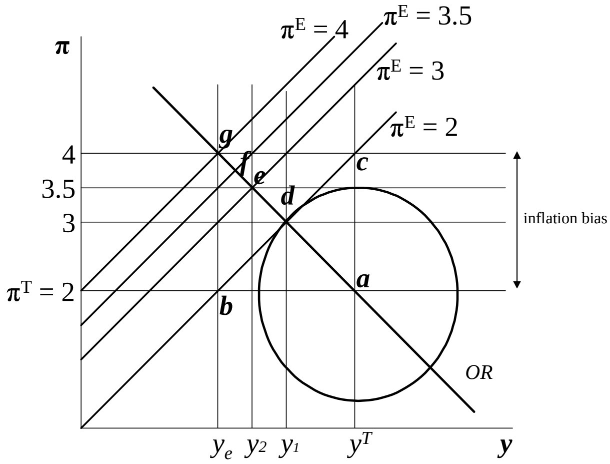


Figure 12.15: The inflation bias

Rational expectations

The same conclusion is reached if wage-setters form their expectations about inflation rationally. The intuition is that wage-setters know that whatever their expected rate of inflation, the condition for $\pi^E = \pi$ is that $y = y_e$. Since the government chooses y *after* wage-setters have chosen π^E, in order for wage-setters to have correct inflation expectations, the wage-setters must choose the $\pi^E = \pi$ line such that it pays the government to choose $y = y_e$. That must be where the government's output reaction function cuts the $y = y_e$ vertical line. As can be seen in Fig.12.15 that is where $\pi^E = 4\%$. Inflation must be sufficiently high to remove the temptation of the government to raise output toward its target. With $\pi = 4\%$ and $y = y_e$, the temptation has been removed because any increase in output puts the government on a loss circle more distant from its bull's eye point a.

We can derive the same result mathematically and pin down the determinants of the size of the inflation bias. Minimising the government's loss function — equation (12.20) — subject to the $EAPC$ — equation (12.21) implies

$$y - y^T + \alpha\beta.(\pi^E + \alpha.(y - y_e) - \pi^T) \quad (12.22)$$

$$= \quad y - y^T + \alpha\beta.(\pi - \pi^T) = 0 \quad (12.23)$$

so the new output reaction function is:

$$y = y^T - \alpha\beta.(\pi - \pi^T). \tag{12.24}$$

This equation indeed goes through (π^T, y^T). Since $\pi^E = \pi$ when $y = y_e$, we have

$$\begin{aligned} y_e &= y^T - \alpha\beta.(\pi^E - \pi^T) \\ &\Rightarrow \pi = \pi^E = \pi^T + \frac{(y^T - y_e)}{\alpha\beta}. \qquad \text{(Inflation bias)} \end{aligned}$$

In equilibrium, inflation will exceed the target by $\frac{(y^T - y_e)}{\alpha\beta}$. This is called the inflation bias. The significance of this result is that $\pi^E > \pi^T$ whenever $y^T > y_e$. The steeper is the government's output reaction function, (i.e. the less inflation-averse it is), the greater will be the inflation bias. A lower α also raises the inflation bias. A lower α implies that inflation is less responsive to changes in output. Therefore, any given reduction in inflation is more expensive in lost output; so in cost-benefit terms for the government, it pays to allow a little more inflation and a little less output loss.

12.5.2 The problem

The inflation bias presents a problem. As is clear from Fig.12.15 , the loss to the government at g is greater than the loss to the government at b. This is because at both g and b the level of output is the same (y_e) and the rate of inflation is lower at b than at g. So the government would clearly be better off at b. Moreover, wage-setters would be just as happy at b as at g, since in both cases $y = y_e$ so that $\pi = \pi^E$. What is to stop the government being at b? The problem is called that of *time inconsistency.* It arises because wage-setters choose π^E before the government chooses y. In order to be at b, wage-setters need to choose $\pi^E = \pi^T = 2\%$. (Remember this is because the government can only choose a point on the π^E line previously chosen by wage-setters.) *But if wage-setters actually did choose* $\pi^E = 2\%$, *it would then pay the government to choose* $y = y_1$. Thus, if wage-setters choose π^E before the government chooses y, the government has to accept $\pi = 4\%$.

12.5.3 Is a monetary policy rule a solution to the time inconsistency problem?

We can now see that in order to eliminate the inflation bias problem, it is necessary to shift the output reaction function to the left so that it goes through the combination of π^T and y_e. The problem arises not because of the absence of a monetary rule but because of the government's ambition of having output above the equilibrium. There are two broad approaches to solving the problem, which are referred to as *delegation* and *reputation*.

Delegation The first involves the transfer of powers to an independent central bank charged with delivering low inflation. Since the inflation bias is equal to

$$\frac{(y^T - y_e)}{\alpha\beta},$$

the government can reduce this by transferring control of monetary policy to a central bank with an output target closer to y_e and with more inflation aversion (higher β) than the government's. Since output in equilibrium is at $y = y_e$ and assuming the inflation target of the central bank is the same as the government's, inflation would be brought closer to the target and the government would be unambiguously better off if it delegates monetary policy to an independent central bank.

Fig.12.16 illustrates the reduction in inflation bias through delegation of monetary policy to the central bank. The flatter sloped output reaction function is that of the central bank, OR_{CB}, and the more steeply sloped that of the government, OR_G. OR_G evidently implies a higher inflation bias (the intersection of OR_G with y_e is way above the frame of the diagram). OR_{CB} on the other hand implies $\pi = 3\%$. The reduction in the inflation bias is due to the flatter slope of the central bank function, $\beta_{CB}^{-1} < \beta_G^{-1}$ and also to fact that central bank's output target is closer to equilibrium output than is the government's: $y_{CB}^T < y_G^T$.

For delegation to be successful, wage-setters must actually believe that the objective function has changed in the appropriate way. If the government can delegate powers to the central bank, why can't it take them back when it wants to? It would pay the government to take back those powers at the moment that wage-setters chose a low π^E corresponding to the loss function parameters of the central bank. For then the government would be tempted to opt for a level of output greater than y^e. This kind of reasoning may explain why governments have often found it necessary to make central banks constitutionally independent. This discussion highlights that what matters is not whether there is a monetary policy rule but whose it is.

Reputation An alternative solution to the problem of inflation bias lies with the government building a reputation for being tough on inflation. Suppose that the government has delegated monetary policy to the central bank

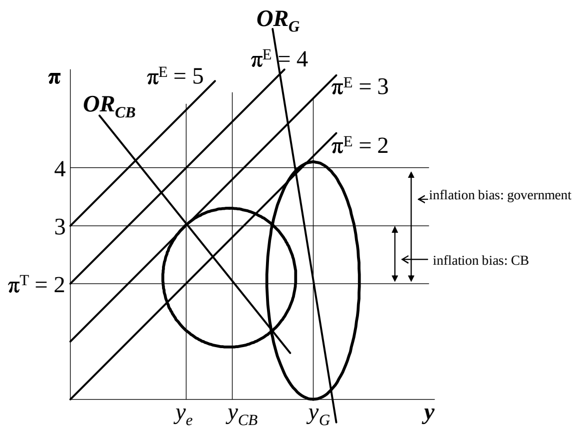


Figure 12.16: Inflation bias: central bank and government

but wage-setters remain unsure of just how independent the central bank is. They only know that there is a probability γ that the central bank is independent and a probability $(1 - \gamma)$ that it is a puppet of the government. The only way that they can find out is by observing the decisions taken by the central bank. How should the central bank behave? This problem can be analyzed in detail using game theory. This is done in Chapter (Political Economy). Here we simply convey the flavour of the solution.

The situation is one in which the central bank interacts with wage setters more than once. Will a 'weak' central bank with an output target above the equilibrium find it rational to behave as if it were tough — i.e. with an output target closer to the equilibrium? If so, then we can say that it is possible to build a reputation for toughness as a method of solving the inflation bias problem. Let us begin with the case in which the interaction between the central bank and wage setters occurs twice: in period one, wage setters choose π_1^E with no knowledge of whether the central bank is weak or tough (but they know there is a probability of γ that it is tough); the central bank then chooses output in period one, y_1 knowing π_1^E. In period two, the wage-setters choose π_2^E knowing y_1; the central bank then chooses y_2 knowing π_2^E.

The result is that a weak central bank will choose to act like a tough one in the first period, which will establish a low expected inflation rate in the second period, thereby providing bigger gains from boosting output in the second period. The central bank gains because in the first period, the outcome is inflation at its target (no inflation bias) and output at the equilibrium (instead of the time inconsistency outcome of inflation above the target and output at equilibrium) whilst in the second period, it can gain by setting output above the equilibrium (i.e. by exploiting the $EAPC$ trade-off). As discussed in detail in Chapter 15, when the game is extended from two to many periods, the benefits from the central bank behaving as if it were tough increase. This is because the situation in period one is repeated again and again until the last period. This type of model provides an explanation for the process by which a reputation for toughness can be built in the face of public scepticism.

12.5.4 Rules and expectations

We now return to the case in which there is no inflation bias and ask whether there are any gains from a framework of a clearly defined public monetary policy rule as compared with a framework of 'constrained discretion'. In practice, we observe a wide spectrum of arrangements for monetary policy amongst central banks. The US under Alan Greenspan is the most famous case of a central bank operating constitutionally with discretion. Yet many articles have been written suggesting that the Fed has covertly been following an inflation-targeting rule[6]. It seems clear that there are gains from the operation of a widely understood and transparent process of monetary policy making. This suggests that providing information about the monetary policy reaction function is likely to be useful. The main gain arises because economic agents are at least in part forward looking and will therefore anticipate the reaction of the central bank to a shock. If the reaction function is well understood, anticipation by the private sector may help to stabilize the economy's response to the shock.

For example, if we think of a negative aggregate demand shock, then the monetary policy reaction function indicates that interest rates will be lowered — with all three components pulling in the same direction (the long term stabilizer, the short term stabilizer and the nominal anchor). The knowledge of this reaction will influence the expected future path of interest rates, which will help shift the long term interest rate downwards — the rate relevant for interest sensitive spending. Asset prices such as share prices or house prices may react rapidly to the expected path of interest rates and reinforce the efforts of the central bank to boost demand. In our example, the expectation of a lengthy period of low interest rates would tend to boost asset prices

[6] For example, see the discussion in G. Mankiw (2001) 'US Monetary Policy during the 1990s', Harvard working paper.

immediately (e.g. share prices and house prices). In turn, this raises Tobin's Q and permanent income and would therefore tend to raise investment and consumption, reinforcing the recovery of aggregate demand.

12.6 Monetary policy in the open economy

The remaining task in this chapter is to connect the analysis of monetary policy reaction functions with the open economy analysis of Chapter 6. If you have not read Chapter 6, you will not be able to follow the diagrammatic analysis below. You may, however, still find the verbal analysis of some use. In Chapter 6, we took two extreme monetary regimes for the small open economy — fixed exchange rates and freely floating exchange rates. Monetary policy is impotent under fixed exchange rates and perfect capital mobility. Medium-run inflation is fixed by the inflation rate in the rest of the world. Under floating exchange rates, we assumed that the government controlled the monetary growth rate and that the nominal exchange rate was determined by the uncovered interest parity condition. We now ask how the analysis is altered if the government (or central bank) follows a policy of inflation targeting via a monetary policy reaction function as discussed in this chapter.

We begin with an aggregate demand shock. Fig.12.17 shows the open economy diagram with the real exchange rate on the vertical axis and output on the horizontal. To refresh your memory, we show the path to the new medium run equilibrium under fixed (Fig.12.17(a)) and flexible exchange rates (Fig.12.17(b)). With a fixed exchange rate, output rises following the increase in aggregate demand. The economy moves from point a to point b. Inflation is pushed up above world inflation by the rise in output. This depresses competitiveness (appreciates the real exchange rate) and the economy moves toward the new medium-run equilibrium at c.

In a floating exchange rate regime, a rise in domestic aggregate demand leads to a rise in the domestic interest rate. This opens up a discrepancy vis a vis the world interest rate and by the uncovered interest arbitrage condition, the nominal exchange rate appreciates. The economy goes to point b. The real appreciation cuts the real cost of imports and leads to inflation dropping below world inflation. The economy moves to point c as net exports respond to the rising price competitiveness.

We now turn to the case of the small open economy where the central bank pursues an inflation targeting policy using a monetary policy reaction function.[7] We assume that the target is defined in terms of consumer price

[7] For a much more advanced treatment, see L.E.O. Svensson (2000) 'Open-economy

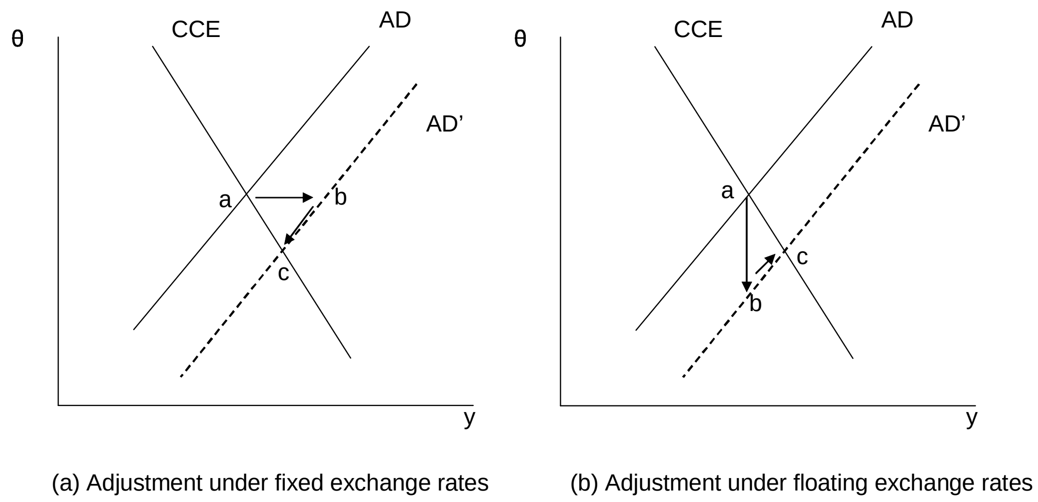


Figure 12.17: Open economy: aggregate demand shock

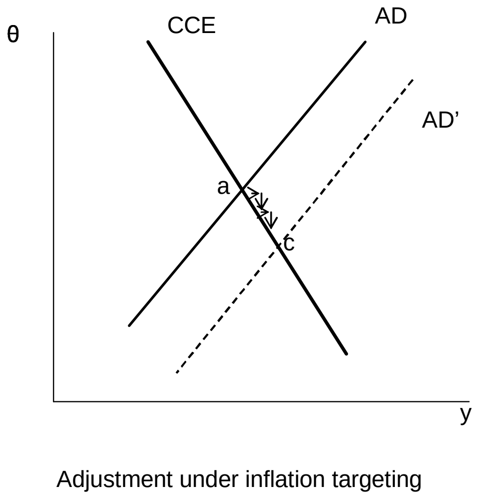


Figure 12.18: Aggregate demand shock

inflation. The medium run equilibrium at point c is independent of the monetary regime but the path to it is different if the central bank is targeting consumer price inflation (see Fig.12.18).

Following the rise in aggregate demand, output begins to rise. This puts upward pressure on inflation and first, via the short-run stabilization component and second, via the nominal anchor component, the Central Bank raises the interest rate. The UIP condition translates this into an appreciation of the exchange rate. This process continues until the new medium-run equilibrium is reached at point c. The policy of inflation targeting results in an adjustment path that closely tracks the CCE curve. This is the set of constant inflation equilibria so the rule prevents large swings in the nominal exchange rate that would require correction through subsequent changes in

inflation targeting' Journal of International Economics 50. 155-183.

consumer price inflation. Equally, the rule prevents large deviations from the CCE curve through output changes. The fixed exchange rate case illustrates that in the absence of the nominal exchange rate instrument, the required adjustment of the real exchange rate must occur via inflation or deflation relative to world inflation.

In the case of an inflation shock, this is represented in the $\theta - y$ diagram by a movement along the AD curve: inflation higher than world inflation takes the economy to the south-west along the AD as the fall in competitiveness dampens activity. Conversely for a negative inflation shock, the economy would move to the north-east. An inflation shock is therefore self-stabilizing in a small open economy: a positive inflation shock entails a real appreciation, which reduces output and weakens wage inflation. The economy would return to the initial equilibrium through a period of inflation below world inflation. An inflation targeting central bank may hasten this process by cutting the interest rate with the result that a nominal depreciation speeds up the recovery of output.

A negative supply-side shock shifts the CCE curve to the left. For example, suppose that the wage-setting curve is shifted up because of the collapse of a wage accord (or because the government introduces new, more generous unemployment benefits). The new medium run equilibrium is at lower output and at a 'higher' real exchange rate (lower θ). Without policy intervention, the economy would move to the south-west down the AD-curve to the new equilibrium via a rise in CPI inflation relative to the rest of the world. However, an inflation targeting central bank would tend to respond to the initial rise in inflation by raising the domestic interest rate. This would lead to an immediate appreciation of the exchange rate and would take the economy more swiftly along the CCE to the new medium run equilibrium. The bulge in home country inflation would be reduced as the nominal appreciation took a higher share of the required real appreciation. We can see that the central bank's reaction to a positive aggregate demand shock and a negative supply shock is the same: a tightening of monetary policy through a rise in the interest rate. In each case, the central bank is using monetary policy to facilitate the required real appreciation.

12.7 Conclusions

In this chapter, we have put the spotlight on monetary policy. We began with the familiar model in which the government uses control of the money supply as its monetary policy instrument. We showed that

1. monetary policy can affect output and employment in the short run

but not in the medium run;

2. the inflation rate in the medium run is fixed by the growth rate of the money supply.

We examined the reasons behind episodes of rising inflation and the unsustainability of attempts to hold output above the equilibrium level. The costs of disinflation were identified: the more backward looking are inflation expectations and the stronger are the nominal rigidities in the economy, the higher will be the cost in terms of high unemployment of bringing down inflation. A falling general price level (deflation) has disadvantages. Important institutional features of economies suggest that achieving the necessary adjustments in relative wages is easier in the context of some positive inflation.

In a modern economy, monetary policy is not typically implemented through the control of the money supply for the following reasons:

- a money supply rule can lead to costly output fluctuations;
- the demand for money may be unstable;
- the money supply is not fully under the control of the government (or central bank).

Rather, the government or the central bank uses the interest rate to achieve its objectives. This highlights another reason for having a mildly positive inflation target. Since the nominal interest rate cannot be negative, monetary policy will become ineffective at very low or negative rates of inflation. Another way of making the same point is that only with positive inflation, is it possible to create a negative real interest rate — in a deep recession, this may be needed to boost activity.

We looked at how a systematic approach to monetary policy can be modelled: this entails specifying the objectives of the government (or central bank) and identifying the constraints it faces. As the core case, we have taken the objectives of the government to be to minimize the extent to which the economy diverges from a target rate of inflation and from a target level of output. We have shown that:

1. when the output target is the equilibrium level of output, y_e, a monetary policy reaction function will enable the government to steer the economy to its inflation and output targets if the economy experiences an inflation shock, an aggregate demand shock or an aggregate supply shock.

2. it is the government's inflation target that determines the inflation rate in the medium run equilibrium.

3. when the output target is above the equilibrium level of output, the government will not be able to achieve its inflation target in equilibrium. There will be an inflation bias.

Two methods of solving the problem of inflation bias have been mentioned: the government delegates authority over monetary policy to a central bank with an output target at or at least closer to the equilibrium. The second solution is referred to as 'reputation': when the monetary authority repeatedly interacts with forward-looking wage-setters, it will be in its interest to acquire a reputation for toughness in relation to inflation by acting as if it was targeting equilibrium output.

The usefulness of openness and transparency in monetary policy was discussed. A fuller understanding by the public of the monetary reaction function can help to stabilize forward looking expectations and facilitate the movement of asset prices consistent with the government's stabilization objectives.

The open economy model of Chapter 6 was extended in this chapter by showing how an inflation-targeting central bank in a small open economy would respond to an aggregate demand, inflation and aggregate supply shock. This was contrasted with the monetary regimes of fixed and floating exchange rates studied in Chapter 6. The major difference that characterizes the inflation targeting regime is that the central bank adjusts the interest rate so as to keep the economy close to the constant-inflation CCE line by prompting appropriate changes in the exchange rate. Required changes in the real exchange rate are therefore achieved without the large swings in the nominal rate characteristic of a floating regime or the large output swings and sluggish adjustment in the real exchange rate via wage and price inflation characteristic of the fixed exchange rate regime.