6

Practical issues of effective stabilization

In the last chapter we asked whether there was a case for monetary policy to stabilize the economy: we concluded that there was. In this chapter we ask what in practice must be done to carry out this stabilization function successfully. We begin with the issue that has haunted policy makers since rational expectations became widely accepted: Lucas' critique of policy choice (Lucas, 1976) which makes the point that the models being used for the formulation of policy rules may well not remain constant as these rules are reset because the behaviour modelled depends on expectations which themselves depend on the rules. Dealing with this critique turns out to be an elusive business. Many economists have however persuaded themselves that models with overlapping wage (and sometimes price) contracts have sufficient constancy under changing rules to be reasonably reliable as a guide to policy formulation. A large literature has grown up using such models to test different sorts of rules. We look at these tests and other ways of evaluating policy in practice.

THE LUCAS CRITIQUE OF POLICY EVALUATION

It was Lucas (l976) who first pointed out that if expectations are formed rationally, then unless the estimated equations used by model builders to evaluate the consequences of alternative government policies are genuinely structural or behavioural, the implications of such simulations or evaluations may be seriously flawed. The essential insight of Lucas is that, when expectations are formed rationally, agents react to the behaviour of government. Consequently, unless the equations estimated by the model builder are structural, the coefficients in equations which are estimated over one policy regime will implicitly depend on the parameters of the government policy rule in operation. Consequently, the evaluation of alternative policies can be quite misleading.

Let us take as an example the following simple model, with overlapping contracts (so that stabilization policy is effective), a quantity theory demand for money function and a money supply rule that responds to past output. All the variables are measured in deviations from their normal values.

$$y_t = \beta(p_t - 0.5[E_{t-1}p_t + E_{t-2}p_t]) \tag{1}$$

$$m_t = p_t + y_t \tag{2}$$

$$m_t = \mu y_{t-1} + \varepsilon_t \tag{3}$$

The solution is

$$y_t = \frac{\beta}{1+\beta}\varepsilon_t + \frac{0.5\mu\beta^2}{(1+\beta)(1+0.5\beta)}\varepsilon_{t-1} \tag{4}$$

from which it is immediately apparent that the optimal monetary response is nil ($\mu = 0$).

What we have just done is to set out the model in its 'structural' form (that is, in terms of its underlying relationships). But suppose we had written the model in a 'reduced' or solved form, with each variable in terms only of its ultimate determinants after all the model's relationships have worked themselves out in the current period. Equation (4) is such a form, but since the error term, ε_t, is not directly observable (it is an implication of equation (3), we could write (4) in terms of observable ultimate determinants m_t and y_{t-1} (using $\varepsilon_t = m_t - y_{t-1}$ from (3)) as:

$$y_t = \sigma_1 m_t + \sigma_2 m_{t-1} + \sigma_3 y_{t-1} + \sigma_4 y_{t-2} \tag{5}$$

where $\sigma_1 = \frac{\beta}{1+\beta}$; $\sigma_2 = \frac{0.5\mu\beta}{(1+\beta)(1+0.5\beta)}$; $\sigma_3 = -\mu\sigma_1$; $\sigma_4 = -\mu\sigma_2$.

Having recovered this relationship from the data, we could compute the optimal monetary policy for time t, given what has already occurred in $t-1$ (the planning period). It is obvious that we must set m_t so as to make $y_t = 0$ (we have one instrument, m_t, and one target, y_t, so the problem here is simple) or:

$$m_t = -\frac{1}{\sigma_1}(\sigma_2 m_{t-1} + \sigma_3 y_{t-1} + \sigma_4 y_{t-2}) \tag{6}$$

According to our relationship (5), this feedback rule for money supply ought to deliver zero fluctuation in output. However, in fact it may deliver worse fluctuations even than the feedback rule (3) the central bank was previously following! Actual money supply will be given by (6) plus ε_t, which is the unpredictable error in executing monetary intentions. The resulting rule can be written as:

$$m_t = \mu y_{t-1} + \frac{\varepsilon_t}{1 + \frac{0.5\mu\beta}{1+0.5\beta}L} \tag{7}$$

(using our knowledge of the σ_i in terms of the model's structural parameters). When this is substituted into the model, we find the new solution for y_t as

$$y_t = \frac{\beta}{1+\beta}\varepsilon_t + \frac{0.5\mu\beta^2}{(1+\beta)(1+0.5\mu\beta)^2}\varepsilon_{t-1} \tag{8}$$

Here output is far from perfectly stabilized with respect to past events — though it will in this instance be slightly more stable.

Where we went wrong was that we used the reduced form to calculate the optimal rule. But that reduced form itself depends on the monetary rule because the rule influences (rational) expectations and so economic behaviour (this problem would not arise in adaptive expectations models, where the effect of money on output does not depend on the rule itself). So the reduced form will not remain constant (as assumed) as we change the rule towards the 'optimum'. Hence we must compute a false optimum.

The policy maker using these methods of optimal control is doomed to go on recomputing his 'optimal' rule as his 'model' constantly changes: it will not necessarily converge to a constant rule and model, however, nor is there any guarantee that it will get any better over time. It could get worse, or alternatively better and worse. In general, we cannot say.

The problem we have just described is not too difficult to solve. Once the policy maker recognizes that the model underlying (5) is a rational expectations model consisting of (1) to (3), he will use the appropriate method and set $\mu = 0$! Estimating the structural parameters of the model is a technical problem not in principle more difficult than estimating the reduced form parameters (we discuss the problem briefly in chapter 16).

DEEP STRUCTURE

We have assumed that (1) and (2) are truly 'structural', that is, that they are invariant to the policy maker's rule. However, this may well not be so. People's behaviour is itself the result of optimizing subject to constraints of budgets and technology; policy rules will typically change their budget constraints because expected future prices and incomes will depend in general on the economy's behaviour which in turn depends on the rules. Equations (1) and (2) express people's resulting behaviour in demand and supply functions; these may therefore alter as policy rules alter. Rational expectations implies that the vast majority of the economic relationships econometricians typically estimate are not strictly structural.

A simple example of this arose with the model of equations (22) and (23) in chapter 4, where we assumed signal extraction from local prices. We saw that output depended on the stabilization parameter, μ:

$$y_t - y^* = \frac{\frac{(1-\phi)}{\delta}}{1 + \frac{(1-\phi)}{\delta} + \alpha\phi + \frac{\alpha\mu\phi(1-\phi)}{\delta(1+\alpha)}}\varepsilon_t \tag{9}$$

It might seem from this that for maximum stability μ should be pushed as high as technically feasible (implying dramatic monetary contraction in booms, expansion in recessions). However, this conclusion treats ϕ as a structural parameter. It is not, since we know that $\phi = \frac{\pi_o^2\sigma_\varepsilon^2}{\sigma_v^2+\pi_o^2\sigma_\varepsilon^2}$, the slope of the Phillips curve, depends on the extent to which the variance of local prices reflects local shocks and overall monetary instability. To compute the appropriate value of we must allow for this as discussed in chapter 4.

Lucas' critique therefore raises deep difficulties for econometricians attempting to recover from the data relationships which are usable for policy making.

One reaction to this problem has been to assert that only the parameters of preferences and technology ('deep structure') will be regime-invariant and that macroeconomists should therefore estimate these. Some early examples are Hansen and Sargent (1980) and Sargent (1978, 1981). A research methodology along these lines is now in full swing. This work models agents at the microeconomic level as intertemporal optimizers subject to the constraints of budget and technology, and attempts to retrieve the parameters of the (aggregated) utility and production functions. In chapters 11-13 we set out some key features of these 'representative agent' models. The problem is to find a way of embedding sufficient detail into the constraints facing agents to allow these models to confront the data successfully.

The models use estimates of utility and production function parameters derived from microeconomic studies (usually of large cross-sectional data sets). Processes for shocks (error terms) to technology and preferences are then estimated from the time series when restricted by the results of these studies. The success of a model in predicting the facts of the business cycle is evaluated by comparing the second and higher moments of the predicted and actual series: techniques of statistical inference from this comparison are not yet widely in use, though available, whether because of the high costs of using them or because the model practitioners do not feel that such stringent testing is appropriate, given the models' relative infancy. Whether such models yet have sufficient dynamic structure to be useful for evaluating stabilization policy is still a matter of debate. However, they do have the clear strength that, being in principle invulnerable to the Lucas critique, they should give a useful guide to the longer-run effects of policies once people have understood the new environment.

Models of this general equilibrium type are widely used in evaluating such policy issues as the effects of world tariff reduction rounds or the introduction of funded private pensions. But for this purpose the interest is in the long-run steady state results and often we have reasonable confidence in at least the rough magnitude of the long-run parameters to be used. The problem with using these general equilibrium models for evaluating stabilization policy is that the parameters of importance are the dynamic ones that govern lags of response — that is, those of expectations and adjustment principally; these have generally been retrieved from time-series estimation as in cross-section there is usually not enough time variation to estimate response to change. However, in recent years 'panel' data-sets (where there is variation across agents and also over time) have offered the promise of resolving this problem.

A second school of thought, of which a major proponent is Sims (1980), asserts that there is no practical possibility of policy evaluation and the best we can achieve is the estimation of time-series models whose parameters will shift in an unpredictable way with regime change. He has proposed the estimation of simultaneous time-series models (i.e. where each variable depends on its past and also on the past of the other variables in the model). These 'Vector Autoregression' (VAR) models have proved extremely popular as ways of summarising an economy's behaviour. The difficulty with them is of interpretation: plainly they are not structural and so inferring what the structural relations may be that underlie these solved-out time-series relationships requires the assumption of 'identifying restrictions', in other words the modeller must assume some structural model. The method however means that the links between the structural model and the VAR parameters are complex; in practice the structural parameters cannot be retrieved solely from the VAR estimation. Again, this strand of thought has prompted a huge research programme to refine the method.

A final reaction has been to model expectations explicitly, but to continue to treat as structural the parameters of such macroeconomic model equations as the consumption and investment functions; this approach has been adopted for example in the Liverpool model (chapter 16) and other examples are Blanchard and Wyplosz (1981), Taylor (1979a) and Holly and Zarrop (1983). It is recognized by these authors that the parameters of these equations will change as regimes change, but it is argued that the major impact of regime change will be felt in the expectations variables, while that on the parameters themselves, except for quite violent regime change, may be of second order importance. Nevertheless, these models have increasingly attempted to introduce 'micro-founded' equations, thereby getting closer to deep structure. This approach has tended to dominate hitherto, practical policy evaluation mainly being done using models of this type, with on the face of it reasonable success in the past decade in controlling both inflation and output fluctuations; we discuss the results in the next section.

We end this section, therefore, in a cautious vein: policy evaluation is certainly difficult, but various researches are in hand which may offer scope for better evaluation in the future.

EVALUATING POLICY IN NEW KEYNESIAN MODELS WITH OVERLAPPING WAGE/PRICE CONTRACTS

In practice many modellers in the 1990s work with overlapping contract models of the New Keynesian type which we discussed in chapter 4. As we have seen these models exhibit a high degree of nominal rigidity which enables monetary policy to be effective in stabilizing the economy.

A simple framework for looking at this work is the New Keynesian model of chapter 4, discussed earlier in this chapter (equation 55), together with the assumption that the government or central bank controls aggregate demand through monetary policy. In that set-up, let us ignore the time-inconsistency issue, as we argued was appropriate at the end of chapter 5; we will assume that there is some mechanism, such as that of popular disapproval, restraining the government from trying to exploit the Phillips Curve by systematically stimulating the economy beyond its natural rate. So the government's actions are restricted to varying policy in response to shocks to the economy, as summarised in the Phillips curve shock (remembering this can reflect the whole menu of supply and demand shocks through intertemporal substitution or exchange rate effects on the supply of labour and output). Since this set-up is known, people will also know the rule, and hence will form their inflation expectations knowing it will hold; therefore inflation expectations over the long term are equal to the inflation target, while in the short term they depend on the speed with which inflation converges on the target, as determined by the parameters of the model including policy. Our New Keynesian supply curve is:

$$y_t = \sigma(p_t - 0.5[E_{t-1}p_t + E_{t-2}p_t]) + \gamma y_{t-1} + u_t \tag{10}$$

where y_t is the log deviation from the natural rate (i.e. $y^* = 0$).

In practice of course models used for policy evaluation are more complicated than this. But this simple model is sufficient to illustrate the nature of the choices available. What emerges is a trade-off between the variability of inflation and the variability of output; not of course between the average levels of output and inflation between which there is no (long-run) trade-off — the average level of output is its natural rate and the average level of inflation is its target value, varying which will of course make no difference to output. But inflation changes can accommodate shocks to some degree and so dampen down their effect on output; this reduces output variation at the cost of raising inflation variation.

We saw in chapter 5 that if there is a social welfare function which includes the squared variations in inflation and output around their target and natural rate respectively then expected social welfare will depend on the variances of inflation and output. The optimal feedback response of inflation to the shock (which we assume is held to for as long as the model prevails) will then as we saw depend on the degree of dislike of output variation and on the slope of the Phillips Curve. The flatter the slope (the higher c) the less the response required; the greater the dislike of output variation (α) the higher the response.

One can interpret this social welfare function — which is certainly widely used by central banks in practice — as reflecting on the one hand the individual agent's dislike of inflation uncertainty (in creating consumption uncertainty which needs then to be insured at some cost) and on the other hand the social cost of unemployment variation, as discussed above in chapter 5. Various efforts have been made to produce such micro-based justifications (e.g. Rotemberg and Woodford (1998), Woodford (1998), and Minford, Nowell and Webb (1999)). If one uses this interpretation it follows that reducing the extent of the unemployment benefit subsidy to unemployment would reduce the extent of the distortion from unemployment variation and so reduce the size of α and the need for activist monetary accommodation. However, few societies appear to have reached this situation; and the consensus among policymakers is that monetary policy ought to stabilize output fairly actively. Witness for example the behaviour in 1997-8 of the Federal Reserve Board in response to the Asian Crisis or that of the Bank of England's

Monetary Policy Committee to the threat of recession in autumn 1998; in both cases quite sharp cuts in interest rates were made in order to avert recession.

In recent policy therefore, as dominated by this New Keynesian framework, active feedback monetary response has been prevalent. To implement this response central banks have favoured using interest rate rather than money supply rules. Demand for broad money functions have proved unstable in the world of deregulated banking that has generally prevailed in the 1980s and 1990s; while narrow money demand functions, though immune to deregulation, have proved vulnerable to technological change (credit cards and cash machines), to movement in the black economy, and to increasing use of home notes in foreign economies (e.g. 'dollarization' in Israel and Russia). As the interpretation of money supply movements became more uncertain central banks have relied increasingly on direct evaluation of economic conditions and a response via interest rates (this implies some equivalent money supply response — but evaluating it is of course uncertain when demand functions are unstable).

In chapter 5 (and the appendix to chapter 11, on dynamic programming) we derive the optimal response of inflation to the Phillips curve shock on the assumption that this can be exactly delivered by interest rate movements; the optimal response to other shocks is nil on this assumption. In practice however the shocks cannot be observed and interest rate policy cannot deliver an exact inflation outcome; and so a choice must be made between rules (of reasonable simplicity) that respond to observable variables, usually inflation and output themselves. This choice can be made by embedding these rules in a model of the economy and checking the resulting variances of output and inflation (either analytically or by stochastic simulation).To see what sort of interest rate response would be optimal on this basis, assume that aggregate demand depends on real interest rates (an IS curve expressed in nominal terms; using interest rates bypasses the LM curve):

$$p_t + y_t = -\beta r_t \tag{11}$$

where p_t is in log deviations from the (moving) price level target and r_t is in deviations from the natural real rate of interest.

We use prices in place of inflation and a moving price level target in place of an inflation target as this simplifies our exposition. (To re-express policy in terms of inflation targeting would introduce more complicated dynamics.)

We now write the interest rate rule as:

$$r_t = \mu_p p_{t-1} + \mu_y y_{t-1} \tag{12}$$

(To turn this rule into one for nominal interest rates one simply adds in the expected inflation rate.) We can set the solution up using the Muth method, with $p_t = \sum_{i=0}^{\infty} q_i u_{t-i}$, by substituting from (10) and (12) into (11) for y_t and r_t, to obtain

$$\begin{aligned}(1+\beta\mu_y L)([1+\sigma q_0]u_t + 0.5\sigma q_1 u_{t-1}) + \\ (1-\gamma L)(1+\beta\mu_p L)\sum_{i=0}^{\infty} q_i u_{t-i} = 0 \end{aligned} \tag{13}$$

Collecting terms then gives us:

$$(u_t) \qquad q_0 = \frac{1}{1+\sigma} \tag{14}$$

$$(u_{t-1}) \qquad q_1 = \frac{\beta(\mu_p - \mu_y - \gamma)}{(1+\sigma)(1+0.5\sigma)} \tag{15}$$

$$(u_{t-2}) \qquad q_2 = -q_1(0.5\beta\mu_y\sigma + \beta\mu_p - \gamma) + (\gamma\beta\mu_p)q_0 \tag{16}$$

$$(u_{t-i},\ i \geqslant 3) \qquad q_i = -(\beta\mu_p - \gamma)q_{i-1} + (\gamma\beta\mu_p)q_{i-2} \tag{17}$$

Now turn to the variance of output. Because

$$\begin{aligned} y_t &= \frac{(1+\sigma q_0)u_t + 0.5q_1 u_{t-1}}{1-\gamma L} \\ &= (1+\sigma q_0)u_t + \sum_{i=1}^{\infty}(1+\sigma q_0 + \frac{0.5q_1}{\gamma})\gamma^i u_{t-i} \end{aligned} \tag{18}$$

the variance of output is

$$vary_t = \{(1+\sigma q_0)^2 + (1+\sigma q_0 + \frac{0.5q_1}{\gamma})^2 \frac{\gamma^2}{1-\gamma^2}\}\sigma_u^2 \tag{19}$$

By contrast the variance of prices is:

$$varp_t = \sum_{i=0}^{\infty} q_i^2 \sigma_u^2 \tag{20}$$

Policy cannot affect q; but it does affect all other q_i. The optimal set of these for minimising $varp_t$ are $q_i = 0 (i \geqslant 1)$. The optimal set for minimising $vary_t$ is $(1+\sigma q_0 + \frac{0.5q_1}{\gamma}) = 0$, that is $q_1 = \frac{-\gamma}{0.5(1+\sigma)}$, implying that

$$\mu_y = \mu_p - \gamma + \frac{\gamma(1+0.5\sigma)}{0.5\beta} \tag{21}$$

whereas for $q_1 = 0$ we must have

$$\mu_y = \mu_p - \gamma \tag{22}$$

Hence there is a trade-off between $vary_t$ and $varp_t$, involving the choice of q_1. This is a general feature of these models (Taylor, 1999; Clarida, Gali and Gertler, 1999) in respect of the Phillips Curve shock, u_t. Plainly, in such models r_t should aim to offset any 'pure' demand shocks (i.e. any shock to equation 11) entirely, since they must add to the variances of either prices or output or both; however, in practice matters are not so simple since as we have seen demand shocks will also enter u_t (via supply or cost effects induced by interest rates or exchange rates). So the trade-off between the two variances is pervasive across most relevant shocks and should therefore show up in stochastic simulations of models for a complete set of shocks. One can see that a society that cared a lot about output fluctuation would set a $\mu_y$close to (21) and then find a μ_p that minimised q_i^2 $(i \geqslant 2)$ subject to this. Clearly the closeness of μ_y to (21) would depend on how much society cared about output variability.

Rather than find the optimal μs for this particular, illustrative and highly simplified model, we report on findings from full models about the results of stochastic simulations with interest rate rules of the form of (12). Rules of this type have been called Taylor rules after John Taylor who first propagated them having completed a spell on the US Council of Economic Advisers, where he felt the need to come up with a 'monetarist' rule that did not rely on targeting the money supply given its instability — the original suggestion for such rules was by Henderson and McKibbin (1993). Econometric work has found that rules of this type fit central bank behaviour quite well; this does not necessarily mean that they actually adopted these rules but rather that whatever rule they did adopt produces interest rate behaviour of this sort (Minford et al. (2001), show that a wide variety of monetary rules can produce an appearance of a Taylor rule). Given that economic behaviour varies with the policy regime, we should be rather cautious in translating results for Taylor Rules into equivalent results say for money supply rules. But we will assume in what follows that having a coefficient on output in a Taylor rule is qualitatively at least similar to having a feedback coefficient on output in a money supply rule.

In a recent article Taylor (1999) compared various parameterizations of such rules within a variety of econometric models of different economies (containing many complexities omitted here but obeying the basic logic of our simple model) and concluded that a quite simple rule, $i_t = 1.5\pi_t + 0.5y_t + i_0$, did best out of those investigated. His results show that if the lagged interest rate is included with a coefficient of unity (so

Standard deviations* of	Inflation	Output	Interest Rate
Output Coefficient = 0.5	2.13	1.94	2.82
Output Coefficient = 1.0	2.16	1.63	3.03

*average across nine models; % p.a. for inflation and interest rate; % for output.

Table 6.1: Average behaviour of rules of nine models

that it is the change of the interest rate that reacts to output and inflation) then in models without rational expectations the results are often unstable; this is because the interest rate keeps on rising in response to a stubborn inflation shock and since expectations of the future effect on inflation fall only slowly, interest rates overreact. It is possible to reduce the variance of output by increasing the coefficient on output to 1.0 say. But the cost is a slightly higher variance of inflation and a much higher variance of interest rates. The average behaviour with these two rules across all the nine models examined is shown in Table 6.1

There is therefore some evidence of a trade-off in estimated models between output and inflation variability; also between output and interest rate (instrument) variability, the latter naturally rising as rules are more 'activist' with regard to stabilising the business cycle (i.e. with a higher output coefficient). Different central banks adopt varying positions along these trade-offs, with the more 'conservative' ones adopting lower output coefficients; during 2000 Mr. Wim Duisenberg, the chairman of the new European Central Bank (ECB), for example, stated that the ECB would not be 'activist'. However, it is too early to say whether its policies will adhere closely to this position in practice.

During the 1990s central bank practice, following this sort of behaviour — whatever its degree of activism —, appears also to have been successful, both in curbing inflation and in preventing large swings in economic activity, at least in the Anglo-Saxon world and in Europe. Japan has had an unhappy decade of persistent recession after the 'bubble-bursting' monetary squeeze at its start and the Asian Crisis of 1997 caused a massive recession in Asia; but these developments were limited in their impact on the rest of the OECD and much of the credit for that seems to be due to effective monetary policy.

CALVO CONTRACTS

A popular device for modelling long-term nominal contracts is due to Calvo (1983). Price-setters (or wage-setters, analysed analogously) operate under imperfect competition where if prices were flexible they would be continuously set as a mark-up on marginal cost. They are assumed to face a menu cost of changing their price: this takes the form of a lump sum cost which acts as a threshold. If some unexpected shock to costs exceeds this threshold, they will change their price and set it to the newly expected marginal cost. It is assumed that there is a constant probability, $1-\xi$, of such a shock for each (identical) price-setter. The expected losses at $t=0$ of the hth price-setter can be written:

$$\sum_{t=0}^{\infty} E_0 \beta^t [p_t^h - (1+m)c_t^h]^2 \tag{23}$$

where m is the mark-up and c is the marginal cost.

The first-order condition with respect to the decision to set his price at $\widetilde{p}_0^h$ then implies:

$$\widetilde{p}_0^h = (1+m)(1-\beta\xi)\sum_{t=0}^{\infty}(\beta\xi)^t E_0 c_t^h \tag{24}$$

In other words the reset price is equal to a weighted average of all future expected marginal costs plus the mark-up. This expression is justified as follows. Consider the losses associated with the decision to set $\widetilde{p}_0^h$. For $t=0$, $\widetilde{p}_0^h$ can be freely set and so the loss is $[\widetilde{p}_0^h - (1+m)c_0^h]^2$. At $t=1$ there is a ξ chance of being unable to change his prices from $\widetilde{p}_0^h$ and a $1-\xi$ chance of being able to reset it, in which case any loss is not to do with today's decision; hence the expected loss at $t=1$, due to today's decision, is $\beta\xi[\widetilde{p}_0^h - (1+m)E_0 c_1^h]^2$. Similarly at $t=2$, there is a ξ^2 chance of being unable to change it from $\widetilde{p}_0^h$ in either $t=1$ or $t=2$; there is a $(1-\xi)^2$ of being able to change it in both periods, a $\xi(1-\xi)$ chance of changing it in $t=1$ but not in $t=2$, and similarly of not changing it in $t=1$ but doing so in $t=2$. In all these last theree cases nothing decided for $t=0$ affects the losses which are due to decisions taken in later periods. So the expected loss at $t=2$ due to the decision at $t=0$ is $\beta^2\xi^2[\widetilde{p}_0^h - (1+m)E_0 c_2^h]^2$. Analogously at $t=i$ it is $\beta^i\xi^i[\widetilde{p}_0^h - (1+m)E_0 c_i^h]^2$. Equation (23) will only contain these terms in $\widetilde{p}_0^h$ in other words. So differentiating it with respect to $\widetilde{p}_0^h$ yields the first-order condition above. In general at time t the hth's agent's decision is therefore:

$$\widetilde{p}_t^h = (1+m)(1-\beta\xi)\sum_{i=0}^{\infty}(\beta\xi)^i E_t c_{t+i}^h \tag{25}$$

Across the population $1-\xi$ will on average reset their prices in exactly the same way, and ξ will retain last period's price, hence $\widetilde{p}_t^h = \widetilde{p}_t$, $E_t c_{t+i}^h = E_t c_{t+i}$ and

$$p_t - p_{t-1} = (1-\xi)(\widetilde{p}_t - p_{t-1}) \tag{26}$$

Now let $(1-m)E_t c_{t+i} = \delta E_t(y_{t+i} - y^*_{t+i})$, that is marginal costs are a rising function of output (and approximately linear in the region of y^*_t, the natural rate of output). Then we can rewrite (26) as:

$$\pi_t = p_t - p_{t-1} = \frac{(1-\xi)(1-\beta\xi)\delta(y_t - y^*_t)}{1-\beta\xi B^{-1}} - (1-\xi)p_{t-1} \tag{27}$$

where B^{-1} is the forward operator, leading the variable but not the date of expectation. Hence, multiplying through by the expression in the forward operator and collecting terms, we obtain

$$\begin{aligned}\pi_t = \frac{\beta\xi}{1-\beta\xi(1-\beta\xi)}E_t\pi_{t+1} + \frac{\delta(1-\xi)(1-\beta\xi)}{1-\beta\xi(1-\beta\xi)}(y_t - y^*_t) \\ - \frac{(1-\xi)(1-\beta\xi)}{1-\beta\xi(1-\beta\xi)}p_{t-1}\end{aligned} \tag{28}$$

This is the Calvo forward-looking Phillips Curve in which effectively the whole path of future output (marginal costs) affects current price rises.

In what we did above we implicitly assumed that price-setters were resetting their prices when expected general inflation was zero; the idea is that the shocks they face are relative, micro, shocks. If they expect rises in the general price level, then it is usual to argue that, being general, all would be expected to raise their own prices in line. It would be like a general relabelling or indexing of prices that would not incur the menu cost, which arises from getting out of line with others. Thus all authors (e.g. Erceg, Henderson and Levin, 2000; Christiano, Eichenbaum and Evans, 2002) add on an 'updating term' to allow for general expected (or 'core') inflation. Thus π_t is to be read as $\pi_t - \overline{\pi}_t$ where $\overline{\pi}_t$ is this expected general inflation rate. Strictly therefore we should write:

$$\begin{aligned}\pi_t = \overline{\pi}_t + \frac{\beta\xi}{1-\beta\xi(1-\beta\xi)}E_t(\pi_{t+1} - \overline{\pi}_{t+1}) + \frac{\delta(1-\xi)(1-\beta\xi)}{1-\beta\xi(1-\beta\xi)}(y_t - y^*_t) \\ - \frac{(1-\beta\xi)(1-\xi)}{1-\beta\xi(1-\beta\xi)}(p_{t-1} - \overline{p}_{t-1})\end{aligned} \tag{29}$$

where the last term is usually neglected of small order. $\frac{\beta\xi}{1-\beta\xi(1-\beta\xi)}$ can be greater or less than one (so that the forward sums converge provided that $(y_t - y^*_t)$ converges at a rate γ such that $\gamma\frac{\beta\xi}{1-\beta\xi(1-\beta\xi)} \prec 1$).

$\overline{\pi}_t$ can be thought of as the rate of general indexation; for that reason some authors (e.g. Christiano et al., 2002) write it as π_{t-1} to allow for a lag in indexation; this introduces lagged inflation as well as expected future inflation into the Phillips Curve. It must be confessed however that there is some confusion on this point; clearly, for example, if $\overline{\pi}_t = E_t\pi_t = \pi_t$ and $E_t\overline{\pi}_{t+1} = E_t\pi_{t+1}$, the relationship dissolves. If we introduced an information lag, so that $\overline{\pi}_t = E_{t-1}\pi_t$, then it becomes the standard surprise inflation Phillips Curve of Lucas, Sargent and Wallace discussed *passim* in earlier chapters.

Equation (28) is typically used in New Keynesian models with an IS curve and an interest-rate-setting rule, so that the causation runs from the interest rate to output and so to inflation; notice that the rule must drive output back to y^* faster than $\frac{\beta\xi}{1-\beta\xi}$ to avoid inflation divergence. Rotemberg and Woodford (1999) have argued in favour of 'super-inertial' interest rate rules of the form:

$$r_t = \frac{1}{\lambda} r_{t-1} + a(y_t - y_t^*) + b(\pi_t - \pi^*) \tag{30}$$

where $\lambda \prec 1$. The reason is that only very small reactions of interest rates are required to stabilise output and inflation because these reactions are not only very long-lasting but also diverge so that output and inflation are driven rapidly back to their targets by the prospect of such interest rate paths. However, as we saw above, with backward-looking influences on behaviour, such super-inertia creates possible instability.

Calvo-style Phillips Curves have a form that is analytically tractable but their interpretation in the context of ongoing inflation is problematic. When underlying inflation is zero, one can under certain assumptions write the representative agent's welfare as a linear combination of the variance of inflation (which creates relative price distortions disturbing consumption) and the variance of the output gap (which disturbs employment and so leisure) — e.g. Gali and Monacelli (2002). This then justifies the standard approach to optimal monetary policy which involves trading off the variance of inflation and the output gap, in the manner used in earlier sections.

DOES THE LUCAS CRITIQUE AFFECT NEW KEYNESIAN (TAYLOR) RULES?

However, even if this monetary policy devised using New Keynesian methods has apparently been successful, we must ask whether this success is stable or could be undermined by some parameter shift of the sort implied by the Lucas Critique. For the models assume that the parameters (of Phillips and IS curves) remain constant even though the monetary regime is being altered towards an optimum.

We saw in the first section of this chapter that the Phillips curve slope in particular depended on the variability of inflation. The more activist the monetary policy, the higher this variability; and hence the the steeper the Phillips Curve (the lower σ). This in turn implied that activism should be more moderate than implied with a fixed slope of the Phillips Curve. (In other words excess activism would actually, by steepening the Phillips Curve, make the combined variability of inflation and output worse.) The calculations reported by John Taylor do not take account of this extra loop of effect on the economy's behaviour; and we may reasonably expect, given this argument, that the rules understate the response to inflation (i.e. interest rates should keep inflation closer to target instead and not be so influenced by output fluctuation).

This line of thinking might also lead us to consider other aspects of monetary policy that could affect the slope of the Phillips Curve. In a recent paper Minford, Nowell and Webb (1999) pointed out that the persistence of shocks to the price level within the period of overlapping contracts has the effect of raising the variance of real wages within the contract period — because the more persistent the shock the more are contracted nominal wages disturbed from their intended average level over the contract period. This persistence could be expected to produce a high level of indexation which would greatly steepen the Phillips Curve; there is strong evidence of widespread indexation or equivalent practices since the 1970s with no real sign of any reduction during the low-inflation 1990s. In terms of quarterly monetary policy it implies that central banks should pay a great deal of attention to keeping prices on average in the contract period close to the trajectory expected — effectively targeting the price level not the inflation rate. A rule that targets inflation (or indeed the growth rate of the money supply) implies that the price level will be non-stationary (i.e. has an infinite variance in the long run). Such total long-run uncertainty must undoubtedly carry economic costs.

What these, and no doubt other related issues of parameter variation, indicate is that the optimization of monetary policy is a still more complicated matter than these New Keynesian methods imply. The classical economists set great store by the certainty of the price level in both the short and long run, in order to underpin the efficiency of the market price signalling process; they put no emphasis on activist monetary policy, believing that a constancy of prices (and they thought by implication the money supply) would generate sufficiently stabilizing output behaviour by the private sector. Since Keynes monetary policy has increasingly been pressed into service to stabilize output. What we have yet to work out is how great a conflict there is between these two aspirations for monetary policy.

CONCLUSIONS

In this chapter we accepted that monetary policy could effectively stabilize output fluctuations and also that there was at least in principle a case for so using it, at least to some degree; we thus turned to a consideration of what that degree might be in practice and how to calculate the appropriate rule of behaviour, whether for interest rates or for the money supply. We began by setting out the key practical problem of such calculations: Lucas' critique of macro models whose parameters would shift in response to changing monetary rules. Clearly to calculate the appropriate response we must know the parameters of the model that will occur under every relevant monetary rule; this means in effect that we must know the parameters of the underlying structural model of the economy (i.e. the one with the parameters that will not shift in response to a changing environment). From that model — even if we do not use it directly — we can work out what will happen to the parameters of any other model that we do use directly. Just relying on estimated reduced form models would be insufficient because we would know they must change with changing monetary rules as the expectations implicit in them changed. Unfortunately the problem of parameter shift runs deep: IS/LM/Phillips Curve models with rational expectations solved explicitly are still vulnerable because their supply and demand parameters are those of optimising behaviour and with different rules the optimal behaviour changes. We discussed three main approaches to the problem. First, to build new models whose parameters were those of tastes and technology (presumably immune to policy change); this is empirically difficult because these parameters can only be observed indirectly. Second, to abandon any pretence of structural models by estimating time-series models whose parameters are easily recoverable; and to design policy rules that are robust to any possible variations in these parameters. The problem here is that we have little way of knowing how big these parameter variations might be in the absence of a structural model to predict them. Third, to assume that IS/LM/Phillips Curve models' parameters (with overlapping New Keynesian contracts) are in practice reasonably immune to relevant variations in monetary rules. Much practical work has been done with such models to find optimal interest rate (Taylor) rules; and this work has been very influential on central bank practice with apparently successful results in the 1990s. The question with which we concluded was whether these rules were in spite of these hopes vulnerable to Lucas' critique (given the extent of indexation and equivalent practices that could steepen the Phillips Curve); at this stage we offer a guarded 'yes' to this question (the evidence also suggests that indexation or equivalent practices are extremely widespread) and suggest that future work may give a stronger role to price level stability.