10.3 Aggregate Supply and Demand, Wage Indexation, and Supply Shocks

The following model has played a central role in the analysis of economic fluctuations in the presence of nominal rigidities:

$$y^d = m - p + v, \tag{20}$$

$$y^s = \beta(p - w + u), \qquad \beta > 0, \tag{21}$$

$$n^d = \gamma(p - w + \alpha u), \qquad \gamma > 0, 0 \leqslant \alpha \leqslant 1, \tag{22}$$

$$n^s = \delta(w - p), \qquad \delta \geqslant 0, \tag{23}$$

$$w \mid En^d = En^s, \qquad n = n^d. \tag{24}$$

Here y, n, w, and p are the logarithms of aggregate output, employment, the nominal wage, and the price level, respectively, and u and v are supply and demand shocks. Constants are ignored for notational simplicity, and all variables are implicitly indexed by t. For any variable x, Ex denotes $E[x|u(-i), v(-i), i = 1, \ldots, \infty]$; it is the expectation of x conditional on lagged, but not on current, values of u and v.

The simplest motivation for equation (20), aggregate demand, is simply as a statement of the quantity theory equation or the Clower constraint, with velocity assumed to be exogenous.

The next two equations give output supply and labor demand as functions of the real wage and a technological shock. They can be derived from profit maximization under perfect competition. As we saw in chapter 8, they can also be derived as implicit supply and demand functions under imperfect competition; equation (21) can be inverted to give the price set by firms given the nominal wage, the technological shock, and the level of output. The parameters β, γ, and α depend on the technology and are likely to be related; we do not specify this relation here.[13] An interesting special case, which we considered at various points in chapter 9, is that of constant returns to labor in which the price depends only on the wage and the technological shock, and not on the level of output.

The last two equations characterize wage setting. Equation (23) is labor supply. Equation (24) specifies the nature of the nominal rigidity: the nominal wage is set so as to equalize expected labor demand and expected labor supply. Given the nominal wage, employment is determined by labor demand. Again, as we saw in chapter 9, the behavior of the nominal wage implied by (23) and (24) can be given noncompetitive interpretations. The wage may be set by bargaining between firms and workers, with the nominal wage set one period in advance. Or the wage may be set by firms, based on efficiency wage considerations, and again set one period in advance.

The model can be simplified further. By substituting (22) and (23) into (24) and taking expectations conditional on the information set, we obtain the nominal wage:

$$w = Ep + \left(\frac{\alpha\gamma}{\delta + \gamma}\right) Eu. \tag{25}$$

The nominal wage is equal to the expected price level plus a non-decreasing function of the expected technological shock. Unless labor supply is perfectly elastic, an expected positive shock leads to an increase in both employment and wages. Replacing in equation (21), and utilizing equation (20), gives

$$y^d = m - p + v, \tag{20}$$

$$y^s = \beta(p - Ep) + \beta(u - aEu),$$

$$a \equiv \frac{\alpha\gamma}{\delta + \gamma}. \tag{26}$$

The output supplied depends on the unexpected movement in the price level as well as on the actual and the expected technological shock. The reason for the presence of the last term is that an anticipated positive technological shock leads workers to increase their real wage demands, thus decreasing its effect on equilibrium output. The coefficient a is between zero and one. It is equal to zero only when labor supply is perfectly elastic (or more generally when wage-setters want to set a constant real wage, regardless of the level of employment), if δ is infinite. Note also the similarity of equations (20) and (26) with the equilibrium model of Lucas analyzed in chapter 7. The Lucas supply curve is also given by equation (26) (except for the productivity terms). In that model suppliers react, under imperfect information, to perceived relative price differentials. Although the mechanism is different, the equations are the same.

Equations (20) and (26) give us a simple aggregate demand-aggregate supply system. Stripped down as this model is, it has nevertheless been immensely useful. It was particularly helpful in understanding the basic effects of supply shocks and the pros and cons of wage indexation in the 1970s.[14]

Supply Shocks, Output, and Inflation

The first oil shock of 1973 presented an analytic problem to economists who up to that point were used to thinking of most shocks as coming from the demand side. The analytic problem was to explain the simultaneous existence of high inflation and recession.

The supply-demand system gives a simple answer. Figure 10.2 shows the aggregate demand curve, given money and velocity, and the aggregate supply curve, given the expected price level and the expected value of the supply shock as embodied in the nominal wage. Aggregate demand is downward sloping, and aggregate supply upward sloping. An unexpected adverse supply shock shifts the aggregate supply curve to the left, to *AS′*, shifting the economy's equilibrium to *E′*, with a higher price level and a lower level of output. Given the past price level, a higher price level means higher inflation. This is a strikingly simple explanation for simultaneous high inflation and low output.

The figure also makes clear the well-known dilemma of aggregate demand policy confronted with an adverse supply shock: any attempt to fight the higher price level by reducing the money supply further reduces output, but trying to maintain the level of output with an expansionary monetary policy means a higher price level. This, however, raises another more basic question: Should demand policy actually be used (assuming that it can be used) to stabilize output in the presence of such shocks?

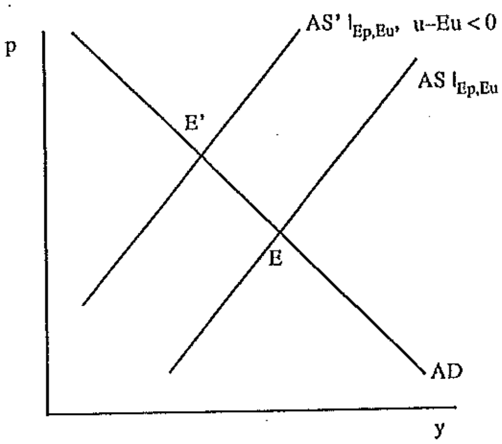


Figure 10.2
Effects of an adverse supply shock

A good starting point is to compare the response of output to supply shocks in the presence and absence of nominal rigidities. Suppose first that there were no nominal rigidities, that, for example, wages could be set after observing the shock. In this case, from (26), output would react to the supply shock according to

$$y = \beta(1 - a)u, \tag{27}$$

or equivalently

$$y = \beta(1 - a)(u - Eu) + \beta(1 - a)Eu.$$

In the presence of nominal rigidities, we must first solve for the expected price level and then for the actual price level and output. Eliminating output between (20) and (26) and taking expectations gives

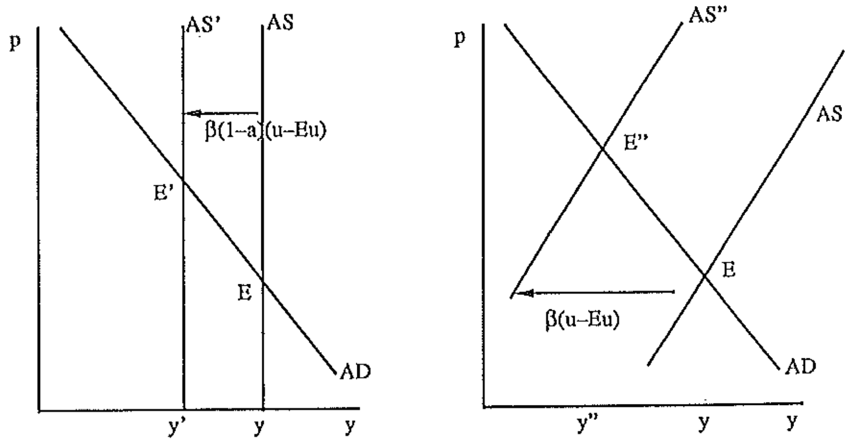
$$Ep = Em + Ev - \beta(1 - a)Eu.$$

Replacing this in (26) and solving for output gives

$$y = \left(\frac{\beta}{1 + \beta}\right)(m - Em + v - Ev + u - Eu) + \beta(1 - a)Eu. \tag{28}$$

The response of output to expected supply shocks is, not surprisingly, the same in both cases. Whether nominal rigidities increase the response of output to unexpected supply shocks is, however, ambiguous and depends on whether $1/(1 + \beta)$ exceeds $1 - a$. If labor supply is completely elastic, or equivalently if wage-setters desire a constant expected real wage that is independent of employment, then $a = 0$, and output moves less in the presence of nominal rigidities. The more inelastic is labor supply, the higher is a, and the lower will be the variability of output without nominal rigidities (i.e., the more likely are nominal rigidities to destabilize output in the presence of supply shocks).

The intuition for this result can be derived from figure 10.3. Figure 10.3a plots supply and demand, absent nominal rigidities, and shows the effects of an adverse unexpected supply shock. The shift in the vertical supply curve is equal to $\beta(1 - a)(u - Eu)$. Unless $a = 1$, an adverse supply shock leads to lower output even in the absence of nominal rigidities: y declines to y'. Figure 10.3b plots supply and demand under nominal rigidities. The supply curve, equation (26), is now upward sloping, with slope β. An adverse unexpected supply shock shifts the supply curve by $\beta(u - Eu)$, decreasing output from y to y''. Whether y' is smaller than y'' is ambiguous, since there are two effects at work. Because wages are set in advance, they can respond



(a) no nominal rigidities

(b) nominal rigidities

Figure 10.3
Effects of an adverse supply shock, with or without nominal rigidities

neither to unexpected movements in the supply shock nor to those in the price level. That they cannot respond to the supply shock is (unless $a = 1$) unambiguously destabilizing: if they could adjust, wages would decrease in response to the adverse shock, mitigating the effect of the shock on output. That they cannot respond to the price level is, however, stabilizing: an adverse supply shock increases the price level, thus automatically decreasing real wages. Whether this second effect leads to a sufficient decrease in real wages is doubtful, and it depends, as we have seen, on the parameters of the model.

We therefore do not get an unambiguous answer to the first question. But suppose that the answer was, for example, that nominal rigidities led to more fluctuations in output in response to supply shocks. Would this imply that trying to stabilize output by the use of, say, monetary policy is desirable? The answer to this second question is equally ambiguous but for a different set of reasons. If apart from the nominal rigidity the economy were otherwise undistorted, then there would be a strong case for trying to achieve the same outcome as would arise without nominal rigidities. Thus, if output responded excessively to a real disturbance—drought, an earthquake, or an oil price shock, for example—there would be a strong case for using nominal money to decrease, though not to eliminate, the effects of the disturbance on output. But the presence of other distortions complicates the answer. If, for example, considerations of efficiency wages are important in the labor market, there is no reason to give much normative significance to the no-nominal-rigidity equilibrium. Or shocks may reflect nontechnological factors, such as a push for higher wages, coming from a stronger bargaining position of insiders. The best policy in this case may well be to negate the effect of the shock on output and employment by an expansion of the money stock.[15] When these considerations are important, as we have argued that they are, the model presented above can no longer help us to assess what policy should try to achieve. A normative analysis must start much closer to microfoundations, that is, from the models reviewed in chapters 8 and 9.

Wage Indexation

A very similar set of issues arises in the context of wage indexation. Although wage indexation had been widely thought to be attractive in protecting workers' real wages from unanticipated inflation and in reducing the effects of nominal fluctuations on output, its desirability was questioned in the 1970s in the face of the large supply shocks. Analyses of the implications of wage indexation under different types of shocks were provided by Gray (1976) and Fischer (1977). The above model provides a convenient framework to use in thinking about the issues.

Suppose that wages, instead of being predetermined, can be partially or fully indexed to the price level. That is, instead of being determined by equation (25), wages are given by

$$w = \left[Ep + \left(\frac{\alpha\gamma}{\delta + \gamma} \right) Eu \right] + \lambda(p - Ep). \tag{25'}$$

The coefficient λ is the degree of indexation. There is full indexation when $\lambda = 1$, and no indexation when $\lambda = 0$. Note that in accordance with reality, indexation does not allow wages to respond to other variables than the price level; in particular, it does not allow for a direct response to unexpected supply shocks. Substituting (25′) into (21) gives us a modified aggregate demand-supply system:

$$y^d = m - p + v, \tag{20}$$

$$y^s = \beta(1 - \lambda)(p - Ep) + \beta(u - aEu). \tag{26'}$$

The effect of unanticipated movements in the price level on output is inversely related to the degree of indexation. Under full indexation output is unaffected by unexpected price level movements.

To study the effects of wage indexation, we solve for output and the price level. To simplify notation, we assume that v is identically equal to zero and that both m and u are white noise so that Em and Eu are equal to zero. Given these assumptions, we obtain

$$p = \left[\frac{1}{1 + \beta(1 - \lambda)}\right](m - \beta u), \tag{29}$$

$$y = \left[\frac{1}{1 + \beta(1 - \lambda)}\right][\beta(1 - \lambda)m + \beta u]. \tag{30}$$

Higher indexing (a higher value of λ) unambiguously increases the variance of the price level, increasing its response to both money and supply shocks. The effects of indexing on the variance of output depend on the source of shocks. By making wages respond, through the price level, to nominal disturbances, indexing decreases the real effects of money on output. But by decreasing the response of real wages to supply shocks, indexing increases the response of output to supply shocks. The mechanisms at work are the same as those described earlier.

What is therefore the optimal degree of indexing? This question gets us back into the issues discussed above. It requires us to specify what we think the optimal response of output should be to supply shocks, something we cannot answer without being much more specific about the nature of shocks and distortions in the economy.

Suppose, for example, that nominal rigidities are the only source of distortions. We may want to look at the variation in output around its value in the absence of nominal rigidities, $y^* = \beta(1 - a)u$. We briefly consider this case. Suppose that we give no weight to price fluctuations and thus try to minimize the variance of $y - y^*$. What is then the optimal degree of indexation? From (30),

$$y - y^* = \left[\frac{1}{1 + \beta(1 - \lambda)}\right]\beta(1 - \lambda)m + \beta\left\{\left[\frac{1}{1 + \beta(1 - \lambda)}\right] - (1 - a)\right\}u.$$

Minimizing the variance of $y - y^*$ gives us an optimal value for λ. Rather than writing down the solution, we consider two special cases. If the variance of supply shocks is equal to zero (if $u \equiv 0$), then $\lambda^* = 1$. In an economy in which nominal disturbances dominate, full indexing is optimal. If the variance of nominal shocks is equal to zero (if $m \equiv 0$), then $\lambda^* = 1 - [a/(1 - a)\beta] < 1$. It is optimal to let the real wage decrease in response to adverse supply shocks and thus to have less than full indexing. In the general case it is easy to show that the optimal degree of indexation is a decreasing function of the variance of supply shocks relative to that of monetary shocks. Thus, to the extent that the 1970s were a period of large supply shocks, full indexation was indeed a bad idea.

Research on indexation has considerably progressed since those early papers (e.g., see Dornbusch and Simonsen 1983). It has studied why wages are indexed only to the price level and whether indexation to other aggregates might not dominate price level indexation. It has examined the implications of actual indexing rules in which wages do not respond to current but to past inflation developments. It has studied how indexation changes the rules of the policy game and optimal monetary policy. But the basic model is still at the core of current developments.

Learning about Permanent and Transitory Shocks

It was frequently argued in 1973 that the oil price shock was transitory, likely to last about six months; in fact, it was simply not clear at the time whether the shock was permanent or transitory. Uncertainty about the permanence of the shock must have slowed real adjustment to it, for instance, the adaptation of the capital stock to the higher price of energy. We now show, using the above model, how this uncertainty may have contributed to the dynamics of price level and output adjustment. By using this otherwise static model, we isolate most clearly this particular source of dynamics. In what follows, we draw on an important article by Muth (1960) on the formation of expectations.

Suppose that the supply shock, u_t (we now reintroduce the time index), is the sum of two components, one that displays persistence and follows a random walk and another that is white noise:

$$u_t = e_{1t} + e_{2t},$$
$$e_{1t} = e_{1t-1} + \varepsilon_{1t}, \tag{31}$$

where ε_{1t} and e_{2t} are uncorrelated and both white noise, with zero mean and variances σ_1^2 and σ_2^2, respectively. The only information available to individuals is past values of u_t; even ex post they cannot observe separately the two components of u, e_1, and e_2.

The key result on which we draw is that

$$E[u_t|t] \equiv E[u_t|u_{t-j}, j = 1, 2, \ldots] = \sum_{j=1}^{\infty} \theta_j u_{t-j}, \tag{32}$$

where