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SUPPLY SHOCKS AND MONETARY POLICY REVISITED

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ABSTRACT

This paper reviews the main issues that supply shocks pose for the conduct of monetary policy. A simple version of the Gordon-Phelps model shows that the necessary condition for actual real GNP to be maintained at its equilibrium level in the wake of a supply shock is for the change in nominal GNP to exceed the change in the nominal wage by the change in the income share of the raw material in GNP. The required "wedge" between nominal GNP and wage growth can be accomplished by any combination of monetary accommodation and nominal wage flexibility. Without this combination a "macroeconomic externality" occurs, with real GNP falling below its equilibrium level.

The obstacles to monetary accommodation are examined in terms of a taxonomic wage adjustment equation that allows for differing responses to current inflation, lagged inflation, and lagged wage change. Monetary accommodation is infeasible when there is full indexation to current inflation and creates a permanent acceleration of inflation following a one-time permanent shock when there is indexation to lagged inflation. With "forward-looking" expectation formation in the sense of Taylor, a supply shock is likely to cause changes in parameters of the wage adjustment equation as workers attempt to avoid the macroeconomic externality.

The final section of the paper discusses doctrinal debates that originated in part from the empirical failures of earlier Phillips curves that neglected supply shocks.

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A macroeconomic supply "disturbance" or "shock" is any event which creates an autonomous shift in the aggregate supply curve relating the economywide price level to the level of output or utilization. The autonomous nature of such shifts distinguishes them from other movements in the supply curve that represent the consequences of a current or prior changes in aggregate demand. The distinction between supply and demand shocks is valid only with reference to their origin, whereas the consequences of supply shocks for output and inflation depend fundamentally on the aggregate demand policies that are pursued in their wake.

Autonomous supply disturbances can originate from natural causes, including a drought that parches the corn or soybean crop, a freeze that withers the oranges in Florida, or a straying ocean current that nudges the Peruvian anchovies away from their familiar feeding grounds. Unnatural sources of supply shocks include the formation of a cartel that constricts the supply of a raw material like oil, and price controls that temporarily squeeze normal profit margins. Persistent changes in the foreign exchange rate have similar effects to those of supply shocks. While supply shocks occurred in earlier eras, e.g., the Napoleonic wars (Joel Mokyr and Gene Savin), their profound effect on economic analysis and performance occurred only within the last decade.

This paper is written almost a decade after the first attempts in 1974 to develop a theory of policy response to supply shocks.[1] It provides a simple algebraic framework that facilitates a summary of the central issues posed by supply shocks for macroeconomic policy. Primary emphasis is placed on the case for and against monetary accommodation, on the nature and extent of wage indexation, and on the distinction between permanent and transitory shocks. A tight space constraint precludes more than passing mention of cost-oriented

fiscal policy, oil tariffs, buffer stocks and other policies that mainly influence the magnitude of the shocks themselves rather than their consequences for macroeconomic performance. Given the difficult tradeoffs faced by monetary policymakers considering the merits of accommodation, these supply-side alternatives may actually represent the best available policy options. The first line of defense against a real disturbance is a real policy.

I. A Simplified Hybrid Model

The original case for the monetary accommodation of an adverse supply shock, as developed by my 1975(a) paper and by Edmund Phelps, rests on a "macroeconomic externality," that is, a spillover from the unavoidable loss of output in the shocked sector of the economy to a loss of output in the unshocked sector that may be avoidable by monetary accommodation. The case for accommodation is strongest in a model with rigid or sluggishly adjusting nominal wages in the unshocked sector, is weaker in the presence of partial wage indexation, and is nonexistent in the presence of complete wage indexation or instantaneous market clearing achieved by perfectly flexible wages. Both my paper and that of Phelps developed explicit algebraic conditions required for the macroeconomic externality to occur. These conditions look quite different in the two papers, because I was dealing with a two-sector model and assumed exogenous nominal GNP, while Phelps developed a one-sector model but allowed the velocity of money to respond endogenously to the external shock. Here I set out a hybrid model, sharing Phelps' one-sector production technology with my exogenous nominal GNP assumption, that allows the analysis of macroeconomic externalities and monetary accommodation to be presented in a more transparent fashion than in the two original papers.

Consider an economy that produces output (Q) using only labor (N) and a raw material (σ):

$$Q = F(N,\sigma), \qquad F_N>0, \; F_\sigma>0. \tag{1}$$

The supply of labor in the economy is fixed at N^*, and so "natural" (or "full employment" or "potential") output is:

$$Q^* = F(N^*,\sigma). \tag{2}$$

Note that no capital is used in production. Capital appears in Phelps' model, but its only role there is to introduce a set of complex and ambiguous impacts of supply shocks on the real rate of interest and on velocity. Here these second-order effects are neglected through the assumption that nominal GNP (Y) is exogenous. The economy's demand price (P^d) is then simply nominal GNP divided by actual real GNP:

$$P^d = YQ^{-1} = Y[F(N,\sigma)]^{-1}. \tag{3}$$

Assuming that the product market always clears and labor is paid its marginal product, the economy's supply price (P^s) is equal to the nominal wage rate divided by the marginal product of labor:

$$P^s = W[F_N(N,\sigma)]^{-1}. \tag{4}$$

The conditions for a macroeconomic externality can now be examined by subjecting this economy to a single comparative static experiment, a change in the raw material input, σ, caused by some unexplained event. A macroeconomic externality is defined as occurring when, starting in equilibrium with $Q = Q^*$, the percentage change in Q needed to keep $P^d = P^s$ is not equal to the change in Q^*. Here we shall use the "dot" notation for percentage changes ($\dot{Q}=dQ/Q$), and so the difference between the rate of actual and natural output change is, from (3):

$$\dot{Q} - \dot{Q}^* = \dot{Y} - \dot{P}^d - \dot{Q}^*. \tag{5}$$

The condition necessary for this to be zero can be worked out by setting

$\dot{P}^d = \dot{P}^s$, and by noting that if the change in actual GNP is equal to that in natural real GNP, then both output change terms can be evaluated by assuming that labor input remains at N^*, i.e., that $\dot{N} = 0$. We have from (2) and (4):

$$\dot{Q} - \dot{Q}^* = \dot{Y} - \dot{P}^s - \dot{Q}^* = \dot{Y} - \dot{W} + \frac{F_{N\sigma}}{F_N}d\sigma - \frac{F_\sigma}{F}d\sigma. \qquad (6)$$

Thus the condition for real GNP to remain at equilibrium can be written,

$$\dot{Y} - \dot{W} = -(\frac{F_{N\sigma}}{F_N} - \frac{F_\sigma}{F})d\sigma, \qquad (7)$$

i.e., that the <u>difference</u> between the percentage change in nominal GNP and that in the nominal wage rate remain equal to the right-hand side of (7).

And what is this unfamiliar-looking term? We can write the income share of the raw material (α) as unity minus the share of labor.

$$\alpha = 1 - \frac{F_N N}{F}, \text{ so that } \dot{\alpha} = -(\dot{F}_N + \dot{N} - \dot{F}).$$

Because at Q^* there is no change in labor input ($\dot{N} = 0$), the change in the raw material share is just:

$$\dot{\alpha} = -(\dot{F}_N - \dot{F}) = -(\frac{F_{N\sigma}}{F_N} - \frac{F_\sigma}{F})d\sigma. \qquad (8)$$

Thus substituting (8) into (7), we have the condition:

$$\dot{Y} - \dot{W} = \dot{\alpha}. \qquad (9)$$

While it is completely consistent with the analysis in the original Gordon and Phelps papers, the appeal of (9) is that it is both simpler and more general.[2] There is no need to assume that nominal GNP or the nominal wage rate is fixed. Condition (9) applies to either a market-clearing or non-clearing economy. In a market-clearing economy the perfectly flexible wage can adjust downward by any amount needed to open up the required "wedge" between dY/Y and dW/W when the raw material share increases, and there is no necessity for monetary accommodation. However, a rigid or sticky nominal wage

rate and an increase in the raw material share together imply that full employment can be maintained only if policymakers generate a sufficient increase in nominal GNP.

The role of a changing raw material share in creating the basis of the case for nominal GNP accommodation applies equally when the raw material is used as a productive input, as in the Phelps model, or purely for consumption, as in my 1975(a) model. Other authors, e.g., Leonardo Leiderman, have attempted to analyze this topic within the straightjacket of a Cobb-Douglas production function, but by assuming away any change of income shares, this approach misses the heart of the problem, the macroeconomic externality. In the case of energy, the most important example of a supply shock in the last decade, the value share of energy in GNP increased sharply after both the 1973-74 and 1979-80 oil price shocks, in contrast to its decline in previous decade:[3]

	1960	1972	1976	1978	1981
Energy Value Share Index (1972=100)	117	100	186	192	323

Energy is used both in production and for direct consumption, and its rising income share after 1972 reflects the relatively low elasticity of substitution between energy and other factors on the production side, as well as a relatively low short-run price elasticity of demand on the consumption side.

II. Accommodation and Indexation

The theory of monetary policy responses to supply shocks is clear-cut in unrealistic extreme cases and ambiguous in more realistic intermediate cases. Here we ignore effects of supply shocks on the velocity of money, allowing us to link central bank control of the money supply with control over the growth rate of nominal GNP ($\dot{Y}_t$). Effects of indexation are examined in a mechanical

adjustment equation which allows changes in wage rates to depend only on current and past price changes, on past wage changes, and on the output ratio (Q_t/Q_t^*):

$$\dot{W}_t = \beta\dot{P}_t + \gamma\dot{P}_{t-1} + (1-\beta-\gamma)\dot{W}_{t-1} + \phi(\dot{Q}_t/Q_t^*). \qquad (10)$$

This equation is not intended to represent the outcome of maximizing behavior, but rather to allow examination of a taxonomy of consequences of an accommodating monetary policy that maintains full employment, i.e., $Q_t = Q_t^*$. In each of the following cases, we normalize on an assumed situation in the period prior to the shock in which $\dot{W}_0 = \dot{Y}_0 = \dot{Q}_0^* = 0$, and we assume that the supply shock has a permanent impact on the level of the raw material share only in period "1" $(\alpha_0 < \alpha_1 = \alpha_2 = \ldots. = \alpha_n)$. Thus the only nonzero value of $\dot{\alpha}_t$ is $\dot{\alpha}_1 > 0$. We note also that for full employment to be maintained, $\dot{P}_t = \dot{Y}_t - \dot{Q}_t^*$. Substituting (10) into (9), we have:

$$\dot{Y}_t = \frac{1}{1-\beta}\left[\dot{\alpha}_t - \beta\dot{Q}_t^* + \gamma(\dot{Y}_{t-1}-\dot{Q}_{t-1}^*) + (1-\gamma-\beta)\dot{W}_{t-1} + \phi(Q_t/Q_t^*)\right]. \qquad (11)$$

When wage changes depend only on their own past values and on the output ratio ($\beta = \gamma = 0$), full monetary accommodation is clearly optimal. During period "1" $\dot{W}_1 = 0$, so that an accommodative policy would set $\dot{Y}_1$ to equal $\dot{\alpha}_1$. The opposite extreme occurs with complete indexation of wage changes to current changes in the price level, $\beta = 1$ while $\gamma = 0$. Now the right-hand side of (11) becomes infinite, implying that there is no change in nominal GNP that will maintain full employment. Full indexation in the presence of supply shocks is clearly suboptimal, as pointed out by Joanna Gray and by Stanley Fischer (1977).

Another possible case is that wage changes are indexed fully to lagged price change ($\beta = 0$ while $\gamma = 1$). In this case (11) reduces to the following, when we note that from (2) that $\dot{Q}_t^* = \dot{F}_t$:

$$\dot{Y}_t = \dot{Y}_{t-1} + \dot{\alpha}_t - \dot{F}_{t-1}.$$

In the example of a one-period supply shock, in the first period, $\dot{W}_1 = 0$, and this requires the same accommodative policy as if $\gamma = 0$, i.e., $\dot{Y}_1 = \dot{\alpha}_1$. In the second period, however, lagged indexation prevents nominal wage and GNP growth from returning to zero. Instead, from (8)

$$\dot{Y}_2 = \dot{W}_2 = \dot{Y}_1 - \dot{F}_1 = \dot{\alpha}_1 - \dot{F}_1 = -\dot{F}_{N_1}.$$

In all future periods,

$$\dot{Y}_t = \dot{W}_t = \dot{P}_{t-1} = -\dot{F}_{N_1},$$

i.e., maintenance of full employment requires a permanent acceleration of inflation and in the growth of nominal wages and GNP following any supply shock that permanently shifts the raw material share. In this plausible case of lagged indexation, supply shocks pose a tradeoff between a permanent acceleration of inflation and a temporary loss of output. The severity and duration of the output loss depend on the Phillips curve parameter ϕ or, more generally, on the economy's "sacrifice ratio" (Gordon and Stephen King). For the U. S. case I showed (1982, p. 134) that an accommodative policy that cumulatively raised the money supply by 9 percent in 1975-80 compared to an alternative hypothetical constant-growth money path would have resulted in 1.9 percentage points more inflation in 1980 with the benefit of 3.2 fewer point-years of unemployment during 1975-80 (an output gain of 8 percent of a year's GNP).

In the realistic case of a permanent shock and partial and/or lagged wage indexation, the optimal degree of accommodation depends on a finely balanced comparison of the welfare costs of inflation and unemployment. The optimal outcome is different in a society like the U. S. in 1973-75, where inflation had high costs due to non-neutral tax rules and binding financial rate

ceilings, than in a society like Israel or Brazil, in which real interest rates and tax rates were much more neutral with respect to inflation. In a sense there is a cumulative interaction, as I suggested earlier (1975b), between monetary accommodation, behavior regarding contract lengths and the Phillips curve parameter (ϕ above), and institutional rules regarding tax rates and financial regulations. Inflation begets a neutralized institutional environment, which begets accommodation and more inflation.

III. The Persistence of Shocks and the Formation of Expectations

In the above example an adverse supply shock causes a permanent reduction in the economy's productive capacity. Another possibility is that the shock is temporary, as in the case of an agricultural drought or freeze. In this case the tradeoff with partial or lagged indexation is between a temporary output loss and a temporary rather than permanent acceleration of inflation. Even a temporary upsurge in the inflation rate is not without welfare costs, since it causes a permanent increase in the price level at every date in the future and a corresponding loss in the wealth of holders of high-powered money (effects on interest-bearing assets and liabilities cancel out).

Thus far nothing has been said about inflation expectations. If the indexation parameters β and γ are set by legislation, then wage changes would evolve mechanically in the aftermath of a supply shock, as described above. If β and γ are relatively low at the time of the shock, e.g., if wage changes are determined mainly by their own past values, then the decline in the real wage rate associated with the shock may create political pressure to have indexation legislation changed. Indeed the percentage "pass through" of price changes in the Italian scala mobile indexation agreement was raised in 1975 after the first oil shock. However, in most countries indexation parameters are not set in legislative stone, but are subject to frequent negotiation

between workers and firms. Multi-period wage agreements achieved in delicate negotiations would not tend to be altered in response to a temporary shock that is expected to leave output and the real wage unaffected after a transition period of a few months or a year.

But a shock expected to have a permanent effect on output and the real wage poses a serious dilemma for the parties in wage negotiations, and may well lead to a change in any or all of the parameters of (11). As depicted in the model of John Taylor, newly negotiated contracts depend not just on the current state of demand, as in (11), but also on the expected future state of demand. Taylor's agents are "forward looking", not "backward looking" as in mechanical formulae like (11). Workers with forward-looking expectations can calculate the future consequences of maintaining high β and γ indexation parameters in the face of a permanent supply shock--permanently higher inflation if the policy authorities accommodate, and a period of low aggregate demand (Q/Q^*) if they do not accommodate. Faced with this unpleasant tradeoff, rational workers would suspend indexation and allow the real wage to fall by the required amount. Hence the rational expectations response to a permanent shock merges together with the market-clearing outcome described above.

The painless transition implied by quickly adjusting forward-looking expectations to a permanent shock has not been observed in fact. As Jeffrey Sachs has emphasized, unemployment increased in virtually all OECD countries after the 1973-74 oil shock, reflecting a combination of nonaccommodative aggregate demand policies, and an excess of real wage growth over productivity growth. One possible explanation for this outcome is that economic agents initially thought the oil shock would be temporary and were slow to learn that it was permanent. Karl Brunner, Alex Cukierman, and Meltzer show that, even within the context of a market-clearing model, a permanent reduction in pro-

ductivity can cause stagflation, because agents only gradually learn the permanent values of real variables and only gradually adjust their anticipations. Consistent with their analysis is my 1983(b) finding that real wage growth in most large European countries was much more moderate after the 1979-80 oil shock than after the initial 1973-74 shock. Having seen the effects of the first shock persist, agents were more prepared to believe that the second would persist as well.

IV. Impact on Doctrinal Debates

Supply shocks have helped to unify the teaching of macroeconomic theory with that of microeconomics, since basic results in both subjects can be summarized with supply and demand curves. Undergraduates are now taught that unemployment and inflation may be either negatively or positively correlated. Following an autonomous shift in demand, the extent and duration of any change in unemployment depends on the length of wage contracts and the adjustment of expectations, while following an autonomous shift in supply, the extent and duration of any change in unemployment depends on the interaction of wage indexation and monetary accommodation. The recognition that inflation depends on shifts in both demand and supply, not just on past changes in the money supply, has facilitated econometric explanations of the inflation process that appear able to explain why in the 1970s U. S. inflation was so variable and why in 1981-83 it decelerated so rapidly.[4]

The positive correlation of inflation and unemployment in the 1970s brought forth many responses. In a famous polemic, Robert E. Lucas, Jr. and Thomas Sargent used this positive correlation to challenge the application of "Keynesian" models to macroeconomic policymaking. Their stated intent was "to establish that the difficulties are <u>fatal</u>: that modern macroeconomic models are of <u>no</u> value in guiding policy and that this condition will not be remedied by modifications along any line which is currently being pursued." Especially

with respect to the issue at hand, this dismissal is inappropriate. Observations in the inflation-unemployment quadrant can represent the interaction of demand and supply curves. The Lucas-Sargent challenge failed to notice the concurrent development of new "Phillips curve" formulations which combined the effects of supply and demand shifts with that of sluggish price adjustment, the basic element in Keynesian economics. As put forth in Gordon and King (1982), the U. S. Phillips curve appears to be one of the most stable empirical macroeconomic relationships of the postwar era, one that shows no sign as of yet of being subject to Lucas' econometric critique.[5] In basing their attack on Keynesian economics on the alleged collapse of the Phillips curve, Lucas and Sargent seem in retrospect like a teenage prankster who scares everyone by crying "wolf" and then flees the scene when it is discovered that there is no wolf.

Finally, supply shocks have raised the perennial question of the optimality of decentralized and uncoordinated wage and price setting. Decentralization ("the invisible hand") is usually supported by economists as required for <u>microeconomic</u> efficiency, yet coordination and centralization may be needed to obtain an improved <u>macroeconomic</u> response to supply shocks. In the past decade economists have debated the merits of alternative responses that would have required coordinated action, including a one-time real wage reduction to match the decline in productivity caused by the 1973-74 and 1979-80 oil shocks, changing indexation formulae to exclude oil prices and indirect taxes from the price measure used for escalation, and oil import taxes balanced by reductions in other indirect taxes to put downward pressure on the world oil price and to discourage consumption.

FOOTNOTES

1. Edmund S. Phelps (P. 206) lists the 1974 conferences at which he and I independently developed what Edward Gramlich later called the "Gordon-Phelps model."

2. Although it assumes a constant money supply and a constant nominal wage rate, Phelps' paper does include a condition (in the middle of p. 211) which sets equal the two terms in the parenthesis in (7). Exactly the same condition as (9) is contained in my 1975(a) paper when it is recognized that the right-hand term in equation (9) of that paper is the percentage change in the expenditure share of the external sector. I discovered after writing this paper that Stanley Fischer in 1983 developed an analysis that is compatible with my Part II but is both more complex and more general.

3. The share index is calculated by multiplying total real energy consumption by the composite energy deflator (both from the Statistical Abstract of the United States, 1982-83, pp. 572-3), dividing by nominal GNP, and setting 1972 as the base of the index.

4. Models that combine demand and supply elements include those of Otto Eckstein, Gordon (1982), and Gordon-King. Readable descriptions of the role of supply shocks in the inflation of the 1970s are provided by Alan Blinder. An evaluation of the 1981-3 disinflation is provided by the three papers in the volume edited by William Nordhaus.

5. The stability of the inflation equation to changes in sample period is examined by Gordon and King (p. 218) and related to the Lucas critique (pp. 224-9). Structural shifts in the 20th century prior to 1954 are discussed by Gordon (1983a) and by Meltzer.

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