tion target to the central bank may also replicate the optimal incentives called for under the linear inflation contract (Svensson 1997b).

Dixit and Jensen (2001) extended the contracting approach to the case of a monetary union in which member governments offer the common central bank incentive contracts designed to influence monetary policy. They showed that if the central bank cares about the incentives it receives and about the unionwide inflation rate, the central bank implements a policy that leads to average inflation that is too low and stable. The central bank implements a weighted average of each member country's desired policy only if the central bank cares only about the contract incentives. Hence, mandating that the central bank achieve price stability would result in a deflationary bias under discretion.

Athey, Chari, and Kehoe (2005) reexamined the optimal delegation of monetary policy by employing mechanism design theory in an environment similar to the one studied originally by Canzoneri (1985) in which the central bank has private information. They showed that under certain conditions, the optimal scheme involves an inflation cap—a maximum inflation rate the central bank is allowed to choose. The greater the time inconsistency problem, the lower is the cap. If the central bank has little private information, then the optimal design calls for giving no discretion to the central bank.

7.3.4 Institutions

One interpretation of the contracting approach is that the incentive structures might be embedded in the institutional structure of the central bank. If institutions are costly to change, then institutional reforms designed to raise the costs of inflation can serve as commitment devices. Incorporating a price stability objective directly into the central bank's charter legislation, for example, might raise the implicit penalty (in terms of institutional embarrassment) the central bank would suffer if it failed to control inflation. Most discussions of the role of institutional structure and inflation have, however, focused on the effects of alternative structures on the extent to which political pressures affect the conduct of monetary policy.

A starting point for such a focus is Alesina's model of policy in a two-party system.[39] Suppose there is uncertainty about the outcome of an approaching election, and suppose the parties differ in their economic policies, so that inflation in the post-election period will depend on which party wins the election. Let the parties be denoted A and B. The inflation rate expected if party A wins the election is π^A; inflation under party B will be π^B. Assume $\pi^A > \pi^B$. If the probability that party A wins the election is q, then expected inflation prior to the election will be $\pi^e = q\pi^A +$

39. For a discussion of this model, see Alesina (1987); Alesina and Sachs (1988); Alesina and Roubini (1992; 1997); and Drazen (2000).

$(1-q)\pi^B$. Since q is between 0 and 1, expected inflation falls in the interval $[\pi^B, \pi^A]$. If postelection output is equal to $y = a(\pi - \pi^e)$, where π is actual inflation, then the election of party A will generate an economic expansion (since $\pi^A - \pi^e = (1-q)(\pi^A - \pi^B) > 0$), whereas the election of party B will lead to an economic contraction ($\pi^B - \pi^e = q(\pi^B - \pi^A) < 0$).

This very simple framework provides an explanation for a political business cycle that arises because of policy differences between parties and electoral uncertainty. Because parties are assumed to exploit monetary policy to get their desired inflation rate, and because election outcomes cannot be predicted with certainty, inflation surprises will occur after an election. Alesina and Sachs (1988) provided evidence for this theory based on U.S. data, and Alesina and Roubini (1992) examined OECD countries. Faust and Irons (1996), however, concluded that there is little evidence from the United States to support the hypothesis that political effects generate monetary policy surprises.

Waller (1989; 1992) showed how the process used to appoint members of the central bank's policy board can influence the degree to which partisan political factors are translated into monetary policy outcomes. If policy is set by a board whose members serve overlapping but noncoincident terms, the effect of policy shifts resulting from changes in government is reduced. In a two-party system in which nominees forwarded by the party in power are subject to confirmation by the out-of-power party, the party in power will nominate increasingly moderate candidates as elections near. Increasing the length of terms of office for central bank board members also reduces the role of partisanship in monetary policy making.[40] Waller and Walsh (1996) considered a partisan model of monetary policy. They focused on the implications for output of the degree of partisanship in the appointment process and the term length of the central banker. Similarly, Alesina and Gatti (1995) showed that electorally induced business cycles can be reduced if political parties jointly appoint the central banker.

While most work has focused on the appointment of political nominees to the policy board, the Federal Reserve's policy board (the FOMC) includes both political appointees (the governors) and nonappointed members (the regional bank presidents).[41] Faust (1996) provided an explanation for this structure by developing an overlapping-generations model in which inflation has distributional effects. If monetary policy is set by majority vote, excessive inflation results as the (larger) young generation attempts to transfer wealth from the old generation. If policy is delegated

40. See also Havrilesky and Gildea (1992) and Garcia de Paso (1994). For some empirical evidence in support of these models, see Mixon and Gibson (2002).

41. Havrilesky and Gildea (1991; 1995) argued that the voting behavior of regional bank presidents and board governors differs, with regional bank presidents tending to be tougher on inflation; this conclusion was disputed by Tootell (1991).

to a board consisting of one representative from the young generation and one from the old, the inflationary bias is eliminated. Faust argued that the structure of the FOMC takes its shape because of the advantages of delegating to a board in which the relative balance of different political constituencies differs from that of the voting public as a whole.

Who makes policy and who appoints the policymakers can affect policy outcomes, but institutional design also includes mechanisms for accountability, and these can affect policy as well. Minford (1995), in fact, argued that democratic elections can enforce low-inflation outcomes if voters punish governments that succumb to the temptation to inflate, and Lippi (1997) developed a model in which rational voters choose a weight-conservative central banker. O'Flaherty (1990) showed how finite term lengths can ensure accountability, and Walsh (1995b) showed that the type of dismissal rule incorporated into New Zealand's Reserve Bank Act of 1989 can partially mimic an optimal contract.

The launch of the European Central Bank in 2000 helped to focus attention on the role institutions and their formal structure play in affecting policy outcomes. Because the individual member countries in a monetary union may face different economic conditions, disagreements about the common central bank's policies may arise. Dixit (2000) used a principal agent approach to study policy determination in a monetary union. With a single central bank determining monetary policy for a union of countries, the central bank is the agent of many principals. Each principal may try to influence policy outcomes, and the central bank may need to appease its principals to avoid noncooperative outcomes.

Dixit showed that the central bank's decision problem must take into account the individual incentive compatibility constraints that require all principals to accept a continuation of the policy the central bank chooses. For example, if one country has an large adverse shock, the central bank may have to raise inflation above the optimal commitment level to ensure the continued participation in the union of the affected country. When the incentive constraint binds, policy will diverge from the full-commitment case in order to secure the continued participation of the union members. Dixit showed that when countries are hit by different shocks, it is the incentive constraint of the worst-hit country that is binding—policy must shade toward what that country would want. If the costs of overturning the central bank's policy (and thereby reverting to the discretionary equilibrium) are high enough, there will be some range of asymmetric shocks within which it is possible to sustain the full-commitment policy.

7.3.5 Targeting Rules

The contracting approach focuses on the incentive structure faced by the central bank; once the incentives are correct, complete flexibility in the actual conduct of policy is allowed. This allows the central bank to respond to new and possibly unverifiable information. An alternative approach acts to reduce the problems arising from discretion by *restricting* policy flexibility. The gold standard or a fixed exchange rate regime are examples of situations in which policy flexibility is deliberately limited; Milton Friedman's proposal that the Fed be required to maintain a constant growth rate of the money supply is another famous example. A wide variety of rules designed to restrict the flexibility of the central bank have been proposed and analyzed. The cost of reduced flexibility depends on the nature of the economic disturbances affecting the economy and the original scope for stabilization policies in the first place, and the gain from reducing flexibility takes the form of a lower average inflation rate.

Targeting rules are rules under which the central bank is judged in part on its ability to achieve a prespecified value for some macroeconomic variable. Inflation targeting is currently the most commonly discussed form of targeting, and some form of inflation targeting has been adopted in over 20 developed and developing economies.[42] Fixed or target zone exchange rate systems also can be interpreted as targeting regimes. The central bank's ability to respond to economic disturbances, or to succumb to the temptation to inflate, is limited by the need to maintain an exchange rate target. When the lack of credibility is a problem for the central bank, committing to maintaining a fixed nominal exchange rate against a low-inflation country can serve to import credibility. Giavazzi and Pagano (1988) provided an analysis of the advantages of "tying one's hands" by committing to a fixed exchange rate.

Flexible Targeting Rules

Suppose the central bank cares about output and inflation stabilization but is, in addition, penalized for deviations of actual inflation from a target level.[43] In other words, the central bank's objective is to minimize

$$V^{cb} = \frac{1}{2}\lambda \mathrm{E}_t(y_t - y_n - k)^2 + \frac{1}{2}\mathrm{E}_t(\pi_t - \pi^*)^2 + \frac{1}{2}h\mathrm{E}_t(\pi_t - \pi^T)^2, \tag{7.21}$$

where this differs from (7.2) in that π^* now denotes the socially optimal inflation rate (which may differ from zero), and the last term represents the penalty related to deviations from the target inflation rate π^T. The parameter h measures the weight placed on deviations from the target inflation rate. Targeting rules of this form are known as

42. In addition to the references cited earlier, see Ammer and Freeman (1995); Haldane (1995); McCallum (1997a); Mishkin and Posen (1997); Bernanke et al. (1998); and the papers in Leiderman and Svensson (1995) and Lowe (1997) for discussions of inflation targeting. Walsh (2009) contains an extensive list of references on the topic. See also section 8.4.6.

43. The central bank might be required to report on its success or failure in achieving the target, with target misses punished by public censoring and embarrassment or by some more formal dismissal procedure.

flexible targeting rules. They do not require that the central bank hit its target exactly; instead, one can view the last term as representing a penalty suffered by the central bank based on how large the deviation from the target turns out to be. This type of targeting rule allows the central bank to trade off achieving its inflation target for achieving more desired values of its other goals.

The rest of the model consists of an aggregate supply function and a link between the policy instrument, the growth rate of money, and inflation:

$$y_t = y_n + a(\pi_t - \pi^e) + e_t$$

and

$$\pi_t = \Delta m_t + v_t,$$

where v is a velocity disturbance. It is assumed that the public's expectations are formed prior to observing either e or v, but the central bank can observe e (but not v) before setting Δm.

Before deriving the policy followed by the central bank, note that the socially optimal commitment policy is given by[44]

$$\Delta m_t^S = \pi^* - \left(\frac{a\lambda}{1 + a^2\lambda}\right) e_t. \tag{7.22}$$

Now consider policy under discretion. Using the aggregate supply function and the link between inflation and money growth, the loss function (7.21) can be written as

$$V^{cb} = \frac{1}{2}\lambda \mathrm{E}[a(\Delta m + v - \pi^e) + e - k]^2 + \frac{1}{2}\mathrm{E}(\Delta m + v - \pi^*)^2 + \frac{1}{2}h\mathrm{E}(\Delta m + v - \pi^T)^2.$$

The first-order condition for the optimal choice of Δm, taking expectations as given, is

$$a^2\lambda(\Delta m - \pi^e) + a\lambda(e - k) + (\Delta m - \pi^*) + h(\Delta m - \pi^T) = 0.$$

Solving yields

$$\Delta m = \frac{a^2\lambda\pi^e - a\lambda e + a\lambda k + \pi^* + h\pi^T}{1 + h + a^2\lambda}. \tag{7.23}$$

44. This is obtained by substituting the commitment policy $\Delta m = b_0 + b_1 e$ into the social objective function

$$\frac{1}{2}[\lambda \mathrm{E}(y - y_n - k)^2 + \mathrm{E}(\pi - \pi^*)^2]$$

and minimizing the unconditional expectation with respect to b_0 and b_1.

Assuming rational expectations, $\pi^e = \Delta m^e = (a\lambda k + \pi^* + h\pi^T)/(1+h)$ because the public forms expectations prior to knowing e. Substituting this result into (7.23) yields the time-consistent money growth rate:

$$\Delta m^T = \frac{a\lambda k + \pi^* + h\pi^T}{1+h} - \left(\frac{a\lambda}{1+h+a^2\lambda}\right)e$$

$$= \pi^* + \frac{a\lambda k}{1+h} + \frac{h(\pi^T - \pi^*)}{1+h} - \left(\frac{a\lambda}{1+h+a^2\lambda}\right)e. \tag{7.24}$$

If the target inflation rate is equal to the socially optimal inflation rate ($\pi^T = \pi^*$), (7.24) reduces to

$$\Delta m^T = \pi^* + \frac{a\lambda k}{1+h} - \left(\frac{a\lambda}{1+h+a^2\lambda}\right)e. \tag{7.25}$$

Setting $h = 0$ yields the time-consistent discretionary solution *without* targeting:

$$\Delta m^{NT} = \pi^* + a\lambda k - \left(\frac{a\lambda}{1+a^2\lambda}\right)e, \tag{7.26}$$

with the inflation bias equal to $a\lambda k$.

Comparing (7.22), (7.25), and (7.26) reveals that the targeting penalty reduces the inflation bias from $a\lambda k$ to $a\lambda k/(1+h)$. The targeting requirement imposes an additional cost on the central bank if it allows inflation to deviate too much from π^T; this raises the marginal cost of inflation and reduces the time-consistent inflation rate. The cost of this reduction in the average inflation bias is the distortion that targeting introduces into the central bank's response to the aggregate supply shock e. Under pure discretion, the central bank responds optimally to e (note that the coefficient on the supply shock is the same in (7.26) as in (7.22)), but the presence of a targeting rule distorts the response to e. Comparing (7.25) with (7.22) shows that the central bank will respond too little to the supply shock (the coefficient falls from $a\lambda/(1+a^2\lambda)$ to $a\lambda/(1+h+a^2\lambda)$).

This trade-off between bias reduction and stabilization response was seen earlier in discussing Rogoff's model.[45] Note that if $\pi^T = \pi^*$, the central bank's objective function can be written as

$$V^{cb} = \frac{1}{2}\lambda \mathrm{E}(y_t - y_n - k)^2 + \frac{1}{2}(1+h)\mathrm{E}(\pi - \pi^*)^2. \tag{7.27}$$

45. Canzoneri (1985); Garfinkel and Oh (1993); and Garcia de Paso (1993; 1994) considered multiperiod targeting rules as solutions to this trade-off between stabilization and inflation bias. Defining money growth or inflation targets as averages over several periods restricts average inflation while allowing the central bank more flexibility in each period to respond to shocks.

It is apparent from (7.27) that the parameter h plays exactly the same role that Rogoff's degree of conservatism played. From the analysis of Rogoff's model, the optimal value of h is positive, so the total weight placed on the inflation objective exceeds society's weight, which is equal to 1. A flexible inflation target, interpreted here as a value for h that is positive, leads to an outcome that dominates pure discretion.[46]

The connection between an inflation targeting rule and Rogoff's conservative central banker approach has just been highlighted. Svensson (1997b) showed that a similar connection exists between inflation targeting and the optimal linear inflation contract. Svensson demonstrated that the optimal linear inflation contract can be implemented if the central bank is required to target an inflation rate π^T that is actually less than the socially optimal rate of inflation. To see how this result is obtained, let $H = 1 + h$, replace π^* with π^T in (7.27), and expand the resulting second term so that the expression becomes

$$\begin{aligned} V^{cb} &= \frac{1}{2}\lambda \mathrm{E}(y_t - y_n - k)^2 + \frac{1}{2}H\mathrm{E}(\pi - \pi^* + \pi^* - \pi^T)^2 \\ &= \frac{1}{2}\lambda \mathrm{E}(y_t - y_n - k)^2 + \frac{1}{2}H\mathrm{E}(\pi - \pi^*)^2 + D\mathrm{E}(\pi - \pi^*) + C, \end{aligned}$$

where $D = H(\pi^* - \pi^T)$ and $C = \frac{1}{2}H(\pi^* - \pi^T)^2$. Since C is a constant, it does not affect the central bank's behavior. Notice that V^{cb} is equal to $V + \frac{1}{2}h\mathrm{E}(\pi - \pi^*)^2 + D\mathrm{E}(\pi - \pi^*) + C$. This is exactly equivalent to the incentive structure established under the optimal linear inflation contract if and only if $h = 0$ and $D = a\lambda k$. The condition $h = 0$ is achieved if the central banker is not weight-conservative but instead shares society's preferences (so $H = 1$); the condition $D = a\lambda k$ is then achieved if

$$\pi^T = \pi^* - a\lambda k < \pi^*.$$

Thus, the optimal linear contract can be implemented by assigning to the central bank an inflation target that is actually below the rate that is socially preferred. But at the same time, policy should be assigned to an agent who has the same preferences between inflation and output stabilization as society in general.

Strict Targeting Rules

The preceding analysis considered a flexible targeting rule. The central bank was penalized for deviations of π around a targeted level but was not required to achieve the target precisely. This flexibility allowed the central bank to trade off the objective

46. That is, of course, unless h is too large.

of meeting the target against achieving its other objectives. Often, however, targeting is analyzed in terms of strict targets; the central bank is required to achieve a specific target outcome regardless of the implications for its other objectives. For an early analysis of strict targeting regimes, see Aizenman and Frankel (1986).

As an example, consider a strict money growth rate target under which the central bank is required to set the growth rate of the money supply equal to some constant:[47]

$$\Delta m = \Delta m^T.$$

Since the desired rate of inflation is π^*, it makes sense to set $\Delta m^T = \pi^*$, and the public will set $\pi^e = \pi^*$. With this rule in place, the social loss function can be evaluated. If social loss is given by

$$V = \frac{1}{2}\lambda \mathrm{E}_t(y_t - y_n - k)^2 + \frac{1}{2}\mathrm{E}_t(\pi_t - \pi^*)^2,$$

then under a strict money growth rate target it takes the value

$$V(\Delta m^T) = \frac{1}{2}[\lambda k^2 + \lambda\sigma_e^2 + (1 + a^2\lambda)\sigma_v^2].$$

Recall that under pure discretion the expected value of the loss function was, from (7.9),

$$V^d = \frac{1}{2}\lambda(1 + a^2\lambda)k^2 + \frac{1}{2}\left[\left(\frac{\lambda}{1 + a^2\lambda}\right)\sigma_e^2 + (1 + a^2\lambda)\sigma_v^2\right].$$

Comparing these two, one obtains

$$V(\Delta m^T) - V^d = -\frac{1}{2}(a\lambda k)^2 + \frac{1}{2}\left(\frac{a^2\lambda^2}{1 + a^2\lambda}\right)\sigma_e^2.$$

Notice that this can be either positive or negative. It is more likely to be negative (implying that the strict money growth rate target is superior to discretion) if the underlying inflationary bias under discretion, $a\lambda k$, is large. Since the strict targeting rule ensures that average inflation is π^*, it eliminates any inflationary bias, so the gain is larger, the larger the bias that arises under discretion. However, discretion is more likely to be preferred to the strict rule when σ_e^2 is large. The strict targeting rule eliminates any stabilization role for monetary policy. The cost of doing so will depend on

47. Alternatively, the targeting rule could require the central bank to minimize $\mathrm{E}(\Delta m - \Delta m^T)^2$. However, this occurs if the central bank sets policy such that $\mathrm{E}(\Delta m) = \Delta m^T$. If Δm is controlled exactly, this is equivalent to $\Delta m = \Delta m^T$.

the variance of supply shocks. Eliminating the central bank's flexibility to respond to economic disturbances increases welfare if

$$k > \sigma_e \sqrt{\frac{1}{1 + a^2\lambda}}.$$

If σ_e^2 is large, pure discretion, even with its inflationary bias, may still be the preferred policy (Flood and Isard 1988).

Another alternative targeting rule that has often been proposed focuses on nominal income (e.g., Hall and Mankiw 1994). If $y - y_n$ is interpreted as the percentage output deviation from trend, one can approximate a nominal income rule as requiring that

$$(y - y_n) + \pi = g^*,$$

where g^* is the target growth rate for nominal income. Since the equilibrium growth rate of $y - y_n$ is zero (because it is a deviation from trend) and the desired rate of inflation is π^*, one should set $g^* = 0 + \pi^* = \pi^*$. Under this rule, expected inflation is $\pi^e = g^* - \mathrm{E}(y - y_n) = g^* - 0 = g^* = \pi^*$. Aggregate output is given by

$$y = y_n + a(\pi - \pi^e) + e = y_n + a(y_n - y) + e \Rightarrow y - y_n = \left(\frac{1}{1 + a}\right)e,$$

since $\pi = g^* - (y - y_n) = \pi^e - (y - y_n)$ under the proposed rule. A positive supply shock that causes output to rise will induce a contraction designed to reduce the inflation rate to maintain a constant rate of nominal income growth. The decline in inflation (which is unanticipated because it was induced by the shock e) acts to reduce output and partially offset the initial rise. With the specification used here, exactly $a/(1 + a)$ of the effect of e is offset. Substituting this result into the policy rule implies that $\pi = \pi^* - e/(1 + a)$.

Using these results, the expected value of the social loss function is

$$V(g^*) = \frac{1}{2}\lambda k^2 + \frac{1}{2}\left[\frac{1 + \lambda}{(1 + a)^2}\right]\sigma_e^2.$$

In the present model, nominal income targeting stabilizes real output more than pure discretion (and the optimal commitment policy) if $a\lambda < 1$. In this example, it is assumed that the central bank could control nominal income growth exactly. If, as is more realistic, this is not the case, a term due to control errors will also appear in the expected value of the loss function.

Nominal income targeting imposes a particular trade-off between real income growth and inflation in response to aggregate supply disturbances. The social loss function does not weigh output fluctuations and inflation fluctuations equally (unless $\lambda = 1$), but nominal income targeting does. Nevertheless, nominal income targeting is often proposed as a "reasonably good rule for the conduct of monetary policy" (Hall and Mankiw 1994). For analyses of nominal income targeting, see Bean (1983); Frankel and Chinn (1995); McCallum (1988); Taylor (1985); and West (1986). Targeting rules in new Keynesian models are discussed in section 8.4.6.

The analysis of targeting rules has much in common with the analysis of monetary policy operating procedures (see chapter 11). Targeting rules limit the flexibility of the central bank to respond as economic conditions change. Thus, the manner in which disturbances will affect real output and inflation will be affected by the choice of targeting rule. For example, a strict inflation or price level rule forces real output to absorb all the effects of an aggregate productivity disturbance. Under a nominal income rule, such disturbances are allowed to affect both real output and the price level. As with operating procedures, the relative desirability of alternative rules will depend both on the objective function and on the relative variances of different types of disturbances.

7.4 Is the Inflation Bias Important?

Despite the large academic literature that has focused on the inflationary bias of discretionary monetary policy, some have questioned whether this whole approach has anything to do with explaining actual episodes of inflation. Do these models provide useful frameworks for positive theories of inflation? Since monetary models generally imply that the behavior of real output should be the same whether the average inflation rate is zero or 10 percent, the very fact that most economies have consistently experienced average inflation rates well above zero for extended periods of time might be taken as evidence for the existence of an inflation bias.[48] However, earlier chapters examined theories of inflation based on optimal tax considerations that might imply nonzero average rates of inflation, although few argue that tax considerations alone could account for the level of inflation observed during the 1970s in most industrialized economies (or for the observed variations in inflation). There are several reasons for questioning the empirical relevance of time inconsistency as a factor in monetary policy. Some economists have argued that time inconsistency just isn't a problem. For example, Taylor (1983) pointed out that society finds solutions to these sorts of problems in many other areas (patent law, for example) and that there is no reason to suppose that the problem is particularly severe in the monetary

48. While most monetary models do not display superneutrality (so that inflation does affect real variables even in the steady state), most policy-oriented models satisfy a natural rate property in that average values of real variables such as output are assumed to be independent of monetary policy.