IS DELEGATING HALF OF DEMAND MANAGEMENT SENSIBLE?

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Is Delegating Half of Demand Management Sensible?*

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Abstract

A 1990s view is that inflation is best avoided by delegating monetary policy to an independent central bank. However most analyses overlook fiscal policy, which cannot be delegated. Here we make a very simple extension of the usual policy game by introducing the government as a third player, in charge of a fiscal instrument for demand management. If the government delegates monetary policy, there will be a battle over aggregate demand. Although the bank wins, so that inflation is avoided, it is at the cost of an excessive interest rate. Society's welfare may be lower than with no delegation.

JEL Classification

E52, E63

Keywords

central bank independence, monetary-fiscal coordination, demand management

That democratic governments should curb their inflationary instincts by delegating monetary policy to an independent and conservative central bank has become part of 1990's orthodoxy. Objections to this view in the economic literature have been notably muted. A potentially key objection, it might have been imagined, starts from the fact that although monetary policy can be delegated, fiscal policy cannot. With an independent central bank, control of macroeconomic policy is therefore split between two authorities with different objectives. This causes an inevitable loss of coordination in macroeconomic policy making, and a potential for conflict. It seems very possible that the costs of such conflict could turn out to outweigh the anti-inflationary benefits.

Recent German experience provides a conspicuous example of this problem. The 1990 reunification of East and West was the signal for the German government to increase its spending very substantially, in order to assist the East German economy. This put upward pressure on German inflation, which the Bundesbank countered by tightening monetary policy. The result was a battle for the control of aggregate demand, with monetary contraction fighting fiscal expansion. In this battle the main damage was suffered by the German interest rate, which both players' actions contributed to forcing up. There has been much discussion of the recessionary impact of this on other countries in the ERM at the time and of the destructive impact on the ERM itself, but in addition such an outcome was also damaging for the German economy, with the high interest rate causing a depression of investment and loss of future productive potential. This type of conflict, with its bias towards excessive interest rates, has a likelihood of emerging in any system with an independent central bank. U.S. macroeconomic policy in the early Reagan years followed a similar pattern. The Federal Reserve instituted a regime of tight monetary targets in a monetarist attack on inflation, while the government pursued an expansionary fiscal policy by increasing defence spending and cutting taxes, leading to large budget deficits. This inappropriate fiscal/monetary mix resulted in the high American and worldwide interest rates of the 1980's. Britain may find itself in the same bind, if the Bank of England is given its head. In 1995 the first signs of inflationary

forces are causing the Bank to advocate higher interest rates while the government, mindful of an approaching election, has an eye on tax cuts.

The literature on central bank independence has largely neglected the coordination issue. Probably the best known attempt to model it together with the time-consistency, inflationary-bias problem which motivates the case for central bank independence is the study by Alesina and Tabellini (1987). However this study assumes that fiscal policy operates only through the supply side of the economy. (Implicitly Alesina and Tabellini take an extreme monetarist view of the demand side in which the LM curve is vertical.) The essence of the problem described above is that monetary and fiscal policy are both instruments for controlling demand, and that a tug-of-war over demand may develop: this aspect is absent from their analysis. Blake and Westaway (1993) analyse coordination as a dynamic game by carrying out simulations on a macroeconometric model, concluding that unless the authorities cooperate, welfare is likely to fall when the bank is made independent. Other authors have addressed the coordination issue but separately from the time-consistency, inflationary-bias problem. Sargent and Wallace (1981), focusing on the government's budget constraint, pointed out that an independent fiscal policy may make it impossible for the central bank to control inflation in the long run, or even in the short run. Sargent (1985) verbally extends this analysis to describe the coordination problem as a "game of chicken", and Tabellini (1986) models coordination formally as a dynamic game, but still without the time-consistency, inflationary bias problem. Meade (1990) argues that instability is likely to result from using monetary and fiscal policy sequentially to achieve separate targets.

To our knowledge none of the formal analyses carried out so far combine the time-consistency, inflationary-bias problem motivating the case for central bank independence with the potential *demand management* conflict between monetary and fiscal authorities to which such independence gives rise. In this paper we provide a very simple analysis of this question. We argue that even a very basic static-game model can capture the German experience. Our model indicates that there is a trade-off between low inflation, which is what central bank independence achieves, and low interest rates, which are for the benefit

of the long-run real economy. These costs and benefits can be weighed using the government's own welfare function. We show that there is no guarantee that a government which makes its central bank independent will achieve a net gain in welfare. It depends in particular on the cost which the government attaches to high interest rates. If this is too small, the battle for control of aggregate demand will be fierce, and the costs of the high interest rates which result will outweigh the low-inflation benefits. It also depends on the way in which monetary policy is conducted: by setting the money supply, or by setting the interest rate. Interest rate control makes monetary policy more accommodating and tempts the government into thinking it can win the demand management battle. Hence it turns out that in this case an independent central bank is always inferior to a government-controlled one.

Some commentators, such as Goodhart (1993), have argued that an independent central bank will "discipline" the government, so that this problem will not arise. Goodhart suggests that it depends on which policy instrument "moves first", i.e. on whether the bank or the government is the leader in the policy game. This argument can be examined formally in our framework. We find that there is no change to the outcome under simultaneous decision-making if the bank is the leader, but a "disciplinary effect" *does* operate if the government is the leader. In this case it is true that the problem of interest rate bias is avoided, and making the bank independent is beneficial. However one problem with using this as a defence of central bank independence is that proposals for independence are typically designed to try to make the *bank* the leader. The broad idea has been that to solve the time consistency problem we need to find a way of precommitting monetary policy, which means making the bank the leader not only in the game with the government, but also, and more essentially, in the game with the public. Even if we reverse conventional wisdom and try to make the bank the follower, this will not necessarily succeed since the bank has no incentive to be the follower, whereas the government does.

The interest of the results apart, the merit of this simple exercise, we hope, is in its transparency. We use a very standard and well-known macroeconomic model, and

extend the familiar Kydland-Prescott (1977) (or Barro-Gordon (1983)) inflation policy game to three players (public, bank and government) in a rather straightforward way. Our analysis is similar in motivation to that of Blake and Westaway (1993), but goes to the opposite extreme in terms of model sophistication, in an attempt to provide some simple analytical insight. It is essentially a first attempt to explore the simple analytics of this issue. More developed analyses should, and doubtless will, be undertaken in due course, but we believe that taking account of monetary/fiscal conflict over aggregate demand will make the case for central bank independence intrinsically much less clear-cut than in most studies to date.

2. A Simple Model

The macroeconomy is represented in a completely conventional AD-AS manner. The demand side consists of IS and LM equations. The central bank controls the money supply, m, and thus the position of the LM curve. The government controls the summary fiscal policy variable d, and thus the position of the IS curve. d may be thought of as the government's budget deficit, since we shall not distinguish government spending and taxation. The supply side consists of a "surprise" supply equation. Following Rogoff (1985), we view this as arising from the labour demand relationship between employment and the real wage, where the money wage is set at the start of each period on the basis of the public's expectation of the price level, p^e. By choosing p^e the public thus control the position of the AS curve. Hence we have a model with three structural equations and three players, each player controlling the position of one of the relationships.

In algebraic form, the model is:

$$y = -\delta i + \sigma d \qquad \text{IS}$$

$$m - p = ky - \lambda i \qquad \text{LM}$$

$$y = y_N + \alpha(p - p^e). \qquad \text{AS}$$

All variables except for i are logs: y is output, i is the interest rate, p is the price level, and remaining terms are positive parameters.

The government is assumed to care about three macroeconomic variables: inflation, output, and the interest rate. Its preferences are taken also to represent the average preferences of society; that is, we view the government as democratic. Formally, the government's objective is to use fiscal policy, d, to minimise the loss function:

$$L_G = (p - p_{-1})^2 + \beta(y - y^*)^2 + \gamma(i - i^*)^2$$

where p_{-1} is the lagged price level, and y^*, i^* are the government's target output and interest rate levels. We assume $y^* > y_N$: it is the desire to raise output above its natural rate which gives rise to the time-consistency problem. To assume that the government cares about the interest rate is less standard: we justify this on the grounds that the government is also concerned about the long run growth of the economy, and that a low interest rate is conducive to this. In reality it is clear that governments are not indifferent to the interest rate: for example, in Britain, a high interest rate leads to a high mortgage rate and political unpopularity. This assumption is also necessary from a formal point of view for an equilibrium to the game to exist.

The central bank, by contrast, is assumed to care only about inflation. It has the loss function:

$$L_B = (p - p_{-1})^2$$

This captures the much-touted idea that the person appointed to be the central bank governor should be a "conservative", someone concerned more about inflation relative to output than society as a whole. To recap a now-familiar argument (see Rogoff (1985)): the best policy for the government would be to create zero inflation, but it cannot achieve this since, if the expectation of zero inflation were once built into wage contracts, the government would have an incentive to create inflation after contracts had been set, in order to get nearer to its output target. Optimal policy is time-inconsistent, and the actual outcome will be a positive rate of inflation equal to the level expected by a rational

public. To overcome the problem the government needs to find a way of precommitting monetary policy, and delegating it to an independent central bank which is known to have more anti-inflationary preferences than the government is a way of achieving this. In fact there is an alternative, simpler, version of the argument for independence. Kydland and Prescott (1977) originally saw the solution to the time-consistency problem as being to conduct monetary policy according to a rule rather than according to discretion. The rule might be "pursue a target of zero inflation". However, in order to succeed, there needs to be a mechanism to prevent the government from breaking its self-imposed rule. Putting the implementation of the rule in the hands of an independent central bank is one way of achieving this. In this version of the argument, then, the preferences of the bank are not the issue: independence is just a way of more effectively binding monetary policy to a rule. The two versions are observationally equivalent if the bank's preferences are defined only over inflation, as we assume here, and this is consistent with the fact that they are typically not clearly distinguished in public discussion.

Finally the public is simply assumed to act to equate its expected price level, p^e, to the actual price level, p. That is, its only task is to form rational inflation expectations. In forming expectations, the public is also implicitly embodying them in nominal wage contracts which cannot be changed for the rest of the period. The fact that wages are set at the start of the period, before monetary or fiscal policy is chosen, is the source of the time-consistency problem. By assumption, the public is the first mover. If instead it could be made the last mover the problem would be solved, but we assume that rigidity in the wage determination process makes this impossible.

Using this framework we now consider a very simple one-shot game. The sequence of decision-making is the following: first the public chooses p^e, then the bank and the government simultaneously choose m and d. In the game over demand management policy between the bank and the government, we thus assume a Nash outcome. To see how this outcome is in principle determined, first suppose p^e has already been set: for concreteness, take the case $p^e = p_{-1}$. This locates the AS curve through the point (y_N, p_{-1}) in Figure 1. The outcome for output and inflation now just depends on the outcome for

the position of the AD curve. Since the bank's sole concern is to achieve zero inflation, we can picture its indifference, or iso-loss, curves on the AD-AS diagram as horizontal lines, "bliss" being achieved where $p = p_{-1}$. On the other hand the government, which also cares about output, has indifference curves which are ellipses centred on (y^*, p_{-1}). Optimising subject to the AS curve, the government would want to position the AD curve through point A (for the moment we ignore the government's concern for the interest rate), while the bank would want to position it through point B. Here is the basic conflict over demand management: the government wants a higher level of demand than the bank, since it cares about the real economy whereas the bank does not.

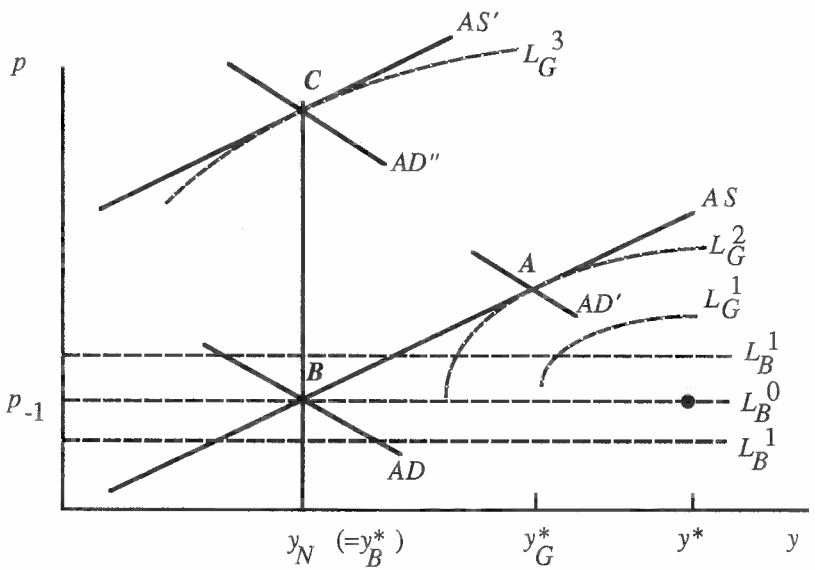

Figure 1

We next translate these preferences onto the IS-LM diagram, allowing us to focus on the interaction of monetary and fiscal policy. With p^e given, different levels of y in Figure 2 will correspond to different positions on the AS curve in Figure 1. Let y_B^* and y_G^* be the bank's and government's preferred levels of y conditional on the economy being on the AS curve. These are "conditional" targets for output which depend on the position of the AS curve and thus on p^e. Since the bank does not care about the interest rate, its indifference curves in (y,i)-space are vertical lines, with "bliss" at $y = y_B^*$. The government, on the other hand, does care about the interest rate: its indifference curves in (y,i)-space are ellipses centred on (y_G^*, i^*). Both sets of indifference curves, it should be

repeated, depend for their position on the given p^e. (In the appendix we derive expressions for these curves algebraically.)

In outline, the procedure for locating the overall equilibrium is to begin with the "second stage" of the game. Treating p^e as already determined, we find the Nash equilibrium policy choices of the bank and the government. This determines the "joint reaction function" of the two authorities to any given choice of p^e by the public, associating a price p to each p^e. We then move back to the "first stage" and find what p^e the public will choose in order to make $p^e = p$, i.e. what price level will be rationally expected. In fact, we will show that the expectation $p^e = p_{-1}$ used in Figure 1 is the rational one.

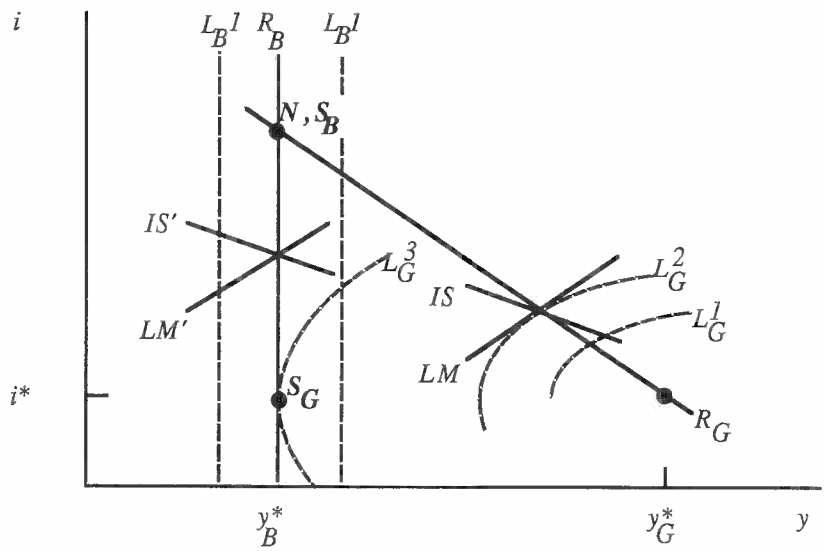

Figure 2

Starting then with the bank's policy choice: facing a given fiscal policy and thus position of the IS curve, the central bank chooses m and thus the position of the LM curve to reach its most preferred indifference curve. In Figure 2, this is where the IS curve intersects the vertical line $y = y_B^*$. Joining up the (y,i) outcomes for different positions of the IS curve we obtain the bank's reaction function, the locus R_B in Figure 2. This is a vertical line coinciding with $y = y_B^*$. The bank thus single-mindedly goes for its conditional output target, no matter what fiscal policy it faces. Turning to the government's policy choice: for any given position of the LM curve, the government

chooses d and thus position of the IS curve so as to reach its most preferred indifference curve. In this case Figure 2 shows it will select a point of tangency with the LM. The government's reaction function is thus the downward-sloping locus R_G. Unlike the bank, the government compromises on the achievement of its conditional output target for fear of the high interest rates which would result.

The Nash equilibrium is where the two reaction functions intersect. Here, each authority is doing the best it can given the policy of the other. We can see from Figure 2 that the outcome of the demand management war is a victory for the bank. However, the cost of this victory is an upward bias to the interest rate. Obviously, the reason why the bank wins the war is that it only has to worry about one objective - fighting inflation. The vigour with which the government is willing to use fiscal policy to try to expand demand is eventually restrained by its worry about the rising interest rate. Nevertheless, at low interest rates the government perceives an opportunity to counteract the deflationist bank by sliding the economy up its LM curve, and it is this perception which gives rise to the conflict and the interest rate bias.

Considering now the first stage of the game, what p^e will the public select? Since the bank always wins the war over aggregate demand and thereby succeeds in its objective of holding inflation to zero, it is clear that to expect $p^e = p_{-1}$ is in fact rational. The full outcome is thus zero inflation, output equal to the natural rate y_N, and an interest rate greater than i^*. The interest-rate bias is in fact given by (derived in appendix):

$$i - i_G^* = \frac{\beta\lambda}{k\gamma}(y^* - y_N)$$

This broadly captures the German experience: inflationary pressure was successfully contained, but at the cost of a very high interest rate. Incorporating the effect of fiscal policy on aggregate demand and modelling the government's fiscal policy choice thus makes the case for central bank independence much less clear cut.

For comparison, we now examine the case where the central bank remains under government control. In this case the government can determine the position of the LM curve as well as of the IS curve, and so can hit its interest rate and conditional output

targets (i^*, y_G^*) exactly (see again Figure 2). If p^e were still equal to p_{-1}, the economy would move to point A in Figure 1, where inflation is positive. A rational public would thus now adjust p^e upwards, to expect positive inflation. The full time-consistent equilibrium is at point C in Figure 1, which is a picture familiar from Kydland and Prescott (1977). The level of inflation here is (derived in appendix):

$$p - p_{-1} = \alpha\beta(y^* - y_N)$$

Thus, when the central bank is government-controlled, there is inflationary bias but not interest-rate bias.

Overall, is making the central bank independent desirable? The answer depends on how society values low inflation relative to low interest rates. The appropriate objective function for assessing this is the government's loss function, which represents society's preferences. In the appendix we use this function to calculate L_G under both institutional arrangements. We find that L_G is lower with an independent central bank if and only if the following parameter condition holds:

$$\gamma > (\lambda/k\alpha)^2$$

That is, society must care sufficiently about high interest rates in order for an independent central bank to be a good idea. Intuitively, a low value of γ has two effects: it makes the loss from a given interest rate bias smaller, but it also makes the government less restrained in attempting to stimulate demand, increasing the amount of the bias. The model shows that the second effect dominates. To express this finding in another, more paradoxical, way: a society which greatly values low inflation relative to the other macroeconomic goals of low unemployment and low interest rates (thus has low β and γ) should *not* make its central bank independent.

So far we have assumed that monetary policy is operated by setting the money supply. An alternative operating procedure is to set the interest rate: this corresponds more closely to the way central banks seem to behave in practice. How does the use of this alternative monetary instrument affect the conclusions? There is, first of all, a well-

known problem with pure interest rate-setting in a flex-price, rational-expectations economy, which is that the price level becomes indeterminate (see Sargent and Wallace (1975)). We handle this by assuming that the bank chooses a "money supply function", i.e. a relationship of the form:

$$\mu = (1-\phi)m - \phi i \qquad 0 \leq \phi < 1$$

Here μ is the monetary policy parameter, and ϕ is a parameter which determines the extent to which policy emphasises money supply-setting or interest rate-setting. (See, for example, Poole (1970) for a similar treatment.) We can approximate pure interest rate setting by letting ϕ be arbitrarily close to 1. Using this relationship to determine m in the LM equation, we get

$$\frac{1}{1-\varphi}\mu - p = ky - (\lambda + \frac{\varphi}{1-\varphi})i$$

This is similar to the original LM equation except that the extra term $\phi/(1-\phi)$ in the coefficient on i makes the LM curve flatter, and in the limit as ϕ tends to 1 the curve becomes horizontal. From this remark we can see that the effect on the outcome of the game of introducing an element of interest-rate setting is going to be the same as that of allowing λ, the interest-elasticity of money demand, to become larger. Thus, our earlier expression indicates that the greater is the emphasis on interest-rate setting, the worse is the interest-rate bias. As pure interest-rate setting is approached ($\lambda \rightarrow \infty$), the interest rate tends to infinity. The parameter condition for central bank independence to be desirable also becomes harder to satisfy as λ tends to infinity and, in the limit, impossible. Hence if the interest rate is the instrument of monetary policy, to make the central bank independent is always a bad idea. Intuitively this is because interest-rate setting makes monetary policy more accommodating of changes in aggregate demand, tempting the government into thinking it can win the demand battle, even though it cannot.

3. Can an Independent Bank Discipline the Government?

In public discussion of the pros and cons of making the central bank independent, the danger of conflict between monetary and fiscal policy has sometimes been recognised but then argued to be negligible on the grounds that once monetary policy is firmly committed to an anti-inflationary stance, fiscal policy will fall into line. For example, this seems to be the view of the former British Chancellor of the Exchequer, Nigel Lawson, in his evidence to the House of Commons Select Committee report on "The Role of the Bank of England" (1993). Charles Goodhart (1993) provides another version of this argument, claiming that it is a question of who "moves first" in the policy game.

We can examine such an argument within our simple model by departing from the assumption that monetary and fiscal policy are determined simultaneously, and assuming instead that one or other policymaker is the leader and the other the follower. This means moving from considering the Nash equilibrium of the game to considering the Stackelberg equilibrium. Suppose first that the government is the leader. In this case the central bank takes fiscal policy as given and so continues to act according to its reaction function R_B. The government, however, now realises that it can influence the bank's behaviour by moving first, and so rather than taking monetary policy as given, it takes the bank's reaction function as given. In Figure 2 the government thus seeks to reach its most preferred indifference curve subject to being on R_B. It is clear that the government will therefore choose the point S_G, where $i = i^*$, $y = y_B^*$. This is a good outcome: the bank continues to win the aggregate demand war, so there is no inflation; and in addition there is now no interest rate bias, since i is at its target level. In this case an independent central bank does succeed in "disciplining" the government. Now suppose the central bank is the leader. This time the government takes monetary policy as given, while the bank realises that it can influence the government's fiscal policy choices. Hence in Figure 2 it is the bank which seeks to reach its most preferred indifference curve subject to being on the reaction function of the government. It is clear that the outcome in this case will be the same as the Nash outcome. There will therefore still be a conflict over demand

management policy, of which the result will be a victory for the bank at the cost of a high interest rate.

The idea that, if the order of play is chosen appropriately, an independent central bank will discipline the expansionary behaviour of the government, thus does have a basis. However, a priori it might have been thought that the disciplinary effect would be most likely to work if the *bank* was the leader. In the standard analysis of the time-consistency inflationary-bias problem the essential task has been seen as that of making monetary policy the leader in the game. This is because the standard analysis sees the game as being just between the bank and the public. In this case it is true that the problem could be solved if the bank moved before the public. But when the fiscal authority is introduced as a third player, precommittting monetary policy is no longer desirable. Note that if, in our model, we assume that the bank moves before not only the government but also the public, nothing changes: so long as the government moves last it will be tempted to stimulate demand, and in equilibrium there will be the same interest-rate bias. Since it is impossible to make the government move before the public, rather than make the bank the first mover in the game it needs to be made the *last* mover. In this way it is able to threaten to reverse any attempted fiscal expansion of demand with a monetary contraction and higher rate of interest, and give the government the incentive not to attempt to manage demand. This is a kind of "second best" result: the optimal timing of the bank's move, from society's point of view, is completely changed by the addition of a third player to the game in the shape of the government.

Nevertheless, if the bank is leader it can influence the behaviour of the government, so why does this not change the outcome? In Sargent's (1985) discussion of monetary/fiscal coordination, the idea that we need to make the government the leader with respect to the bank is advanced strongly. The reason is that in our model, although it is true that the bank as leader recognises that it has the power to influence the fiscal policy choice of the government, the bank does not try to exploit this because it is already completely achieving its desired outcome for inflation, and it has no incentive to try to alter the outcome for the interest rate since it does not care about interest rates. On the

other hand when the government is leader, the recognition that its fiscal policy choice influences the bank's monetary policy choice in fact makes it perceive *less* scope for achieving its objectives, because it now realises that any attempt to influence aggregate demand will be neutralised by the bank, and so it focuses on its interest-rate objective instead.

4. Conclusions

Delegating half of demand management is not sensible. Unless the bank is guaranteed to be the last mover in the policy game, there will be a conflict in demand management between the deflationist central bank and the reflationist government, with an excessive interest rate as the result. Inflationary bias will be replaced by interest-rate bias, and unless society values low interest rates sufficiently, social welfare will be lower.

In principle this conflict could be avoided if the bank is the last mover, since in this case it will successfully discipline the government. However, as pointed out, the thrust of most (actual and proposed) systems with an independent central bank is to make the bank the *first* mover: to precommit monetary policy. This is especially bad if "precommitment" means not only precommitment to the zero-inflation objective, but precommitment to actual monetary policy instrument settings, as for example in preannouncing money supply targets (as does the Bundesbank). To maximise its chances of being the last mover, the bank needs to retain complete discretion over how it achieves its zero-inflation objective, enabling it to respond quickly and flexibly to the actions of the government. From the constitutional point of view, allowing the bank full discretion carries risks, such as that the governor may deviate from the zero-inflation objective, or may turn out to be incompetent. From the operational point of view, it is not certain that a central bank allowed complete discretion will necessarily want to exploit it: it may choose to tie itself in, as does the Bundesbank. The bank has no particular incentive to be the last mover, since it completely achieves its target of zero inflation whenever it moves. On the other hand the government does have an incentive, ex post, to be the last mover:

given the monetary policy setting it faces at the efficient, no-interest-rate-bias equilibrium, there is always the temptation to try to steal a march on the bank by a last-minute fiscal reflation. This is the root of the time-consistency problem. The argument that an independent central bank will discipline the government is thus one in which we cannot place confidence.

Appendix

The bank's and government's conditional targets for y are found by minimising their loss functions subject only to being on the AS curve. For the bank, $L_B = 0$ is achievable; this is where $p = p_{-1}$, which substituted into the AS yields:

$$y_B^* \equiv y_N + \alpha(p_{-1} - p^e)$$

For the government, the minimisation yields:

$$y_G^* \equiv \frac{\alpha^2\beta}{1+\alpha^2\beta}y^* + \frac{1}{1+\alpha^2\beta}y_B^*$$

Note that this is a weighted average of the bank's target and of the government's unconditional target. To derive the bank's indifference curves in (y,i)-space, we use AS to substitute p out of L_B, giving the indirect loss function:

$$L_B = \frac{1}{\alpha^2}(y - y_B^*)^2$$

Likewise substituting p out of L_G and rearranging, we have:

$$L_G = \frac{1+\alpha^2\beta}{\alpha^2}(y - y_G^*)^2 + \gamma(i - i^*)^2 + \frac{\beta}{1+\alpha^2\beta}(y^* - y_B^*)^2$$

The positions of the indifference curves depend on p^e because the conditional targets y_B^*, y_G^* depend on p^e.

The bank's reaction function R_B is found by minimising L_B subject to the IS function. This is trivially solved by $y = y_B^*$, so that R_B is a vertical line in (y,i)-space.

The government's reaction function R_G is found by minimising L_G subject to the LM function. This yields:

$$i - i^* = -\frac{1+\alpha^2\beta}{\alpha^2}\frac{\lambda}{k\gamma}(y - y_G^*)$$

To find the Nash equilibrium in the game between the bank and the government, we solve R_B and R_G together. It is immediate that $y = y_B^*$. Moving back to the first stage of the game, we know that when the public forms rational expectations, i.e. sets $p^e = p$, the AS implies $y = y_N$. Thus we have $y_B^* = y_N$. From the definition of y_B^* this implies $p^e = p_{-1}$, and from rational expectations, $p = p_{-1}$. Now considering i, in equilibrium we have that $y = y_N$ and $y_G^* = (\alpha^2\beta y^* + y_N)/(1+\alpha^2\beta)$. Using these in R_G gives the expression for the interest rate bias, $i - i^*$, presented in the main text.

Now suppose the bank is government-controlled. As pointed out, the targets $i = i^*$ and $y = y_G^*$ can then be achieved exactly. Imposing rational expectations and thus setting $y = y_N = y_G^*$, we can solve for the expression for inflationary bias, p-p_{-1}, presented in the main text. The government's loss in the equilibrium with a government-controlled bank can thus be computed as:

$$L_G^{no\ delegation} = \beta(1 + \alpha^2\beta)(y^* - y_N)^2$$

Likewise in the Nash equilibrium with an independent bank, we can use the expression for interest-rate bias, i-i^*, to compute the government's loss as:

$$L_G^{delegation} = \beta(1 + \frac{\lambda^2}{\gamma k^2}\beta)(y^* - y_N)^2$$

Comparing these yields the condition for delegation to be preferred which was presented in the main text.

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