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## ABSTRACT

The main issue discussed in the supply shock literature that followed the oil and food price shocks of the seventies was whether to accommodate. The supply shock reduces the equilibrium level of output, and monetary policy cannot affect that. But in the seventies supply shocks were also followed by recessions. The question is whether monetary policy can and should be used to prevent such recessions. The paper analyzes the conditions under which a supply shock will result in recession, and the potential for monetary policy to offset the fall in output. The basic result is that a pure supply shock need not result in a recession if the money stock is held constant. Aggregate demand effects associated with the supply shock--including the effects of monetary policy attempts to fight the inflation caused by the supply shock--may cause a recession, as also may real wage resistance by workers. The choice of policy response to the supply shock then turns on the same basic issues as counter-cyclical policy in general, particularly the relative costs of inflation and unemployment.

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# SUPPLY SHOCKS, WAGE STICKINESS, AND ACCOMMODATION

Stanley Fischer*

The key issue in the supply shock literature that developed after the 1973-74 oil and food price shocks was whether to accommodate.[1] There is of course nothing to be done about the reduction in the equilibrium level of output caused by the supply shock. But twice in the 1970's supply shocks resulted in output falling below its potential level.

The question discussed in the supply shock literature, and taken up here, is whether government policy is either responsible for or can offset the fall in the level of output to below its potential level. I also discuss the costs and benefits of alternative policy responses to a supply shock. It will be seen that the basic issues are precisely those that arise in considering activist policy in general.

The paper opens by discussing optimal responses to a supply shock in a one-sector model; these would be observed if markets cleared at all times. In Section II I examine the behavior of output and prices when wages are slow to adjust to the supply shock. The key factors here are whether the supply shock requires a reduction in the real wage, and whether there is real wage resistance by workers. In contrast to much of the recent literature, I concentrate on the closed economy.[2] The supply shock is domestic, and there is no recourse to

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[1] For example, Gordon (1975), Phelps (1978), Solow (1979), and for a good survey Pindyck (1980).

[2] For open economy issues, see Marion and Svensson (1983) and the references therein.

foreigners to mitigate its effects.

The main result of the paper is that supply shocks by themselves are unlikely to lead to unemployment if monetary policy remains passive and so long as there is no real wage resistance by workers. It is rather the aggregate demand effects associated with the supply shocks--including counter-inflationary policy responses--that are responsible for unemployment.

## 1. The Real Effects of a Supply Shock.

A supply shock is defined to be any disturbance that changes the level of equilibrium real output. The shock may be temporary, like the 1973-74 food price shock, or more long-lived, like the oil price shocks. In this section I analyze optimal responses to a supply shock in a one-sector real model. There is initially only one type of capital good; subsequently we allow for two types of capital good, one more energy efficient than the other.[3]

Aggregate output is produced by a constant returns to scale production function

$$(1)\quad Y = F(a(p)K,\ b(p)L)$$

where $a(p)$ and $b(p)$ are efficiency factors. Changes in $p$ are the supply shock. I drop the functional notation for $a(\ )$ and $b(\ )$ when no confusion is likely.

The representative family,[4] whose size is constant, maximizes the separable utility function:

$$(2)\quad V_0 = \int_0^\infty U(C_t)e^{-\rho t}dt$$

[3] A related model is described in Bruno and Sachs (1982).

[4] In describing the optimization, we talk interchangeably of the decisions of the family or society, since in such a model the optimizing decisions of individual agents on the unique convergent perfect foresight path in a competitive setting result in the socially optimal allocation of resources.

where

$$(3) \quad C_t = Y_t - \dot{K}_t - \delta K_t \qquad\qquad \dot{K}_t + \delta K_t > 0$$

It is assumed that capital, which depreciates at rate $\delta$, cannot be consumed.

The economy is initially in a steady state, with capital stock $K^*$ satisfying the modified golden rule condition:

$$(4) \quad aF_1\,(aK^*, bL) = \rho + \delta$$

Assume henceforth that $L \equiv 1$.

Now we consider the effects of a productivity or supply shock which changes either a or b or both. The effects of a change in a on $K^*$ are given by:

$$(5) \quad \frac{\partial K^*}{\partial a} = \frac{K^*}{a}\left[\frac{\sigma-\alpha}{\alpha}\right]$$

where $\sigma$ is the elasticity of substitution between capital and labor and $\alpha$ is the share of labor in output. Thus an increase in a will increase the steady state capital stock if $\sigma > \alpha$.

Of course, an adverse supply shock <u>reduces</u> a. Thus the steady state capital stock will <u>increase</u> in response to an adverse (capital-depleting) supply shock if the elasticity of substitution is low (specifically if $\sigma < \alpha$). Since estimates of $\sigma$ for aggregate production functions are around but not precisely 1, the direction in which $K^*$ would move following a change in a is not clear.

The effects of a change in b are unambiguous:

$$(6) \quad \frac{\partial K^*}{\partial b} = \frac{K^*}{b}$$

Thus a fall in b reduces the steady state capital stock.

It follows from (5) and (6) that equiproportionate decreases in a and b, corresponding to Hicks neutral technical change, reduce $K^*$. The reduction in $K^*$ is greater the larger the elasticity of substitution. The effects of the supply shock on $K^*$ are a result of savings behavior maintaining the steady state marginal product of capital constant.

Given the change in steady state K, we now analyze the dynamics of the response to changes in a or b, using Figure 1. In Figure 1 $K_1^*$ is the new steady state capital stock. The schedule $\dot{C} = 0$ comes from the Euler equation for this problem:

$$(7) \quad \frac{-U''}{U'} \dot{C}_t = (\rho+\delta) - aF_1(aK_t, b)$$

The schedule $\dot{K} = 0$ comes from

$$(8) \quad C_t = F(aK_t, b) - \dot{K}_t - \delta K_t$$

Also shown in Figure 1 is the schedule C = Y on which all of output is being consumed. On C = Y the capital stock is disappearing at its maximal rate.

The locus AA shows the optimal approach to the steady state if capital can be eaten, that is used up more rapidly than at rate $\delta$. If $K^*_1$ is being approached from below, or from any point to the left of B on schedule AA, then the approach is simply to follow AA.

However, if the initial capital stock is larger than $K_B$, then path AA cannot be followed. Instead society moves along the C = Y locus until point B is reached; then the locus AA is followed. In the process of moving along C = Y gross investment is zero and net investment is $-\delta K$.[5]

The effects of the supply shock on investment, consumption, the real wage, and the return to capital depend on the nature of the shock. Rather than go through the full taxonomy of possible supply shocks, I discuss in the text the responses to a Hicks-neutral supply shock, which reduces the optimal steady state capital stock while noting differences that arise for different types of shock.

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[5] Why not simply scrap any capital in excess of $K_B$? This would not be optimal because on any path starting on C = Y and going to B, thereafter proceeding down AA, consumption is higher at every movement than it is on the path where capital is scrapped.

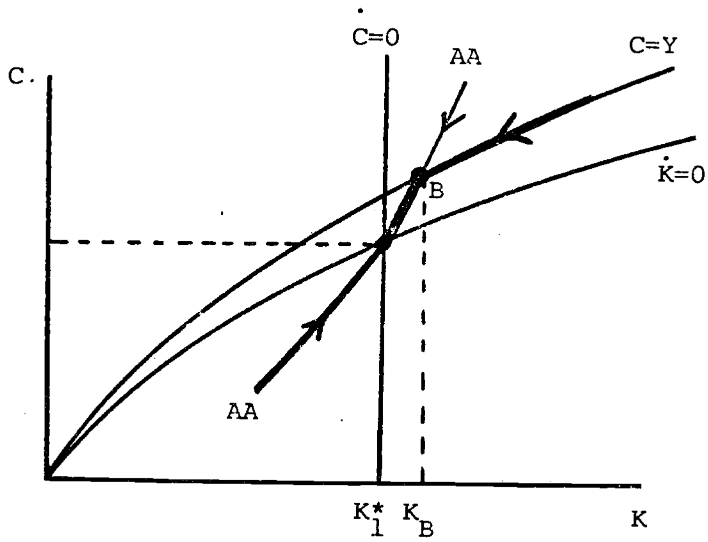


Figure 1: Optimal Response to a Supply Shock

If a and b fall in the same proportion and the steady state capital stock accordingly falls, the economy finds itself in Figure 1 at a point to the right of $K_1^*$. The capital stock is reduced in the adjustment process, with the rate of investment accordingly falling on the impact of the supply shock. If the fall in the steady state capital stock is large, the economy may operate for some time on the locus C=Y, on which there is no gross investment, and capital is being decumulated as rapidly as possible. Then gross investment is started up again, though not at a rate rapid enough to prevent the aggregate capital stock from falling gradually until $K_1^*$ is reached.

As a result of the supply shock, the real wage falls on impact, and then continues to fall as capital is decumulated moving towards $K_1^*$. The real interest rate (the marginal product of existing capital) falls as a result of the supply shock, but then rises back towards its equilibrium level as capital is decumulated.

The effects of the supply shock on consumption depend on the extent of the fall in output. If output falls by less than the previous level of depreciation, and if the economy for some time moves along the path C=Y in Figure 1, consumption may be higher immediately after the shock than it was initially. But consumption falls as capital is decumulated, and in the new steady state is below the initial level before the shock.

In this case of Hicks-neutral technical regress, which will be taken as the standard case, the supply shock reduces the steady state capital stock and consumption. Investment and the real wage decline on impact, along with the real return to capital. This pattern occurs also if the supply shock is Harrod neutral or labor depleting.

However, if the supply shock is capital-depleting (Solow-neutral) and the elasticity of substitution between capital and labor is low, a supply shock may increase the steady state capital stock. As shown by (5), this will occur if $\alpha > \sigma$ (i.e. if the share of labor exceeds the elasticity of substitution). Given that estimated elasticities of substitution are around one, this is a real possibility. Despite the higher steady stae physical capital stock, the steady state output level would be lower. Following the shock investment increases and consumption sharply decreases.

Energy-Efficient Capital:

We now introduce two types of capital, types 1 and 2, with differing productivities. Type 1 can be thought of as energy inefficient and type 2 as more energy efficient.

The production function is now:

(9) $Y = F(aK_1 + K_2, b)$

where, initially, $a > 1$.

In addition

(10) $C = Y - \delta(K_1 + K_2) - \dot{K}_1 - \dot{K}_2$

$$\dot{K}_1 \geq -\delta K_1$$

$$\dot{K}_2 \geq -\delta K_2$$

$$K_1 \geq 0, \; K_2 \geq 0.$$

Unless $a = 1$, the two types of capital will not be accumulated simultaneously. Suppose that a initially takes the value $a_0 > 1$. Then the modified golden rule condition is:

(11) $a_0 F_1(a_0 K_1^*, b) = \rho + \delta$

Assuming a drops from $a_0 > 1$ to $a_1 < 1$, in the new steady state the capital stock will be

(12) $F_1(K_2^*, b) = \rho + \delta$

Whether $K_2^* > K_1^*$ depends on the elasticity of substitution, as in (5). Thus for $\sigma > \alpha$, a decline in the productivity of type 1 capital will lead to a smaller steady state capital stock, where capital is measured in units of consumption goods.

The major difference between the two capital good and the one capital good models is that the marginal products of existing and new capital may now differ; correspondingly the tight link between the change in steady state capital stocks and short run investment behavior is broken. When a supply shock occurs, existing capital becomes less productive, and the marginal product of existing capital falls. But the marginal product of energy efficient capital may be higher than the steady state interest rate. Investment in type 2 or energy efficient capital will begin immediately. The old capital goods remain in service[6] gradually depreciating and being in the long run replaced by more productive or energy efficient capital. Steady state and short run real wages are reduced by the supply shock.

The other patterns of response discussed in the one capital good model are also possible. Supply shocks may lead to an investment slowdown or seizure in the short run, as existing capital is allowed to depreciate and the capital stock works down to a lower steady state level.[7]

## II. Wage Stickiness and Output Behavior.

No serious macroeconomic issues arise when the economy adjusts as smoothly as the neoclassical model described above. We begin macroeconomic analysis in

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[6] I do not assume fixed proportions so the capital is not scrapped as it would be in a vintage model.

[7] The adjustment process to the supply shock in this neoclassical economy could also require some unemployment. For instance, if the economy were modelled as having two sectors, with the shock implying a shift of labor from one sector to the other, there might well be unemployment as labor is reallocated.

this section, locating the source of slow adjustment in wages. I assume the wage is sticky, being predetermined within each period. The demand for labor determines aggregate supply within the period; to minimize complexity aggregate demand is described by the quantity equation. Output and the price level are determined by aggregate supply and demand, and the adjustment of wages is responsible for the dynamics of the response of the system to the shock.

Firms hire as much labor as they want at the going nominal wage and supply output, based on the constant-returns neoclassical production function

(13) $Y = F(aK, bL)$

Taking the capital imput as fixed, the labor demand curve obtained from profit maximization is

$$L^d = \phi(z,a,b)$$

where z is the real wage and $\phi_z = \frac{1}{b^2F_{22}}$, $\phi_a = \frac{L}{a}$ and $\phi_b = -\frac{L}{b} - \frac{F_2}{b^2F_{22}}$

Substituting the labor demand curve back into the production function we obtain

$$(14)\quad \frac{dY}{Y} = \frac{da}{a} + \frac{\alpha\sigma}{1-\alpha}\frac{db}{b} - \frac{\alpha\sigma}{1-\alpha}\frac{dz}{z}$$

where again $\alpha$ is the share of labor and $\sigma$ the elasticity of substitution. In the text we assume the shock is Hicks-neutral, with $da/a = db/b = de/e$ and the Hicks-neutral supply shock denoted e.[8]

Thus

$$(14)'\quad \frac{dY}{Y} = \left(1 + \frac{\alpha\sigma}{1-\alpha}\right)\frac{de}{e} - \frac{\alpha\sigma}{1-\alpha}\frac{dz}{z}$$

We need also to relate unemployment to the level of output. Let $\bar{L}$ be the full employment level of output. Then the unemployment rate is:

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[8] For a Harrod-neutral shock, $da/a = 0$; for a Solow-neutral shock $db/b = 0$.

(15) $u_t = \frac{\bar{L}-L_t}{\bar{L}} = 1 - \frac{L_t}{\bar{L}}$

From the production function we obtain:

(16) $\frac{dL}{L} = \frac{1}{\alpha}\frac{dY}{Y} - \frac{1}{\alpha}\frac{de}{e}$

Approximating (15) around the point of zero unemployment, we write:

(17) $u_t = -c_1 y_t + c_2 e_t$

with $c_1 = c_2 = 1/\alpha$, and where y is the logarithm of output and $e_t$ is the deviation of e from its initial value.[9]

Aggregate Supply, Demand, and Short-Run Price and Output Determination: We can now specify the aggregate supply and demand equations. The aggregate supply equation, based on (14)', is

(18) $y_t = b_1 e_t + b_2(p_t - w_t)$

where $p_t$ and $w_t$ are the logarithms of the price level and nominal wage respectively, and (18) is a linearization of the supply function (14)', with[10]

Aggregate demand is described by the quality theory:

(19) $p_t = m_t - y_t + v_t$

Here $v_t$ is a demand shock, included to make it possible to examine the simultaneous impact of supply and demand shocks.

Within any period, the nominal wage is predetermined. Thus the price level and output are determined by (18) and (19), shown in Figure 2, by the AS and AD curves. The initial equilibrium is at point E.

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[9] If the shock were either Harrod or Solow neutral, we would have $c_1 > c_2$ in (17).

[10] With Harrod neutral technical progress, $b_1 = b_2 = \frac{\alpha\sigma}{1-\alpha}$ ; with Solow neutral technical progress, $b_1 = 1$, $b_2 = \frac{\alpha\sigma}{1-\alpha}$.

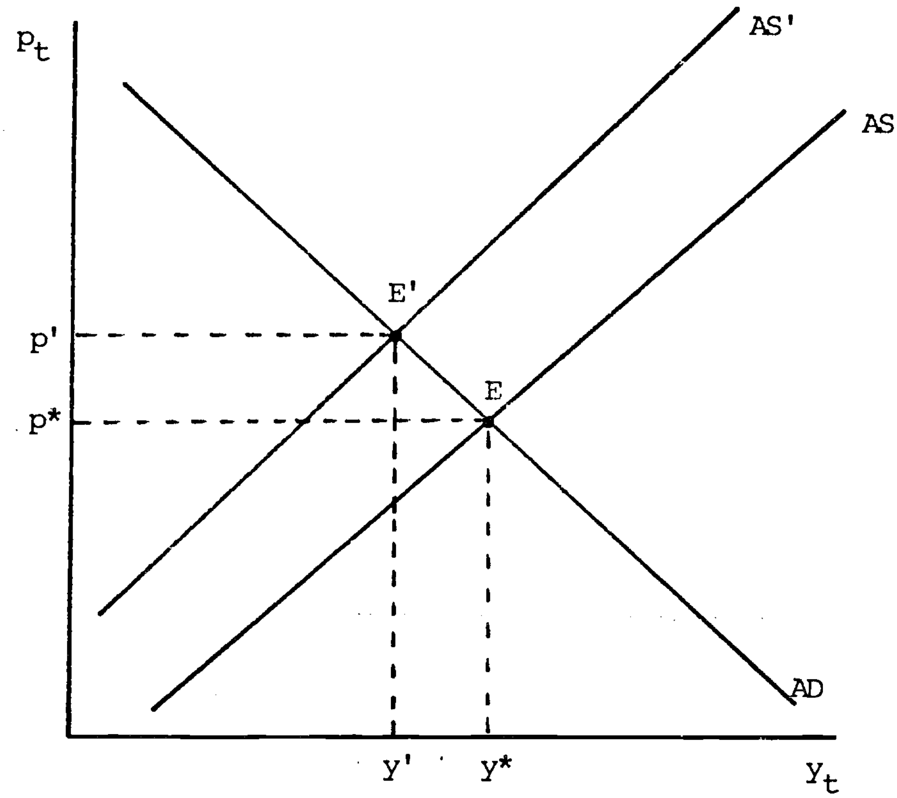


Figure 2: Short Run Price and Output Determination.

Now suppose there is an adverse supply shock, meaning that $e_t$ in equation (18) falls. If this shock is unanticipated, and therefore has not affected the wage rate, the aggregate supply curve shifts up to AS', leaving the aggregate demand curve unaffected. The price level rises and the level of output falls, as we should expect.

The change in the unemployment rate in the current period is determined by the nature of the shock. Using (17), we find in the Hicks neutral case:[11]

$$(20)\quad \frac{du_t}{de_t} = - c_1 \frac{dy_t}{de_t} + c_2$$

$$= - \frac{c_1 b_1}{1+b_2} + c_2$$

$$= 0$$

The intuition of the result in (20) is straightforward. The supply shock requires the real wage to fall in the same proportion as real GNP when the shock is Hicks neutral. With the nominal wage constant, and nominal aggregate demand constant through the quantity theory, both real output and the real wage fall in the same proportion.

<u>Unemployment and the Supply Shock</u>: In this simplest case of a Hicks neutral supply shock there is no change in employment in the short run, even with nominal wage stickiness. There are however several mechanisms that could generate unemployment following a supply shock.

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[11] If the shock is Harrod neutral, the unemployment rate will rise if the elasticity of subsitution exceeds one and fall if the elasticity is less than one. The intuition is as follows. If the elasticity of substitution is one, the share of labor is constant. The real wage should fall by exactly the same proportion as output. Because of the form of the quantity equation, this is precisely what happens. If the elasticity of substitution exceeds one, the share of labor should fall. But since the nominal wage is fixed and prices fall in the same proportion as output, the share of labor can fall only if less labor is employed. There is thus unemployment. In the Solow neutral case, unemployment rises if the elasticity of substitution is less than one.

First, unemployment will occur if an adverse demand shock accompanies the supply shock. Such a shock may occur because of the redistribution of wealth associated with the shock, for instance to OPEC or farmers.[12] Alternatively, the demand shock may result from policy attempts to fight the rise in the price level caused by the supply shock. Such shifts move the AD curve in Figure 2 down to the left, reducing output to below its full employment level.

The use of the simplest quantity theory to model aggregate demand ignores other demand effects that may be associated with the supply shock. For instance, the optimizing analysis of Section I showed that the rate of investment would typically fall following a supply shock. The propensity to consume should rise at the same time. Given the uncertainty generated by a supply shock, it is not clear that consumers would want to raise the propensity to consume. In such a case there would be a reduction in nominal aggregate demand given the real interest rate.

Unemployment may also occur if the supply shock has differential sectoral effects. For instance, as noted above, labor may have to be reallocated from energy intensive to other sectors, and the reallocation could be accompanied kby unemployment.

These effects may modify the basic result of equation (20), which is that if monetary policy is passive, an adverse supply shock need not, on impact, generate unemployment.

Dynamics and the Phillips Curve:

In the next period the nominal wage may be higher, as workers try to recoup for the losses due to the unanticipated inflation caused by the adverse shock.

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[12] This is one of the assumptions by which Gordon (1975) obtains an increase in unemployment following a supply shock.

This by itself tends to cause unemployment. At this point we need to develop more fully the dynamic analysis based on a Phillips curve.

Assume that nominal wages are set one period in advance. The logarithm of the wage is:

$$(21) \quad w_t = w_{t-1} - h_{t-1}u_t + a_1[_{t-1}p_t - p_{t-1}] + a_2[p_{t-1} - {}_{t-2}p_{t-1}]$$

All coefficients are positive. The nominal wage is set equal to last period's wage, $w_{t-1}$, with several adjustments. First, expectations of unemployment reduce the nominal wage, where $_{t-1}u_t$ is the unemployment rate expected at time (t-1) to prevail at t. (A similar notation is used throughout.) Second, to the extent that inflation is expected, the nominal wage is increased, as reflected in the term $[_{t-1}p_t - p_{t-1}]$. If labor is bargaining for a real wage, $a_1$ will be equal to 1. The final term in (21) is a catch-up for real wages: if the price level was higher than expected in period (t-1), the nominal wage for period t is increased to compensate.

The dynamics of response to the supply shock would be more extended and realistic if overlappiing labor contracts were modelled. But the current formulation (21) contains the necessary essentials: short run fixity of the nominal wage combined with slightly longer run responses to unemployment, to expected inflation, and to past unanticipated inflation.

The complete model now consists of the aggregate supply equation (18), the aggregate demand equation (19), and the Phillips curve (21)' in which (17) has been used to substitute out for the expectation of the unemployment rate:

$$(21)' \quad w_t = w_{t-1} + a_1[_{t-1}p_t - p_{t-1}] + a_2[p_{t-1} - {}_{t-2}p_{t-1}] + a_3\,{}_{t-1}y_t - a_4\,{}_{t-1}e_t$$

where $a_3 = -hc_1$, $a_4 = hc_2$.

Solving for $y_t$ we obtain

$$(22) \quad y_t[1 + \frac{1}{b_2} - L(1 + \frac{1}{b_2} - a_1 + a_2) - LE(a_1 - a_3) + a_2L^2E]$$

$$= e_t\left[\frac{b_1(1-L)}{b_2} + a_4 LE\right] + (m_t+v_t)[1-L(1-a_1+a_2) - a_1 LE + a_2 L^2 E]$$

where L is the lag operator ($Ly_t \equiv y_{t-1}$), and E is an expectations operator such that $LEy_t \equiv {}_{t-1}y_t$, $L^2Ey_t \equiv {}_{t-2}y_{t-1}$, etc.

We use (22) to study the effects of an unanticipated permanent supply shock, of magnitude -1, taking place in period 1. Initially $e_t$ was at level 0 (here we think of e as a logarithm), for t < 1. Then $y_t$ would also be zero for t < 1, assuming $m_t$ and $v_t$ were zero. Now $e_t$ falls to -1. Calculations give:

$$(23) \quad y_1 = -\frac{b_1}{1+b_2} = -1$$

$$y_2 = -\frac{\frac{b_1}{1+b_2}[1+b_2+b_2(a_2-a_1)] + b_2 a_4}{1+b_2+b_2(a_3-a_1)} = 1 - \frac{b_2 a_2}{1+b_2(1+a_3-a_1)}$$

$$y_t - y^* = \lambda(y_{t-1} - y^*) \qquad \text{for } t = 3,4,\ldots$$

where $y^* = -\frac{a_4}{a_3} = -1$

$$\lambda = 1 - \frac{b_2 a_3}{1+b_2[1+a_3-a_1]}$$

The expressions following the second equality sign in the first two lines of (23) give the value of output for that period when the supply shock is Harrod neutral. In this case output falls immediately by one unit (as we saw above), which is also the steady state fall in output. The key question then is how the shock affects $y_2$. In particular, if $y_2 < -1$, the shock will cause unemployment followed by an asymptotic return to full employment and potential output. For $b_1 = 1+b_2$

$$(24) \quad y_2 < -1 \iff b_2 a_2 > 0$$

Thus if there is any attempt by workers to catch-up for lost real wages, unemployment will result. However, if $a_2 = 0$, the system moves immediately to its new steady state level of output, without unemployment, when the supply shock hits. Attempts to compensate for <u>future</u> inflation, through the term in (21) involving $a_1$, do not affect the smooth adjustment to a supply shock in the of real wage resistance.

If there is real wage resistance, then real output rises back to its new steady state level at a rate determined by $\lambda$ in (23). The system returns to its steady state more rapidly ($\lambda$ is smaller) the larger are $b_2$, $a_1$, and $a_3$. Large $a_3$ represents a powerful effect of unemployment on wages, and large $b_2$ represents a powerful effect of real wages on output. The reason a large $a_1$ increases the speed of return to equilibrium is that there is deflation from periods 2 on as the economy returns to equilibrium - thus a large $a_1$ ensures the rate of wage increase drops along with the inflation.

Examining price level behavior in more detail, the impact of the supply shock is to raise the price level in the current period. If there is no real wage resistance, there is no further adjustment. If there is real wage resistance, the price level will rise again in the next period. Then the price level gradually falls back to its steady state level - above the level before the shock - as unemployment pushes down the wage.

<u>Demand Shocks</u>: The supply shock may be accompanied by either a monetary policy response--accommodating to try to prevent unemployment, or contractionary to fight the higher price level--or a demand shock. We accordingly examine the dynamics of the response of output and prices to a permanent money or demand shock. Suppose m rises unexpectedly and permanently by one unit in period 1. Then

$$(25)\quad y_1 = \frac{b_2}{1+b_2}\, p_1 = \frac{1}{1+b_2}$$

$$y_2 = \frac{\left[\frac{b_2}{1+b_2}\right]\left[1+b_2(1-a_1+a_2)\right] - b_2a_1}{1+b_2(1-a_1+a_3)} \qquad p_2 = 1 - y_2$$

$$y_t = \lambda y_{t-1} \qquad t = 3,\ldots, \qquad p_t = 1 - y_t$$

In the first period, the demand shock increases output and the price level. In the next period, $y_2$ may be positive or negative.

$$(26)\quad y_2 > 0 \iff (1-a_1) + b_2(1-2a_1+a_2) > 0$$

If both $a_1$ and $a_2$ are equal to 1, the economy will return to equilibrium immediately following the demand shock.

If either $a_1$ or $a_2$ are less than 1, the output response to the demand shock will be prolonged, with output remaining above the steady state level and slowly returning to it. The price level rises in the adjustment process. Conversely, if there is a negative permanent demand shock, output will fall below the full employment level for some time if either $a_1$ or $a_2$ are less than 1.

Summary: The analysis of monetary and demand shocks provides the second component of the response of the economy to a supply shock. If the economy is affected by an adverse demand shock (negative v) along with the supply shock, output will certainly fall and unemployment rise (for a Hicks neutral shock) when the shock hits.

Further, the unemployment is sure to be prolonged. Note from (26) that for an adverse demand shock not to have prolonged effects, $a_2$ has to be equal to 1. But from (23), if $a_2 = 1$, the supply shock has prolonged effects.[13]

[13] This result depends on the assumption that the nominal wage response to a fall in the real wage is the same whether the real wage drop is caused by a supply or a demand shock.

Thus an adverse demand shock--policy induced in an attempt to fight inflation or as a direct result of the supply shock--will ensure a recession, and a prolonged one, if it accompanies a supply shock. But it does mitigate the inflation.

## III. Policy Issues.

There is scope in this model for monetary policy to respond to the supply shock. We consider three circumstances in which active monetary policy might be used:

1. Monetary policy might be used concurrently with the supply shock, either to attempt through expansion of the money supply to reduce the fall in output, or through a reduction in the money supply to fight the aggregate price level increase caused by the supply shock.

2. If the supply shock sets off subsequent unemployment through real wage resistance, there might be an attempt to inflate out of the recession.

3. If the supply shock is accompanied by an adverse demand shock, expansionary monetary policy might be used in an attempt to prevent recession.

It is the third circumstance that should be thought of as accommodating monetary policy.

We discuss policy in two stages. First we ignore the effects of policy actions on expectations of future policy. Then we discuss desirable patterns of behavior for monetary policy makers when their actions in any one episode affect expectations about their future responses.

1. Dealing with the Impact of the Supply Shock. When the supply shock occurs, the equilibrium level of real output falls. Expansionary monetary policy can slow the decline in output. But there seems little purpose in such a policy action, since by hypothesis there would not be unemployment in the new

equilibrium, and the expansionary monetary policy raises the price level. Indeed, there are arguments that the money stock should be reduced rather than raised on the impact of the supply shock. This would be the case if there are costs to changing prices (Rotemberg (1982)), or if the distributional effects of the price rise caused by the supply shock are adverse. Whatever these costs may be, any attempt to fight the inflation through restrictive monetary policy will result in a recession--thus the issues in choosing the appropriate policy action here are precisely those that arise in considering anti-inflationary policy in general.

2. Real Wage Resistance. Assuming the supply shock is pure (aggregate demand is unaffected) then a passive monetary policy will result in no prolonged recession unless there is real wage resistance by workers. If there is real wage resistance, but there is money illusion in the Phillips curve in that $a_1$ and/or a $a_2$ is less than one, then as (24) shows, expansive monetary policy can be used to offset the decline in output caused by the real wage resistance. If both $a_1$ and $a_2$ are equal to one, there is nothing but unemployment that will reduce the real wage. In either case, expansionary monetary policy will reduce unemployment only by producing a higher price level. Once again the decision whether to use active monetary policy turns on the relative costs of inflation and unemployment.

3. Offsetting Aggregate Demand Shocks. Finally, suppose that the supply shock is accompanied by aggregate demand disturbances that tend to produce unemployment. Note that such disturbances would themselves tend to mitigate the inflation caused by the supply shock. Here too the basic issue is the same: expansive aggregate demand policy will reduce unemployment but produce more inflation than there would otherwise have been. Whether such policy is justified depends on the relative costs of inflation and unemployment.

Supply Side Policies. In each circumstance in which the use of expansionary aggregate demand policy to offset the recessionary impact of a supply shock is considered above, the decision turns on a weighting of the cost of increased inflation against the benefit of lower unemployment. Supply side policies, of which a reduction in the payroll tax is the standard example, promise to reduce both inflation and unemployment. In Figure 2, such policies shift the aggregate supply curve down and to the right.

Supply side policies thus seem the perfect answer to supply shocks, since they offset the two macro problems--inflation and unemployment--caused by the supply shock. However, it is always desirable to have less inflation and less unemployment, so we need also to consider what determines the base level of supply side policy instruments. If these instruments--for instance the payroll tax--are set optimally, then the marginal benefit of raising the payroll tax is equal to the marginal cost of raising it. Accordingly, it is unlikely that supply side policies can be deployed in strength and by themselves to offset the effects of a supply shock. It will probably be necessary to use demand side policies as well.

## IV. Basic Policy Issues.

In the cases discussed above, it was assumed that the government's actions had no impact on expectations of future policy actions. This convenient assumption is untenable. When the Fed responds to a particular shock, it sets a precedent that is likely to affect the way it is believed it will behave in future episodes.

Even if accommodation of one supply shock may look desirable, there is an argument against accommodation on the grounds that accommodation to inflationary shocks can become a habit. If so, the Fed loses control over the price level.

This in turn is likely to change the nature of private sector contracts, for instance leading to more indexation which in itself will make future adaptation to supply shocks more difficult.

The question here is what sort of price and wage behavior the Fed should try to induce. At one extreme, by running an erratic policy, the Fed could induce the private sector to insulate itself from monetary shocks and monetary policy. Prices and wages would, in the long run, become flexible. But there do appear to be advantages - difficult to state convincingly - to having stability of nominal values. Thus it might be optimal for the Fed to have the goal of keeping the price level stable, following the monetary rule proposed by Henry Simons. With price level stability, real wage adjustment has to take place through nominal wage changes.

Keynes's alternative (1936, pp. 270-271) was nominal wage stability, proposed as a policy rather than a description of behavior. He argued that monetary policy should aim to keep the nominal wage rising gently, with necessary changes in real wages being brought about by changes in the price level. Successful stabilization of the average nominal wage is presumably self-reinforcing, leading to sticky wage behavior as the norm.

There is as yet no complete analysis of the appropriate choice of a monetary standard. Choosing labor as the standard of value fits the traditional prescription that the commodity in question be widely traded. But then so does choosing goods in general as the standard of value. The typically long term nature of labor contracts and job attachments suggests a preference for nominal wage predictability. The analysis of this choice will turn also on the relative ease of co-ordinating private sector responses to shocks with attractive monetary standards.[14]

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[14] Some of the issues are discussed in Fischer (1980).

Nothing said so far in this section relates particularly to supply shocks. There is one special issue raised by the supply shocks of the last decade. That is the question of the optimal response to what appears to be a new type of phenomenon. When neither the private nor the public sector knows the nature and consequences of a shock, responses of both are bound to be tentative. But the government in general, and the Fed in particular, with its command over research resources and information, is the natural leader in analyzing and carrying out a response. Of course, the basis for its actions should be explained. But it should take those actions that lead the private sector, with its conventional reactions to shocks, towards equilibrium.

## References

Bruno, Michael. "Raw materials, Profits, and the Productivity Slowdown," National Bureau of Economic Research Working Paper No. 660R, 1981.

———— and Jeffrey Sachs. "Input Price Shocks and the Slowdown in Economic Growth: The Case of UK Manufacturing," Review of Economic Studies, 1982, 5, (Special Issue), 679-706.

Fischer, Stanley. "On Activist Monetary Policy with Rational Expectations," in S. Fischer, ed., Rational Expectations and Economic Policy, Chicago: University of Chicago Press, 1980, Ch. 7.

Gordon, Robert J. "Alternative Responses of Policy to External Supply Shocks," Brookings Papers on Economic Activity, 1975, 1, 183-206.

Keynes, J.M. The General Theory of Employment, Interest and Money, London: Macmillan, 1936.

Marion, Nancy P. and Svensson, Lars E.O. "Structural Differences and Macroeconomic Adjustment to Oil Price Changes: A Three-Country Model Approach," March 1983, (mimeo).

Phelps, Edmund S. "Commodity-Supply Shock and Full-Employment Monetary Policy," Journal of Money, Credit, and Banking, May 1978, 10, 206-221.

Pindyck, Robert S. "Energy Price Increases and Macroeconomic Policy," The Energy Journal, October 1980, 1, 1-20.

Rotemberg, Julio J. "Supply Shocks, Sticky Prices and Monetary Policy," M.I.T., Energy Laboratory Working Paper, January 1982.

Sachs, Jeffrey. "Wages, Profits, and Macroeconomic Adjustment in the 1970's: A Comparative Study," Brookings Papers on Economic Activity, 1979, 2, 269-319.

Solow, Robert M. "What to Do (Macroeconomically) When OPEC Comes," in S. Fischer, ed., Rational Expectations and Economic Policy, Chicago: University of Chicago Press, 1980, Ch. 8.