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ABSTRACT

Supply shocks played an important role in macroeconomic fluctuations during the 1970's. Supply shocks are also increasingly important in Keynesian and neo-classical models of the business cycle. This paper is a short survey of these theoretical models. It also discusses the history of supply shocks in recent business cycles.

The decade of the 1970's saw a resurgence of interest in the influence of the supply side on macroeconomic phenomena. The new attention paid to the supply side was driven by two major factors. First, the world economy faced a series of major supply-side shocks. These shocks lead to a breakdown of major relationships embodied in macroeconomic models. Second, the new classical macroeconomics brought about a reconsideration of the Keynesian emphasis on the demand side. The breakdown of the relationships in the Keynesian models would have been predicted by the new classical economists. These relationships were often based on historical correlations that could shift when the nature of the underlying shocks facing the economy changed. Keynes emphasized the role of effective demand in business cycle fluctuations. Following Keynes, much macroeconomic analysis neglected the role of the supply side. In periods when shocks to supply are minimal doing so will provide an adequate, if incomplete, understanding of economic fluctuations. The emphasis on effective demand proved inadequate for forecasting, analysis, and policy prescription in the face of supply shocks of the 1970's.

Output, the Price Level, and Aggregate Supply

If prices and wages are less than fully flexible, changes in the cost of production will have important effects on both the aggregate price level and aggregate output. Shocks to the cost of production yield very different business cycle correlations of prices and output than do the shocks to effective demand. It is convenient to study these movements in terms of the

aggregate supply and aggregate demand schedules in price-output space. The aggregate demand curve traces out the negative relation between aggregate demand and output which holds as long as the interest elasticity of demand for goods and for real balances are both negative. The aggregate demand curve defines the set of equilibria in the goods market and asset market for a fixed price level. Along the aggregate demand curve, output increases as price decreases because real balances increase. An aggregate demand curve (DD) is drawn in the Figure. Stimulative shocks to demand such as a tax cut or a monetary expansion will raise aggregate demand given price. To close the model, the price level is determined by the intersection of aggregate supply and aggregate demand. The aggregate supply curve is determined by the productive capacity of the economy and the market forces determining factor cost. In the strict, neo-classical case, aggregate supply will be fixed for all levels of the general price level. More generally, if frictions in markets for factors of production, especially the labor market, prevent instantaneous adjustment of prices to shocks, then there will be a positive relation between the general price level and aggregate supply. That is, if firms see their prices increasing due to an aggregate demand shock, but do not expect or perceive that their costs may (eventually) increase proportionally, they will supply more output. In the long run, these changes in cost will be fully realized, so there is no long run positive relationship between the aggregate price level and supply. An aggregate supply curve (SS) is drawn in the Figure. The point A, the intersection of the aggregate supply and demand schedules indicates equilibrium output. The long run aggregate supply curve is defined by FF.

In the long run the level of output is invariant to the general price level. The point A is a long run as well as a short run equilibrium.

The positive slope of the aggregate supply curve can be rationalized by a variety of models. If firms set their prices as constant mark ups over their costs and if these costs--especially labor costs--react slowly to changes in demand there will be a positive relation between the aggregate price level and output. [See Dornbusch and Fischer (1984) for a Keynesian treatment of aggregate supply.] The derivation of the positive aggregate supply relation between price and quantity does not depend, however, on Keynesian price stickiness. If firms have imperfect knowledge of the prices facing other agents in the economy, they will not know exactly the relative prices of their outputs and inputs. If, as the general price level increases, the firm first perceives the increase in the price of its output, it will increase output, at least temporarily, when the general price level increases. [See Lucas (1981).] It is difficult to distinguish in the data these two sources of the positive slope of the aggregate supply schedule. Misperceptions of the general price level should be short-lived, but costs of adjustment and other rigidities could make the consequences of a transitory misperception be long-lived.

The observed correlations of aggregate output and the aggregate price level will depend on the shape of the aggregate supply and demand curves and on the nature and magnitude of the shocks shifting them. Different types of shocks will be more or less important at different times, so the output-price correlation will change accordingly. Supply shocks will shift the aggregate supply curve. Specifically, an adverse supply shock will lower

aggregate supply given the aggregate price level. Examples of adverse shocks include declines in productivity and increases in crude materials prices. In order to accommodate such shocks at full employment, the real wage must fall. If nominal wages are sticky, some of this decline will be accomplished through an increase in the general price level. As costs increase due to increases in crude materials prices or declines in productivity, firms raise prices for a given level of output.

Consider the correlation of aggregate output and prices when the economy is subject to both aggregate supply and demand shocks. If the Keynesian view that demand factors are the major determinants of output fluctuations at business cycle frequencies is correct, then one would expect to see a positive correlation of price and quantity in the aggregate data. Business cycles would be fluctuations of demand which would trace out a relatively stable aggregate supply relationship. This positive correlation of price and output is related to, but not identical to the positive correlation of inflation and output (or negative correlation of inflation and unemployment) known as the Phillips curve. With lags of adjustment and data alignment it is difficult, however, to distinguish the relationship in levels and differences. No attempt is made here to sort out these lags.

Suppose, on the other hand, that fluctuations in aggregate supply are relatively more important over the business cycle. That is, that fluctuations in the cost of production trace out a relatively stable aggregate demand relationship. An adverse aggregate supply shock will shift the aggregate supply schedule upward from SS to S'S'. At any level of real economic activity, the price level is higher. The observed correlation

between price and output caused by supply shocks will be negative in the aggregate data. Examination of this correlation, if done in the context of a structurally invariant model, can provide evidence as to the nature of the shocks.

Supply Shocks and Stagflation

The 1970's saw a distinct shift in the output-price correlation. In the 1960's, the correlation was strongly negative. In the 1970's, the correlation became positive. Hence, although in the 1960's, there appeared to be a trade-off between prices and output, the 1970's witnessed the combination of stagnant real economies and increasing prices that became known as stagflation. [See Federal Reserve Bank of Boston (1978), Blinder (1979), and Bruno and Sachs (1985) for extensive discussion of these events and their ramifications for economic theory.] During the 1970's, there were a series of supply shocks that can explain the changing correlation of output and prices and that caused substantial output loss as world economies adjusted to the shocks. In the early seventies, there were a series of bad harvests that raised agricultural prices. These occurred after a policy in the U.S. of depleting grain reserves. The low stockpiles exacerbated the price increases. The price of oil rose dramatically during the 1973/74 Organization of Petroleum Exporting Organization's (OPEC) embargo and again in 1979/80 following the fall of the Shah of Iran. Each of these shocks have the effect of increasing goods price relative to wages and hence require an increase in the general price level unless nominal wages fall. Consequently, the aggregate supply curve shifts upwards. The direct effect

of the energy and food price increases is illustrated in the Table. The first column gives the annual inflation rate of consumer prices in the U.S. The next two columns give the inflation rates for energy and food. These rose dramatically in 1973. Energy prices again began to rise dramatically in 1979. The last column gives the inflation for all items excluding food and energy. The direct impact of increases in food and energy prices accounted for almost all the acceleration in inflation in 1973 and a high fraction of it in the later episode.

The decade of the seventies also witnessed the a dramatic slowdown in the rate of productivity growth in industrialized nations. Measured by per capita real gross national product, productivity in the U.S. grew at 2.8 percent per year from 1964 to 1973. In the European Organization for Economic Cooperation and Development (OECD) countries it grew 3.7 percent over the same period. From 1973 to 1981, these rates fell to 1.3 percent in the U.S. and 1.5 percent in Europe. [See Organization for Economic Cooperation and Development, Historical Statistics, 1952-1982 (Paris, 1984), p. 86, for these statistics.] A decline in productivity growth directly reduces the rate of output growth. It also has an indirect effect through the aggregate supply-aggregate demand mechanism. Lower productivity means higher costs of production for firms. This shifts the aggregate supply schedule up. Consequently, output falls, at least in the short run, by more than the amount due directly to the productivity shock.

This list of supply shocks--those due to OPEC, poor harvests, and slow productivity growth--is clearly motivated by the experience of recent history. It is by no means definitive. Shocks could include exogenous

changes in any commodity price, natural disasters such as earthquakes, floods, and draughts, and man-made disasters such as wars or nuclear accidents. Of course, the shocks need not be adverse. Specifically, technological improvement has been the key to economic growth in the West since the Renaissance.

To see how a supply shock propagates in an economy with less than perfectly flexible prices, consider in detail the effect of an increase in the price of imported oil. Firms will immediately attempt to raise prices to pass through the higher cost of oil used as an input. As long as non-commodity prices are less than perfectly flexible in the short run, the increase in the price of oil will increase the aggregate price level. If the oil price increase took place instantaneously and the cost increase were reflected in final goods prices instantaneously, the price level would rise once and for all. Because of lags in adjustment and reporting, prices will rise only slowly. The slow adjustment of the price level will appear in the data, and perhaps be perceived by households, firms, and policy makers, as an increase in the inflation rate. In terms of the Figure, the aggregate supply curve has shifted up. Holding government policy constant, output will be lower as the economy moves up the aggregate demand curve. The increase in the price level reduces real balances and hence raises the real interest rate and lowers aggregate demand. The change in relative prices could also have income effects that would shift the aggregate demand curve. These are neglected in this discussion. For the economy to return to the long run, full employment equilibrium, real wages must fall. Workers must be less well off because of the increased payments for imported oil. Note

that this real wage cut must be taken in the face of reduced purchasing power for consumer goods that require a large amount of energy to produce or to maintain. Consequently, there is the danger that a wage-price spiral will ensue.

Absent government policy intervention, a protracted period of less than full employment may follow the supply shock during which real wages are reduced. The supply shocks may be attenuated by government policy intervention. Wage-price controls or incomes policies could be used to combat the inflationary pressure from the cost increase. These are likely to be counter-productive, however, because the relative prices of goods and factors of production must adjust after a supply shock. Since the relative price of some goods must rise, price controls are likely to cause shortages. The supply shock can be accommodated by fiscal and monetary policy. Recall that a protracted recession may be necessary to reduce real wages following the supply shock. Expansionary policy can ameliorate this fall in output at the cost of even higher prices. While any expansionary policy will raise demand, cutting excise taxes would have the compound benefit of producing a favorable supply shock by lowering costs of production. The extra inflation from expansionary policy may be a relatively painless way of accomplishing the reduction in real wages necessary to achieve long run equilibrium. On the other hand, contractionary policy to combat the incipient inflation from the supply shock will be particularly costly because it will add to the recessionary pressures from the supply shock itself.

It is instructive to consider briefly actual policy experience in light of the supply shocks of the 1970's. In the U.S., the Nixon price freeze and

controls and the Carter guidelines were ineffective in containing price increases. Moreover, price controls on gasoline created long lines in both 1972 and 1979. Monetary policy became contractionary following the oil price increases of 1973-4 rather than accommodative and produced what was then the largest recession since the Great Depression. [See Blinder (1979) and Solow (1980) on the neo-Keynesian model of supply shocks, the shocks of the 1970's, and the policy experience in the United States.]

In Europe, unlike the United States, there was virtually no recovery between the first and second oil price shocks. Consequently, unemployment was high in Europe throughout the 1970's. In the U.S., there have been recoveries punctuated by increases in oil prices. In Europe, real wages appear to be more rigid than in the United States. Centralized, synchronized wage negotiations allow unions to take into account the effect of the wage bargains on the price level. Hence, achieving real wage cuts is difficult. Moreover, unions appear to have preferred to reduce employment rather than the wages of employed workers. Consequently, the adjustment to accommodate the higher oil price was costly in terms of forgone employment and output. (See Bruno and Sachs (1985)).

Supply Shocks without Price Stickiness

Simultaneously with the collapse of the Phillips curve correlation between price and output there was an attack on the theoretical underpinnings of the neo-Keynesian model. In particular, the belief that

there was an exploitable trade off between output and inflation was called into question. The theoretical revolution, called rational expectations or the new classical macroeconomics, denied the role of Keynesian effective demand by reintroducing price flexibility into macroeconomics. The Keynesian macroeconomics models were criticized for treating reduced form correlations such as the negative correlation between output and inflation as structurally invariant. Specifically, the models were criticized for the fact that the correlations embodied in them would change when economic policy was exercised. [See Lucas and Sargent in Federal Reserve Bank of Boston (1978) and Lucas (1981)].

This critique can be broadened to encompass the case where the changes in the reduced form correlations do not arise from attempts by policy makers to exploit them but rather from changes in the nature of the shocks facing the economy. As discussed above, such a change occurred in the decade of the 1970's when supply shocks were more important than they had been in the past. The development of new classical macroeconomics was certainly driven by theoretical considerations, but its wide acceptance was probably abetted by its explanation of the collapse of the neo-Keynesian models of the 1960's.

Supply shocks can have an important role in economies not characterized by price stickiness. Indeed, since the new classical economics discarded effective demand as a source of fluctuations in output, it is natural that the supply side features prominently in its analyses of business cycles. In most textbook treatments of macroeconomic fluctuations, the business cycle is treated as a cyclical deviation of output from a path determined by

factors relating to long term growth. These factors--growth in population and labor supply, technological progress, and increases in the capital-labor ratio--are assumed to evolve independently of fluctuations at business cycle frequencies. Hence, whether they are deterministic or random, macroeconomic phenomena could be analyzed by abstracting from long run growth in the economy. This dichotomy is especially appealing given the view of business cycle fluctuations as demand driven deviations from supply determined trend.

Emphasis on supply factors, especially productivity shocks, in business cycles vitiates the dichotomy. If factors affecting long term growth are also important at business cycle frequencies then, in both theoretical and empirical studies, business cycle fluctuations cannot be divorced from long term growth. Moveover, statistical tests suggest that it is difficult to reject the hypothesis that current shocks to aggregate output have a permanent component. (In the language of statistical time series analysis, it is difficult to reject the hypothesis that output has a unit root.) The persistence of output shocks does not guarantee, however, that productivity shocks are important in the short run. Demand shocks, especially in an imperfectly competitive economy, may be very persistent.

Consider the macroeconomic effects of a shock to productivity. The effects will depend on whether the shock is temporary (from the weather, for example) or permanent (a technological innovation, for example). A temporary shock will affect output directly, but should not affect the technology or level of factor input in the long run. A permanent shock will affect output in the short run, but the entire response of output should not take place immediately. Because capital is costly to adjust and investment

entails delivery lags, the response of the capital stock to a productivity shock will take time. Hence, output may appear to be leading investment despite the fact that they are each responding to the same, underlying productivity shock.

If productivity shocks are an important determinate of output at business cycle frequencies, two long-standing empirical puzzles are resolved. Real wages are acyclical or slightly pro-cyclical. Both Keynesian sticky wage theory and neo-classical marginal product theory suggest that real wages should vary counter-cyclically. If productivity shocks are important at business cycle frequencies, wages will be pro-cyclical. Productivity shocks can also account for the short run increasing returns to labor. The estimated short run elasticity of output with respect to labor equals or exceeds one, which is inconsistent with a neo-classical, constant returns to scale production function. Such a correlation would be expected, however, if productivity shocks were jointly moving output and labor demand. Short run increasing returns to labor is, however, also consistent with labor hoarding in response to a demand shock.

There are difficulties, however, with attributing too much of the business cycle variance in output to productivity shocks. It seems unlikely that technology moves enough on a quarter to quarter basis to account for all of the variability of observed output. Because it is unlikely that technological regress can be an importance source of fluctuations in modern economies, that output falls in recessions might be taken as evidence that demand as well as supply factors account for fluctuations. Hence, to attribute a high fraction of output variance at the business-cycle

frequencies to technological shocks, it is necessary to postulate frictions or costs of adjustments of either Keynesian or classical character that magnify the effects of the shocks. Examples of such frictions include the cost to workers of changing jobs or locations in response to technological change and the difficulty of adapting old capital to new techniques.

Fiscal and Monetary Policy and the Supply Side

Although fiscal and monetary policy are usually thought to work primarily through aggregate demand, they have important supply side effects. Certain supply shocks can be said to be induced by policy decisions. Tax rules that reduce the cost of capital by investment tax credits and accelerated deductions for depreciation expenses have been an important supply side component of fiscal policy in the United States since 1962. (See the Economic Report of the President (1962) for a discussion of these investment incentives in particular and for an early treatment of the supply-side effects of macroeconomic, demand-management policies.) Tight fiscal policy will encourage investment (for a given level of aggregate demand) by increasing the supply of saving and hence reducing interest rates.

Monetary policy can also have important consequences for the supply side. Monetary tightening will increase the required rate of return for holding commodities or the domestic currency. As the interest rate increases, the opportunity cost of holding these assets increases. Hence, a monetary contraction will reduce commodity prices and appreciate the currency. Such relative price changes work just as uncontrollable supply

shocks by changing the cost of production and hence shifting the aggregate supply schedule. This supply-side channel for monetary policy thus creates a supply shock that amplifies the demand-side deflationary pressure of a monetary contraction.

REFERENCES

Blinder, Alan S. (1979). Economic Policy and the Great Stagflation. New York, Academic Press.

Bruno, Michael and Jeffery D. Sachs (1985). The Economics of Worldwide Stagflation. Cambridge, Mass., Harvard University Press.

Dornbusch, Rudiger and Stanley Fischer (1984). Macroeconomics third ed. New York, McGraw-Hill.

Economic Report of the President (1962). Washington, D.C., U.S. Government Printing Office.

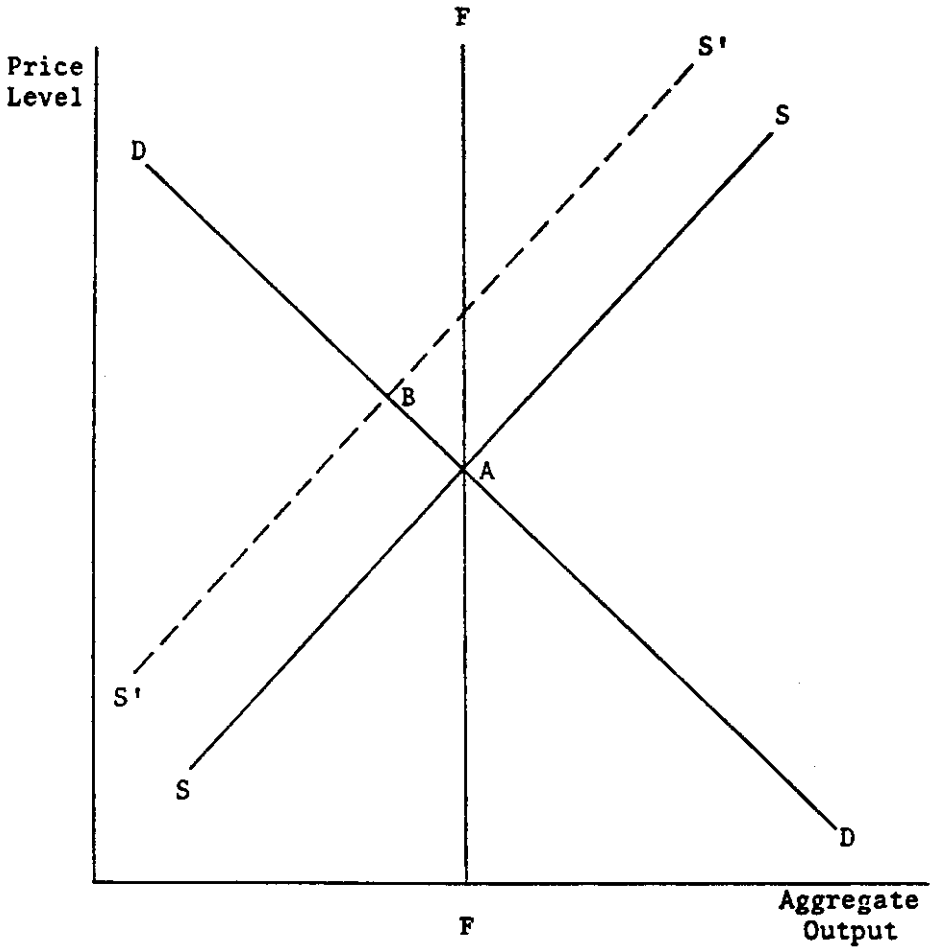
Federal Reserve Bank of Boston (1978). After the Phillips Curve: Persistence of High Inflation and High Unemployment. Boston.

Lucas, Robert E., Jr. (1981). Studies in Business-Cycle Theory. Cambridge, Mass., Massachusetts Institute of Technology Press.

Solow, Robert M., What to Do (Macroeconomically) When OPEC Comes, in Rational Expectations and Econometric Practice, Stanley Fischer, ed. Chicago, University of Chicago Press.

FIGURE

Aggregate Supply and Aggregate Demand



TABLE

Consumer Price Inflation in the United States:

All Items, Energy, and Food

	all items	energy	food	excluding food and energy
1970	5.9	2.7	5.6	6.3
1971	4.2	3.9	3.0	4.7
1972	3.3	2.7	4.4	3.0
1973	6.2	8.1	14.4	3.5
1974	11.0	29.3	14.4	8.3
1975	9.2	10.6	8.5	9.2
1976	5.7	7.2	3.1	6.5
1977	6.5	9.5	6.3	6.3
1978	7.6	6.4	10.0	7.3
1979	11.3	25.2	10.9	9.7
1980	13.5	30.8	8.6	12.4
1981	10.4	13.5	7.8	10.5
1982	6.2	1.5	4.0	7.4
1983	3.2	.7	2.1	3.9
1984	4.3	1.0	3.9	5.0
1985	3.5	.7	2.2	4.4

Data are annual percent changes in the United States Consumer Price Index.
Source: United States Bureau of Labor Statistics.