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Output Fluctuations and Gradual Price Adjustment

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That the price of linen and woollen cloth is liable neither to such frequent nor to such great variations as the price of corn, every man's experience will inform him. *Adam Smith.*

In view of the fact that practically every business is a partial monopoly, it is remarkable that the theoretical treatment of economics has related so exclusively to complete monopoly and perfect competition. *Frank Knight.*

There can be no doubt that in this country ever since 1790 our price structure has included a large number of prices that remained unchanged for months or years at a time, side by side with prices that changed monthly, weekly, daily, or in recent years even hourly. *Rufus S. Tucker.*

I. Introduction

IN MANY DIFFERENT economic environments, across historical eras and national boundaries, changes in the nominal aggregate demand for goods and services have been accompanied by only a partial response of the aggregate price level. Because prices do not carry the full burden of adjustment in the short run, quantities must by definition carry part of the load. In this sense the phenomenon of gradual price adjustment is at the heart of fluctua-

tions in output and employment and of the related debate over activist stabilization policy to control such fluctuations. Yet despite the obvious importance of this topic, its central role in the development of macroeconomics and labor economics, since John Maynard Keynes, and the manifestations of a business cycle in real output all around us, a convincing and widely accepted theoretical explanation of sluggish price responsiveness has nevertheless eluded a generation of economists.

1. *The Dichotomy between Two Paradigms*

The discipline of macroeconomics has been split apart in the past decade by the emergence of two dichotomous and incompatible paradigms of price adjustment. The non-market-clearing tradition originates in John Maynard Keynes' fixed wage (1936). An infant industry has produced several models of gradual price adjustment within the non-market-clearing setting but, as yet, there is no widely accepted explanation of the failure of markets to clear. The opposing "new classical equilibrium macroeconomics" is based on models in which universal auction markets allow prices to adjust instantly to perceived nominal demand changes, and in which agents fail to select the quantity that would maintain an aggregate equilibrium only when imperfect information prevents them from discerning the true value of nominal aggregate demand.

This paper reviews the leading ideas that have emerged within each of the paradigms. Neither, it appears, provides a satisfactory theoretical scheme when taken in isolation. This paper concludes that an attempt to merge the more convincing elements of each is needed, and some suggestions for such a merger are put forward. Until now, however, the much-needed process of merging has been delayed by the tendency of each side to set up a criterion of evaluation that makes it incapable of appreciating the strong points in the literature of the opposing group. Non-market-clearing theorists find empirically realistic a disequilibrium analysis in which price stickiness leads to quantity rationing. They insist that firms make their own marks on price tags and reject the implicit assumption of the new classicists that agents passively receive price information in the hourly mail from some central auction market in London, New York, or Chicago. But the equilibrium the-

orists, in turn, are prevented from recognizing real-world price-setting practices by a shibboleth that any appearance of price stickiness would mark "the nonexecution of some perceived mutually advantageous trades." The hapless firms and workers of non-market-clearing models are characterized as shrouded in a fog of irrationality, voluntarily allowing a succession of business cycles to occur, consisting of "fluctuations in the quantity of perceived, mutually advantageous trades that are not executed" (Robert J. Barro, 1977, p. 315).

In the sections that follow we attempt to make our way through a thicket of theory written in the past 15 years by leading authors on both sides of the debate. Along the way we are confronted with a continual conflict between elegant theories and uncooperative facts. For the models of the new classicists to generate a business cycle, each agent must be equipped with a pair of blinders that arbitrarily cuts him off from information printed in the daily newspaper on aggregate variables like interest rates, price indexes, and the money supply. But to accept the non-market-clearing framework we must recognize impediments to price adjustment that prevent agents from promptly responding to aggregate disturbances. Thus, the current macroeconomic dichotomy is like an election between two unattractive candidates, and the "voters" appear to have chosen their favorite paradigm mainly on the basis of the unattractive features of the opposite approach. The arbitrariness of the non-market-clearing impediments to rapid price adjustment is matched by the arbitrariness of the information blinders strapped onto the handicapped agents of the new classical models.

2. *Phenomena the Theory Must Explain*

The test of any theory is its ability to explain and to predict the facts, and the list of facts that must be explained by the

theory of price adjustment is a long and daunting one.

(1) Some markets have prices that are set at the same level over weeks, months, or years.

(2) Some prices, even though they are marked on price tags, are changed every day (e.g., the price of lettuce in a supermarket), and yet other pre-set prices remain sufficiently fixed to be printed in catalogues and on product containers.

(3) The division of nominal GNP changes between prices and quantities has varied over time in the United States, with a rapid price response during and after World War I, and after the OPEC oil shock in 1974, but virtually no price response to high unemployment in 1938–40 and 1970–71.

(4) The division of nominal GNP changes between prices and quantities varies across countries, with evidence of a greater price response in Europe both during the Great Depression and more recently (Robert J. Gordon and James A. Wilcox, 1981).

(5) Prices, although set in advance and marked on price tags, nevertheless have the potential to move fast enough to allow hyperinflation to occur (Thomas J. Sargent, 1980).

In short, prices are neither perfectly fixed nor perfectly flexible, and variations over time and across countries with regard to the degree of flexibility require explanation as well. Any adequate framework must go beyond the fixed-price paradigm, which has no ingredient that would explain variations over time in the degree of price responsiveness. Similarly, the facts of price-setting and quantity-taking cannot be explained by the new classical paradigm, which simply assumes them away. Yet each side has a key ingredient to contribute to an intermediate approach, since the general-equilibrium analysis of a quantity-constrained economy is already in place, once the reasons

for partial price adjustment have been explained, while the distinction between local and aggregate information stressed by the new classicists helps to explain why the flexibility of pre-set prices varies over time.

3. *Plan of the Paper*

This paper is not an exhaustive survey. It combines exposition and criticism of a selected group of seminal contributions in the literature on price adjustment with suggestions for an intermediate framework that may help to deal more adequately with questions as yet unsettled. Rather than repeating the content of previous surveys, it takes as its point of departure the recent assessments of the non-market-clearing literature by E. Roy Weintraub (1977) and Allan Drazen (1980), and of the new classical equilibrium literature by Barro (1979*b*) and Bennett T. McCallum (1980). It evaluates the most important subset of contributions in these surveys by asking whether the theory can explain some or all of the observed facts and whether it assumes its answers in advance rather than deducing them from the behavior of individual agents.

The paper begins in Part II by reviewing a set of identities that highlights the conditions necessary for price and wage rigidity to imply the existence of fluctuations in output and employment. A summary is then presented of old and new evidence on the extent of aggregate price responsiveness in business cycles. Part III then reviews the main competing frameworks used for discussion of price flexibility and business cycles in the literature of the past 45 years and observes the way unhappiness with the Keynesian paradigm led economists in separate directions. Parts IV and V present a brief exposition and critique of the two paradigms that have attracted the most attention during the past decade: the new classical equilibrium economics, and theories of

gradual price adjustment. Parts VI and VII then sketch the essential ingredients in an intermediate approach. The former summarizes the reasons for price-setting by firms and suppliers, and the factors that allow auction markets to exist for a few commodities but not for most others. The latter examines the reaction of price-setting firms and their suppliers to changes in nominal aggregate demand.

While the scope of this paper is broad enough to encompass several strands of the literature, each of which has already been the subject of comprehensive survey articles, it is explicitly restricted to exclude a large set of topics that are conventionally associated with the discussion of business cycles. Nominal aggregate demand is assumed to be exogenous, determined by the behavior of government policymakers and by the spending decisions of firms and workers, and no attention is given to the various channels of feedback from prices to nominal demand (e.g., through the Pigou and expectations effects of price changes on spending decisions). Nor do we consider "supply-side" feedbacks from inflation and/or interest rates to investment and productivity growth. Wage-setting and labor-market behavior are deemphasized, although the conclusion to the paper suggests how our approach to the explanation of price behavior might also help to explain sluggish wage adjustment. The stress on price rather than wage adjustment reflects both the need to limit the length of the paper and the need to counterbalance the excessive importance placed on labor-market institutions in the recent literature on business cycles. In its appraisal of past work, this paper assumes throughout that gradual price adjustment is purely a short-run phenomenon, and that if nominal aggregate demand were permanently to increase or decrease, the price level would eventually exhibit a parallel and proportionate movement. It is the underlying as-

sumption of long-run monetary neutrality that motivates the choice of the adjective "gradual"—with its sense of dynamic adjustment—for the title of this paper, rather than the word "partial" (which could mean a permanent adjustment that is only fractional).

II. *Gradual Price Adjustment and Business Cycles: Identities and Evidence*

1. *Identities Linking Demand, Prices, Output, and Employment*

Although most economists now accept as obvious the proposition that the sluggish adjustment of prices and wages increases the variability of real output and employment over the business cycle, nevertheless some have argued that price and wage stickiness is not a central issue. In this view, the fixity of wages does not necessarily imply layoffs or fluctuations in employment, since "even in contracts that specify *ex ante* the value of nominal wages over some interval of time, it would be mutually advantageous for workers and firms to determine levels of employment in an efficient manner" (Barro, 1979a, p. 54). There is, in short, a "limited allocational role of the wage payment for employment" (Robert E. Hall, 1980, p. 92). A parallel proposition would be that price rigidity does not necessarily imply output fluctuations.¹

A few simple identities help to clarify the necessary relationships between price and wage adjustment and the evolution of real variables like output and employment. Throughout, we take the exogenous nominal aggregate demand variable to be nominal GNP. By definition, the log of nominal GNP (Y) must be divided be-

¹ I cannot find a quotation to support this latter suggestion, which seems as yet to be limited to an "oral tradition." I am grateful to Stanley Fischer and Herschel Grossman for informing me that some people take this suggestion seriously.

tween the log of the GNP deflator (P) and the log of real GNP (Q):

$$Y \equiv P + Q. \quad (1)$$

Taking the derivative of (1) with respect to time, and using the notation that percentage changes per unit of time are designated by lower-case letters, we have

$$y \equiv p + q, \quad (2)$$

which states that any change in nominal GNP must be divided between a change in the aggregate price level and a change in real GNP. Next, we subtract from both sides of equation (2) the trend or "natural" growth rate of real GNP (q^*) and use a "hat" to designate variables defined net of that trend growth rate of real output:

$$\begin{aligned} y - q^* &\equiv p + (q - q^*); & (3) \\ \hat{y} &\equiv p + \hat{q}. \end{aligned}$$

Thus, any excess of nominal GNP growth over the trend growth of real output (\hat{y}), which we call "adjusted" nominal GNP growth, must be accompanied by some combination of inflation (p) and a deviation of real output from trend (\hat{q}). Since the latter must be zero in the long run, any permanent acceleration or deceleration of adjusted nominal GNP growth must be accompanied by exactly the same acceleration or deceleration of inflation (we neglect any feedback from output or price fluctuations to the natural growth rate of output). To the extent that the long-run growth rate of the money supply is the basic determinant of the long-run behavior of nominal GNP, and both money and nominal GNP are exogenous, equation (3) is a way of restating the claim that *in the long run* "inflation is always and everywhere a monetary phenomenon" (Milton Friedman, 1963).²

² Any permanent acceleration or deceleration of inflation would be accompanied by a one-time change in the level of interest rates, and in the ratio of money holdings to nominal GNP (as long as money

Over shorter business-cycle frequencies, equation (3) states that fluctuations in nominal GNP growth must be divided between price and output fluctuations. Real GNP can be stable only if price changes exactly mimic the proportional change in nominal GNP, and any tendency for prices to adjust only partially to nominal GNP cycles *must* imply procyclical fluctuations in real GNP. For instance, if the rate of change of prices over the business cycle is always equal to some constant fraction (α) of the adjusted nominal GNP movement, then deviations of real GNP from trend must soak up the remaining fraction ($1 - \alpha$):

$$\begin{aligned} p &= \alpha \hat{y}, & (4) \\ \hat{q} &\equiv \hat{y} - p = (1 - \alpha)\hat{y}. \end{aligned}$$

Can one proceed from the identity expressed in (4) to the significant proposition that an economy with relatively sticky prices (a small α) must exhibit correspondingly larger fluctuations in real output? That would follow, other things being equal, except insofar as the responsiveness of prices themselves influenced the amplitude of fluctuations in nominal GNP.

Although the argument that price rigidity increases the amplitude of real output fluctuations seems convincing, the link between nominal wage rigidity and employment fluctuations is much weaker. To see what is involved, let us divide nominal GNP changes between changes in the wage bill and in non-labor income. If μ is the share of labor, and w , e , h , and n are the respective growth rates of the hourly wage rate, employment, hours per employee, and non-labor income, we have:

$$y \equiv \mu(w + e + h) + (1 - \mu)n. \quad (5)$$

does not pay a competitive interest rate). The use of nominal GNP as the exogenous demand variable in this discussion allows us to avoid reference to the transitional behavior of velocity and to use simple identities like (3).

Cyclical behavior relative to trend can be analyzed by making two adjustments to (5). First, we subtract the trend growth rate of output (q^*) from both sides; second, we both add and subtract from the right-hand side the trend growth rates of employment and hours (e^* and h^*). We obtain:

$$\hat{y} \equiv \mu(w - \omega + e' + h') + (1 - \mu)\hat{n}, \quad (6)$$

where ω is trend productivity growth ($q^* - e^* - h^*$), e' is the deviation of employment from trend ($e - e^*$), h' is the deviation of hours per employee from trend ($h - h^*$), and \hat{n} is the growth in nominal non-labor income relative to trend output ($n - q^*$). In the long run, when the cyclical employment and hours deviations are zero ($e' = h' = 0$), (6) states simply that adjusted nominal GNP growth must be a weighted average of trend unit labor cost ($w - \omega$) and the growth of nominal non-labor income relative to trend output (\hat{n}).

What are the implications of nominal wage rigidity for the cyclical behavior of employment (e')? Clearly there are no arithmetically necessary implications, because cyclical fluctuations in adjusted nominal GNP growth can be offset on the right-hand side of (6) by fluctuations in non-labor income and hours per employee without necessarily requiring an adjustment of employment. But, in an economic sense, the downward pressure on profits that occurs when a drop in nominal GNP is accompanied by a fixed wage bill must have allocative consequences if it persists for any length of time, at a minimum by influencing the subsequent allocation of capital. There is surely some drop in nominal revenue large enough to force firms to adjust the wage bill, either by wage cuts, "work-sharing" (reductions in hours per employee), or by a reduction in employment. The mixture of these three responses is the subject of an enormous liter-

ature in labor economics and depends on institutional features of given economies. For instance, the mix between wage (or bonus) cuts and temporary layoffs is very different in Japan and the United States, while work-sharing arrangements are still relatively rare in the United States (Robert W. Bednarzik, 1980) but more common in Europe (Sar Levitan and Richard Belous, 1977). Further, the responsiveness of the wage rate is likely to depend on the variance of demand, with nominal wage cuts most common when firms come perilously close to bankruptcy (e.g., Matthew Wald, 1980).

Thus, in a purely logical sense, economists like Barro and Hall are correct that there are no necessary implications of wage rigidity for employment fluctuations, as long as work-sharing is feasible. The link between wage rigidity and aggregate *hours*, however, seems much less controversial as long as profit fluctuations retain an allocational role. In any case, no consideration of profits or work-sharing is required to establish a link between price stickiness and output fluctuations as long as nominal GNP is taken to be the exogenous transmitter of demand shocks.

2. *Evidence on the Cyclical Adjustment of Prices*

An early set of historical studies was stimulated by the claim of Gardiner Means that "The shift from market to administered prices . . . is the development which has destroyed the effective functioning of the American economy and produced the pressures which culminated in the new economic agencies of government" (1935*a*, p. 8). The crucial piece of evidence provided by Means in support of his allegation was a study of the frequency of price change during the 1926-33 period for 747 items from the Bureau of Labor Statistics (BLS) Wholesale Price Index (1935*b*, p. 402). Fifty percent of the

747 items changed in price at the rate of less than once every four months, and 25 percent changed less than once every 10 months.

Means' findings generated a substantial controversy, and several papers denied his implication that "administered prices" were a recent or novel innovation. Using data previously compiled by Frederick C. Mills (1927), Don D. Humphrey (1937) showed that, in fact, a low frequency of price changes for finished goods was a longstanding phenomenon that dated back at least to 1890. He found no change at all in the degree of price flexibility in Mills' data for 1890–1925, and no important reason to believe that the nature of the price data studied by Means differed from that of Mills. Rufus Tucker (1938) went even further and claimed that the frequency of monthly price changes had remained essentially unchanged since 1791. In fact Tucker claimed that the major historical change had been a movement toward *more* price flexibility for raw materials, since there were virtually no prices that changed every month in the depression of 1837–44 in contrast to a substantial minority of 16 percent of Means' prices that changed almost every month during 1926–33.

During the postwar era there has been an increased concern with measurement issues that were largely ignored in the literature of the 1930s. Harry McAllister (1961) found a positive relationship between the frequency of price change and the number of companies reporting prices to the BLS for a given commodity, suggesting that a key reason for the low frequency of price change found by Means was a small sample size of reporting companies within each commodity class. In discussing McAllister's results, George Stigler and James Kindahl (1970, p. 20) state that they "effectively destroy the entire body of work resting upon frequency of price change," although it is surely rele-

vant for our subsequent theoretical discussion that any *single* company can be sufficiently immune to competitive forces as to allow a price to remain unchanged for considerable periods. A more important line of criticism of Means' work centered on the possibility that the list price quotations reported to the BLS fail to capture cyclical movements in discounts, terms of trade, and secret concessions. In a unique one-time comparison of actual and published prices of steel between 1939 and 1942 (cited by Stigler-Kindahl, 1970, pp. 17–18), the BLS found that the ratio of actual to published price ranged from 85 percent in mid-1939 to 100 percent in the prosperous period after mid-1940. Finally, in an ambitious project, Stigler and Kindahl collected price data from buyers that were compared to BLS seller's price data for the same commodities; the authors found that "cyclical conformity" (i.e., price declines in recessions) dominated perverse price movements in both the official BLS series and in their new data, with somewhat greater evidence of cyclical conformity in the latter.

A common defect of this entire empirical literature, for our purposes, is that it asks the wrong question. What is crucial is not the frequency of price change nor the degree of cyclical conformity, but rather the "coefficient of partial price adjustment," α in equation (4) above. Tabulations of the frequency of price change tell us little, since prices might change seldom but by large amounts, or frequently but by very little. Similarly, the tabulations by Philip Cagan (1975) showing a diminished frequency of actual declines in nominal prices in successive postwar recessions are of little interest, since what matters is the relationship of price behavior to exogenous nominal spending changes. If an anti-inflationary policy involved an instantaneous and permanent drop in adjusted nominal GNP growth from 10 to 5 percent, that policy would

succeed without any cost in lost output if the rate of inflation of all prices decreased from 10 to 5 percent; yet no single price would have exhibited an actual decline.

3. *New Evidence on the Coefficient of Price Adjustment*

An interesting measure of the coefficient of price adjustment can be obtained from a regression of the rate of price change on the adjusted change in nominal GNP, lagged price change, and other variables believed to influence the price-change process.³ I have recently found that the first-year adjustment coefficient is roughly one-third, both over the entire 1892–1978 interval and over three sub-periods broken in 1929 and 1953, with the exception of a much greater coefficient during and after World War I (Gordon, 1980*a*). The major change in cyclical behavior has not been a secular decline in the first-year adjustment coefficient, as implied by the work of Means and Cagan, but rather a change in the nature of the price response in the second and subsequent years. Before 1953 there was no influence of lagged price change on current price behavior; prices changed by about one-third of any change in adjusted nominal GNP growth, with no delayed adjustment. After 1953, however, much of the adjustment was delayed until subsequent years, as signified by a large coefficient of 0.7 on lagged price change. I have attributed this shift to the influence of two innovations of the postwar era, three-year staggered wage contracts and the permanent shift from the gold standard to a fiat money standard.

Another description of the evolution of the adjustment coefficient (α) in the

United States since 1892 can be provided through the use of a new set of quarterly historical data on important aggregate magnitudes.⁴ TABLE 1 presents regression results in which the quarterly change in the GNP deflator (p) is regressed on the current and seven lagged values of adjusted nominal GNP change (\hat{y}). To simplify the presentation other variables that play a role in the inflation process are omitted, with the exception of dummy variables to capture the impact of important episodes of government intervention. Each of these dummy variables is defined to sum to zero, and its coefficient indicates the total cumulative displacement of the price *level* during the period when the program was in effect, a displacement that is assumed to have been completely eliminated when the program was removed (for details see note *b* in TABLE 1). Note that there is no lagged dependent variable; inertia in the inflation process would appear as a string of positive coefficients on the lagged nominal GNP variable.

The results are summarized on lines 4*a* and 4*b*, where the sums of the adjustment coefficients for the first four quarters and second four quarters are listed. Four major conclusions stand out. First, during all periods except for World War I and its aftermath, the first-year elasticity of price response was well below unity, ranging from 0.23 in column (1) to 0.44 in column (5). Second, the first-year adjustment coefficient during and after World War I was a much greater 0.81. Third, there is no evidence of increased rigidity of prices, with the first-year response after 1953 almost double the first-year response before World War I. Finally, the second-year response was negligible before 1953 but af-

³ These other variables include the ratio of actual to natural real GNP, changes in the relative prices of food and energy, and dummy variables for government intervention similar to those listed in TABLE 1.

⁴ These convert published annual series on the GNP deflator and real GNP into quarterly series by using as interpolators published monthly series on wholesale prices, consumer prices, industrial production, and retail sales. Details are provided in the data appendix to Gordon (1981*a*).

TABLE 1
RESPONSE OF PRICE CHANGE TO ADJUSTED NOMINAL GNP CHANGE, VARIOUS
INTERVALS, 1892-1979

Dependent Variable: Quarterly Percentage Change in GNP Deflator Expressed as an Annual Rate
[*t*-ratios in brackets]

	1892:Q1 -1914:Q4 (1)	1915:Q1 -1922:Q4 (2)	1923:Q1 -1941:Q4 (3)	1942:Q1 -1953:Q4 (4)	1954:Q1 -1979:Q4 (5)
1. Constant term	.891 [1.61]	.062 [0.03]	.161 [0.40]	2.57 [3.18]	1.16 [3.93]
2. Adjusted nominal GNP change ^a					
a. Current	.094 [2.99]	.406 [4.56]	.149 [6.61]	.260 [4.26]	.219 [4.81]
b. One-quarter lag	.025 [0.81]	.197 [2.04]	.105 [4.57]	-.068 [-1.03]	.075 [1.54]
c. Two-quarter lag	.061 [1.96]	.125 [1.32]	.085 [3.56]	-.001 [-0.01]	.059 [1.18]
d. Three-quarter lag	.050 [1.59]	.082 [0.85]	.019 [0.82]	.106 [1.53]	.086 [1.77]
e. Four-quarter lag	.056 [1.79]	.006 [0.06]	.015 [0.64]	.052 [0.86]	.102 [2.11]
f. Five-quarter lag	.031 [1.03]	-.133 [-1.30]	.004 [0.19]	-.091 [-1.51]	.091 [1.91]
g. Six-quarter lag	-.027 [-0.89]	.099 [0.95]	.027 [1.15]	.047 [0.82]	.086 [1.29]
h. Seven-quarter lag	.003 [0.10]	.125 [1.32]	-.009 [-0.39]	.051 [0.96]	.077 [1.72]
3. Intervention dummy variables ^b					
a. NRA	—	—	5.54 [4.53]	—	—
b. World War II controls	—	—	—	-16.4 [-10.3]	—
c. Korean war controls	—	—	—	-3.62 [-2.34]	—
d. Nixon controls	—	—	—	—	-4.13 [-6.49]
4. Summary of adjust- ment coefficients					
a. First four quarters	.230	.810	.358	.297	.437
b. Next four quarters	.063	.097	.037	.059	.356
5. R ²	0.19	0.74	0.76	0.84	0.69
6. S.E.E.	5.24	9.11	3.45	3.65	1.58

Notes to Table 1

^aThis variable is the rate of change of nominal GNP, minus the rate of change of "natural real GNP," constructed by a technique described in Gordon (1981*b*, Appendix C).

^bThe dummy variables are defined to sum to 4.0 during the period when the intervention program was "on" and to -4.0 during the period when the program was removed (the summation multiplies each value listed below by the number of quarters during which it is in effect). The detailed definitions are as follows:

NRA: 1933:Q3 = 2.8. 1933:Q4-1934:Q1 = 0.6
1934:Q4-1935:Q2 = -0.8 1935:Q3 = -1.6.

World War II: 1942:Q2-1945:Q2 = 4/13.
1945:Q4-1946:Q2 = -0.4.
1946:Q3 = -2.8.

Korean war: 1950:Q3-1951:Q1 = -4/3. 1951:Q2-1953:Q2 = 4/9.

Nixon controls: 1971:Q3-1972:Q4 = 4/6.

1974:Q2-1975:Q1 = -1.

The Korean war configuration reflects the assessment that the controls during the 1951-53 period simply offset the speculative overshooting of the price level that occurred in the first three quarters of the war.

terward was almost as large as the first-year response.

These results only hint at the interesting features of quarterly U.S. price behavior over the past century, and a full analysis is beyond the scope of this paper (for a more complete evaluation see Gordon, 1981*a*). A fuller understanding of price and output fluctuations in episodes like 1915–22 or 1929–33 may require going beyond our simplifying assumption that nominal GNP is exogenous. Since some portion of military orders in World War I were for physical quantities of munitions, for instance, nominal spending had to increase in response to the higher prices generated by the continuing attempt of government purchasing agents to extract a rising share of real industrial capacity. Keynes and some other economists believed that greater downward flexibility of prices during the Great Depression would have caused a greater drop in nominal spending, rather than greater stability in real GNP as implied by equation (4). Nevertheless, allowance for a partial feedback from prices to nominal GNP would not change our overall conclusion that the first-year adjustment coefficient is relatively small in normal peacetime periods but is capable of jumping to a number much closer to unity during a special period like 1915–22.⁵

III. *The Intellectual Inheritance*

1. *Keynesian Theory and Its Postwar Development*

In the first decade of the postwar era most discussions of aggregate supply revolved around a knife-edge model describing an economy that suffered from either a “deflationary gap” or “inflationary

⁵ I have emphasized previously the importance of treating 1915–22 as a “special period” in studies of the Gibson paradox and of the relationship between interest rates and inflation expectations. See Gordon (1973).

gap” but was rarely at the delicate point of balance between them. The “gap” terminology was itself ambiguous, because a “deflationary gap” was accompanied not by deflation of prices but rather by unemployment and relatively stable prices. The rigidity of prices in underemployment, according to many economists, cut off the private economy’s rudder of automatic stabilization and inevitably led to the conclusion that government intervention was necessary to avoid high unemployment.⁶ The assumption of price rigidity, built into early postwar discussions of the Keynesian multiplier, was hard to reconcile with Keynes’ own treatment of the labor market in *The General Theory*, where competitive firms faced a horizontal labor supply curve at the level of an arbitrarily fixed nominal wage and voluntarily selected the quantity of labor input along a downward-sloping Marshallian labor-demand curve. Changes in employment would be accompanied by *countercyclical* movements in the real product wage and a product price level that was not rigid but, rather, fluctuated *procyclically*.

A first round of critical reactions to *The General Theory* questioned the empirical validity of the countercyclical real-wage assumption (John Dunlop, 1938; Richard Ruggles, 1940; Lorie Tarshis, 1938). Almost immediately, Keynes issued a retraction claiming that the assumption had been included in *The General Theory* only as a sop to traditional economists like Pigou to make the rest of the book more acceptable, and that he was quite happy to accept a cyclically constant real wage and to push the entire burden of explaining employment fluctuations onto movements in effective demand:

If at the present stage of the inquiry, we are to make any single statistical generalization, I should prefer one to the effect that, for fluctua-

⁶ A more complete account of the postwar development of ideas about the supply and demand sides of macroeconomics is contained in Gordon (1980*b*).

tions within the range that has been usual in the periods investigated which seldom approach conditions of full employment, short-period changes in real wages are usually so small compared with the changes in other factors that we shall not often go far wrong if we treat real wages as substantially constant in the short period (a very helpful simplification if it is justified). (Keynes, 1939, pp. 42–43).

In the same paper Keynes also cut the ground out from those who had interpreted him (and some who *still* interpret him) as having assumed a fixed wage, since he explicitly allowed both wages and prices to vary proportionately over the cycle.⁷

Simultaneously with the first round of controversy over the empirical behavior of the real wage, the investigations of R. L. Hall and C. J. Hitch (1939) brought into the economic mainstream the old business-school textbook idea that prices were set as a mark-up over “full cost,” i.e., average variable plus “normal” fixed costs, in contrast to the Marshallian doctrine that marginal revenue was equated to marginal cost (Heflebower, 1955, pp. 361–64). The full-cost-pricing doctrine won wide acceptance, partly because its implicit framework of monopoly price-setting was more compatible with the non-market-clearing environment of *The General Theory* than Keynes’ own assumption of atomistic competitive firms, and partly because its cost-based procedure of mark-up price determination was consistent with the evidence supporting Means’ administered-price hypothesis. For most of the postwar period the hypothesis of mark-up pricing rested more on the twin pillars of two empirical investigations (Means and Hall-Hitch) than on any reasoning about the maximizing behavior of individual economic agents, although,

⁷ “To state the case more exactly, we have five factors which fluctuate in the short period with the level of output.” Of these the third factor is “the marginal wage cost.” (Keynes, 1939, p. 50).

more recently, attempts have been made to provide the necessary theoretical setting (Edmund S. Phelps and Sidney G. Winter, 1970; William D. Nordhaus, 1972; Arthur M. Okun, 1975).

As technical improvements in electronic computers made their development feasible, a succession of econometric models in the 1950s and 1960s first duplicated and then improved on the theoretical framework of the time. After a few crude initial attempts that included a rigid wage, virtually all models—including the seminal effort of Lawrence Klein and Arthur Goldberger (1955) that predates the Phillips curve—made the rate of change of the nominal wage an endogenous variable responding to the volume of unemployment and past changes in the price level. Thus Phillips’ celebrated article in 1958 provided a name and a historical context for a relationship between wage change and unemployment that had already been incorporated into econometric models and that had, in fact, been discovered much earlier by Irving Fisher (1926).⁸ When combined with an equation that determined the price level as a “normal full-cost mark-up” over the wage rate and prices of raw materials, the Phillips curve wage equation provided a consensus description of inflation dynamics that formed the basis for the economic policy prescriptions of the 1960s.

It was Don Patinkin who was first able to provide a theoretical analysis of the labor market that was consistent with mark-up pricing behavior and the empirical finding that the real wage was stable over the cycle rather than varying countercyclically. His insight (1956, Chapter 13) was to see that firms that recognize a sales constraint on output at a given level of wages and prices will be forced to operate off their classical labor demand curve. Robert

⁸ See Friedman (1976, pp. 215–21) for an interesting comparison of the Fisher and Phillips contributions.

Clower (1965) made the parallel point that consumers could not be assumed to translate their Walrasian demand for consumption goods into an effective demand if they were not able to obtain their preferred quantity of employment and wage income in the labor market. Clower coined the term "effective demand curve" to describe the situation of an agent in the labor or product market who was unable, at the going price and wage vector, to sell the desired amount in the other market; as distinguished from the conventional "notional" curves describing behavior with instantly flexible prices to guarantee continuous market clearing. The contributions of Patinkin and Clower were elegantly brought together and synthesized by Barro and Grossman (1971; 1976, Chapter 2), who used the "Hicksian fix-price method" to analyze the establishment of a general equilibrium through the interaction of quantity constraints in the labor and product markets. While the Barro-Grossman synthesis presented a much more satisfactory story of the relationship between markets than the standard version of the 1950s and 1960s, it nevertheless raised more questions than it answered. The crucial question was not what happened *when* prices and wages were arbitrarily assumed to be fixed, since the meaning of quantity constraints had been understood since the 1930s, but rather *why* prices and wages failed to move to clear markets.

2. *From the Natural Rate Hypothesis to the New Classical Equilibrium Paradigm*

At roughly the same time that Clower was reacting against the textbook Keynesian model, Phelps (1967) and Milton Friedman (1968) were reacting against the then-popular view that policymakers could, in the language later used by Robert Lucas, "buy a permanent economic high," i.e., a permanent situation of high

output with stable inflation. Instead, Friedman and Phelps held that, below a critical "natural rate of unemployment," the inflation rate would accelerate continuously, leading the new doctrine to be dubbed, alternatively, as the "accelerationist" or "natural rate" hypothesis. In one brilliant stroke, Phelps invented the "expectational Phillips curve" on which recent textbook and econometric discussions are based; at the same time, by dealing only in reduced-form equations and by avoiding any explicit specification of labor-market behavior, he did not align himself with a particular market-clearing or non-market-clearing model.

Phelps' paper was less noticed than Friedman's, probably because the former's invention of the expectational Phillips curve was imbedded in a relatively dry and technical exercise in optimal control theory, although a second paper brought the main point to a wider audience (1968). It was Friedman's shorter and more readable paper (1968), his 1967 presidential address to the American Economic Association, that probably deserves to be labelled the most influential article written in macroeconomics in the past two decades. In retrospect it can be viewed as part of a long-term research program to subsume Keynesian economics within a resuscitated quantity theory of money. This process, begun earlier with his generalization of the quantity theory demand for money function (1956), continued with the presidential address, which had been motivated by the sharp conflict between the Phillips curve and the quantity-theory tradition of monetary neutrality with respect to real quantities.

For our purposes the crucial feature of Friedman's address was its methodological assumption of continuous market clearing in competitive labor and product markets, in contrast to the non-market-clearing analysis of Patinkin and Clower.

Friedman's labor-market analysis explicitly assumed that both the demand for and supply of labor depended on the real wage. Since firms calculated the real wage by evaluating the nominal wage in terms of the current product price, while workers evaluated the nominal wage in terms of the expected future price of consumer goods, employment could increase in the face of a rise in product prices only as long as worker expectations lagged behind. In long-run equilibrium the expected and actual price level would be equal at only one possible "natural" level of employment and output. Since both firms and workers exhibited competitive maximizing behavior, given the structure of expectations imposed upon them, a necessary condition for cyclical expansions became the "fooling" of workers. Workers failed to notice price changes in their after-work journeys to the supermarket, an information structure that Friedman defended by arguing that "employers may have the same anticipations as workers about the general price level, but they are more directly concerned about the price of products they are producing and far better informed about that. They will initially interpret a rise in the demand for and price of their product as a rise in its relative price" (1976, p. 223). Friedman's distinction between relative prices and the general price level foreshadowed the distinction between local and aggregate information that plays a prominent role in Phelps' (1970) "island parable," the new classical equilibrium analysis of Robert Lucas, and our subsequent discussion in Part VII.

Friedman's model can be reduced to a single reduced-form equation if we combine the labor supply and demand schedules, substituting out the nominal wage rate, and if we use a production function to translate labor input into output:

$$\hat{Q}_t = \gamma[P_t - E(P_t)], \quad (7)$$

where $\hat{Q}_t = Q_t - Q_t^*$ is the current ratio of actual to natural real output, P_t is the current aggregate price level, and $E(P_t)$ is the price level expected by workers to obtain during the current period. (All upper-case letters again represent logarithms of levels.) When expectations are accurate, therefore, the output ratio (\hat{Q}_t) must be zero. An important feature of (7) is the direction of causation, from price movements to an output response, in contrast to Phelps' expectational Phillips curve in which a non-zero output ratio generates an adjustment in the inflation rate.

Although (7) is now usually called the "Lucas supply function," it really should be called the "Friedman supply function." The contribution of the new classical equilibrium macroeconomics built by Robert Lucas (1972; 1973) and his followers was to demonstrate the radical implications of (7) for economic policy rules which react to past values of variables like unemployment and inflation (so-called "feedback" rules), when the expected price level is formed "rationally" in the sense of John F. Muth (1961) as an unbiased predictor of the actual price level, given all information available just before the current period begins. Equation (7) states that the monetary authority can change output only if it can find some "handle" which moves P_t while not simultaneously moving $E(P_t)$ by the same amount. But if the public can analyze the feedback rule and predict how money will behave in a given situation, and if it also knows the structural connection between money and the price level, any predictable monetary change must create a contemporaneous and fully proportional response of all nominal variables (prices, expected prices, and nominal GNP) while leaving output and all other real variables unaffected. Because it was first explicitly stated by Thomas Sargent and Neil Wallace (1975), using the supply function (7) that they attributed to Lucas,

this conclusion is often called the “policy-ineffectiveness” or “Lucas-Sargent-Wallace” (LSW) proposition.⁹

The validity of the LSW proposition depends on three critical ingredients—rational expectations, the supply function (7), and continuous market clearing. When (7) is combined with another approach to expectation formation, e.g., a mechanical formula like adaptive expectations, the monetary authority can vary money and the current price level without causing an instant offsetting movement in the expected price level. In Friedman’s address, where (7) was implicitly combined with adaptive expectations, the monetary authority loses its control over output only in the long run, not in the short run. Just as crucial for LSW is the supply function (7), with its price-taking agents and continuously clearing markets. When combined instead with sluggish price adjustment and markets that do not clear continuously, the hypothesis of rational expectations does not imply the LSW proposition. If, for instance, price change were an average of current nominal GNP change and lagged price changes with weights α and $1 - \alpha$, then a rational expectation of price change would respond to predictable changes in nominal GNP only in a proportion dictated by the adjustment coefficient α . Unless α were exactly unity, the monetary authority would be able to manipulate quantity constraints in the face of fully rational expectations (Gordon, 1976, p. 204; Fischer, 1977).

The LSW revolution dominated macroeconomic discussions in the late 1970s, from the level of popular summaries in *Business Week* and *Fortune* to esoteric dissertations and articles written on prob-

⁹ Lucas currently prefers to stress as the main contribution of his papers (1972, 1973) the construction of plausible models of the business cycle based on competitive maximizing behavior and tends to deemphasize the policy implications analyzed by Sargent and Wallace.

lems of theoretical stability and econometric testing within the context of the equilibrium model. But by the end of the decade it became apparent that the revolution had misfired, and doubts began to appear even in survey articles by adherents of the new framework.¹⁰ The basic problem originated in the continuous market-clearing structure inherited from Friedman, which made deviations of the current local price relative to the expected aggregate price the *only* source of business-cycle movements in the output ratio. The implication is that business cycles would be eliminated if we had accurate current information about the aggregate price level, and if rational LSW agents were smart enough to know that they could avoid departures from their own most efficient levels of activity if they carefully monitored published aggregate price information. Rationality, combined with Friedman’s continuous market-clearing assumption, left equilibrium theorists floundering for an explanation of persistent, serially-correlated business-cycle movements that did not violate rationality or the known availability of current aggregate price information.

IV. *Information Barriers with Price-Taking Agents*

An important reason for the instant popularity of the new classical equilibrium framework was the elegance of its theoretical models and the appeal of a paradigm

¹⁰ For instance, McCallum wrote that “in view of the foregoing discussion . . . it seems difficult to sustain the position that the policy ineffectiveness proposition is applicable to the U.S. economy” (1980, p. 40). Barro, in discussing the ease with which agents could identify an unobservable monetary aggregate by monitoring movements in the nominal interest rate, admits “these results indicate the uneasy balance in modeling strategy here between allowing for private incentives to develop markets or other institutions that disseminate information and the necessity for retaining information gaps that allow for business cycle effects of monetary disturbances” (1979, p. 15).

that claimed to base its aggregate supply framework on the maximizing decisions of rational individual agents. On closer examination, however, the theoretical underpinnings of the new framework are weaker than is generally supposed. Since future model-building efforts can be aided by a study of the weaknesses and strengths of these seminal papers, we examine the underlying assumptions of the much-cited models of Lucas (1972, 1973, 1975) and Barro (1976). The criteria of evaluation are correspondence to observed facts and the avoidance of arbitrary *ad hoc* impediments to Walrasian behavior.

1. *The First Lucas Model*

“Expectations and the Neutrality of Money,” published by Lucas in 1972, is generally considered to be the foundation of the new classical equilibrium macroeconomics. It was the first paper in macroeconomics to derive a Phillips curve with all agents behaving optimally and all expectations formed rationally. In one sense it was a rigorous elaboration of Friedman’s address and Phelps’ “island parable” (1970), with several novel features that were picked up by subsequent writing in the equilibrium tradition. Phelps’ parable had introduced information islands where agents were sealed off from any awareness of aggregate phenomena, whereas Lucas’ agents were fully aware of the aggregate structure of the economy but were unable, instantaneously, to distinguish aggregate from local shocks due to an arbitrary one-period lag in the dissemination of aggregate information. As in the Friedman address, shocks were communicated to price-taking agents solely by price movements coming from the outside.

The theoretical setting is a Samuelson overlapping-generations model with young and old generations consuming, but only the young producing, a homogeneous service. Each time period of the model’s evolution begins with the transfer to the

old generation of fiat money balances, taking the form of a random, proportional increase in the balances that they had previously saved while young. The old spend their augmented balances on purchases of output from the young and do not leave any bequests. A random real fluctuation is introduced in the form of a stochastically variable share of the population of young people on the two otherwise identical islands. The decision problem faced by the young is how much to produce, i.e., how hard to work. The greater one’s labor income is while young, the more one will save and the greater will be the base to which the random, proportional monetary transfer will be applied. But the intertemporal maximization decision requires a guess about the next period’s price level, i.e., about how much real consumption the augmented money balances will be able to purchase.

The resulting output supply equation has the same form as (7). Output increases if the current price rises relative to the expected price next period, because then capital gains will be made on the money balances accumulated while young. Suppose the old benefit from a large current money transfer, and suppose this produces a high price for the current services of the young. If the young were aware of the basis for the high price of their services, there would be no supply response. They would recognize that all of their cohort had shared in this nominal windfall, they would all carry over high balances into their old age, and would dissipate their high nominal balances through high prices paid for the given expected output of the next period’s young generation. But another source of a high current price could be a real fluctuation, a small cohort of current young people on the island, leading to the expectation that in the next period the random cohort of young people would be of normal size and, thus, the greater supply of output at that time

would lead to lower prices and a capital gain. Lucas argues that because the current price is observed, while the current monetary transfer and population distribution are not, young people uniformly assign a positive probability to the chance that a high price level is caused by a low population of young people and respond by increasing their work effort.

This model introduced several common features that were picked up in subsequent papers. First, the positive response of current output to the current price level stems entirely from intertemporal speculation. Second, producing agents observe only their own price, and are arbitrarily cut off from information about the two determinants of that price: that is, the population size of their own cohort and the transfer receipts of the older generation. Lucas' agents live in a peculiar world in which young people are unable or unwilling to pay for either a current population survey or current monetary statistics, even though it would be in their interest to do so. Thus, ironically, Barro's critique leveled at the non-market-clearing literature—that underemployment is due to the nonrealization of mutually advantageous trades—seems equally applicable to the failure of Lucas' agents to invest in obviously useful information.

Despite this criticism the Lucas approach incorporates an important distinction between the variance of local and aggregate information that seems central to an explanation of changes in the degree of price flexibility over time and across countries. The basic idea is that the voluntary decisions of economic agents to change the level of output depends on their perception that the relative price of their product has changed. This relative price is the ratio of a local nominal price to an aggregate nominal price. While agents can observe their own local price, it is harder (at least within the restrictive information framework that Lucas im-

poses) to obtain timely and accurate information about the aggregate nominal price. Each agent must decompose a currently observed local nominal price, based on past relations between the relative variance of the local and aggregate price levels. Some agents, operating in markets where changes in local prices are normally large compared with prices in general, will naturally tend to interpret an observed local price change as a change in the *relative* price and will act upon this supposition by altering the level of production. Other agents will have the opposite experience: finding that in the past their own prices have varied less than aggregate prices, they will interpret an observed local price change as a reflection of a general price movement and will not alter the level of production. While such differences in experience can distinguish one market from another, the same difference can also distinguish different macroeconomic circumstances. A recent experience of highly variable aggregate price movements—or the apprehension of a new situation, e.g., wartime printing-press money creation—can lead agents to believe that a larger proportion of observed local price movements are widespread and do not, consequently, justify a change in the level of production.

In an influential paper, Lucas further developed and tested this idea that the slope of the aggregate supply schedule depends on the variance of aggregate demand shocks (1973). He wrote the supply function of the individual agent in the same form as (7), with an additional lagged output term to help to explain the observed persistence of output (this will be discussed in the next section):

$$\hat{Q}_t(z) = \gamma [P_t(z) - E(P_t | I_t(z))] + \lambda \hat{Q}_{t-1}(z), \quad (8)$$

where z is an index for local markets, E is the mathematical expectations operator, and I_t is the information available on

the aggregate price level, P_t , at the beginning of the period in market z . Traders begin each period with a knowledge of past history that reveals to them a prior normal distribution on the aggregate price level P_t having a mean \bar{P}_t and a variance σ^2 . The deviation of the price in market z is assumed to be distributed independently of the aggregate price index, with a percentage deviation z (so that markets are indexed by their price deviations from average), where z is an independent normal distribution with mean zero and variance τ^2 . Suppliers use this information to calculate the distribution of the expected aggregate price level P_t that appears in (8):

$$\begin{aligned} E(P_t | I_t(z)) &= E(P_t | P_t(z), \bar{P}_t) \\ &= (1 - \theta)P_t(z) + \theta\bar{P}_t, \end{aligned} \quad (9)$$

where $\theta = \tau^2 / (\sigma^2 + \tau^2)$. When (9) is substituted into (8), the individual firm's supply curve becomes:

$$\hat{Q}_t(z) = \theta\gamma[P_t(z) - \bar{P}_t] + \lambda\hat{Q}_{t-1}(z), \quad (10)$$

and the aggregate supply curve is then

$$\hat{Q}_t = \theta\gamma[P_t - \bar{P}_t] + \lambda\hat{Q}_{t-1}. \quad (11)$$

The key insight here is that the slope of the aggregate supply function varies with the coefficient θ which, in turn, is equal to the fraction of total local price variance that is due to the variance of the relative price. When the aggregate price variance is relatively high (as in a wartime situation or hyperinflation), agents will have cause to believe that the observed movements in the local price are most likely caused by aggregate-nominal rather than relative-real disturbances. The θ coefficient, which then approaches zero, reflects that belief, and the aggregate supply curve approaches a vertical slope. The predicted coefficient of price change on current nominal GNP change in regressions like those in TABLE 1 above is $1/(1 + \theta\gamma)$, with a coefficient of $\theta\gamma/(1 + \theta\gamma)$

on lagged nominal GNP change. Thus, as the variance of aggregate nominal shocks becomes large, we would observe θ approaching zero, the coefficient on current nominal GNP approaching unity, and the coefficient on lagged nominal GNP approaching zero. Since this, in fact, occurred in the 1915–22 period for the U.S., in TABLE 1, Lucas' 1973 distinction between relative and aggregate price variance may be central to the questions we have set out to answer in this paper.

The new classical equilibrium model was further developed in subsequent papers. Barro (1976) introduced a symmetric treatment of supply and demand, with a positive speculative supply response to a high current relative price balanced by a negative demand response. In addition, a real-wealth variable was entered symmetrically, with a positive effect on commodity demand and a negative effect on commodity supply. The Barro generalization clarified the sign conditions on the substitution and wealth elasticities in the commodity supply and demand functions that were necessary for the unperceived part of the current money stock to have the expected positive impact on current output. Lucas, who did not incorporate a substitution effect on the demand side or a real-wealth effect on the supply side, had simply assumed the required sign pattern to be satisfied.

2. The Persistence Dilemma

A crucial weakness of the Lucas (1972) and Barro (1976) papers is that there is no device to generate persistence of output movements as observed in real-world business cycles. The divergence of output from the "natural" level in the Lucas version (1972) depends only on an expected capital gain, and there is no relationship between the expected capital gains in two successive periods, because the exogenous variables that change prices are serially independent. The basic dilemma thus

posed for the Lucas-Barro approach is this: allowing for serial correlation in the exogenous variables would improve the ability of agents to make accurate forecasts, and it would then be harder to account for deviations of output from the equilibrium level in the first place; yet, without serial correlation the model cannot generate persistence in those output deviations.

In the 1973 Lucas paper, discussed in the preceding section, persistence is explained by the lagged-output term in (8). Yet this version of the supply function is merely presented to the reader rather than derived from maximizing behavior. While the 1972 paper is cited as the source for the speculative term in square brackets, the only basis cited for the additional lagged-output term is a previous empirical result by Lucas and Leonard Rapping.¹¹ As James Tobin has commented, this lagged-output specification "is an intrusion in the standard model; it has no relation to rational expectations, and so far as I can see very thin intrinsic justification" (1980, p. 791).

A second approach to the explanation of persistence within the context of the new classical models, in addition to the unexplained introduction of a lagged-output term as in (8), above, was introduced by Lucas in 1975. In that paper he allowed output to depend both on the current labor-supply decision and on the stock of capital carried over from last period. A nominal demand shock would create both high labor supply and high investment in period 1, which would endow the economy with a higher capital stock in period 2. Since the extra capital would raise the productivity of workers, output would increase in period 2 even if there is no price surprise. A fundamental weakness in this

approach is the clear incentive for any agent, who knows from past history that he has often erroneously reacted to price movements that later turned out to be caused by nominal rather than real shocks, simply to *wait* for the duration of the information lag to receive news on the aggregate money stock before implementing investment decisions. Given the minimal length of real-world information lags relative to ordering and construction lags on investment projects, there seems to be virtually no room for the sort of error-laden investment cycle that Lucas has in mind.

A more convincing method of coaxing persistence out of the equilibrium model has been developed by Alan Blinder and Stanley Fischer (1979). Any costs of adjusting production, such as the employment adjustment costs discussed by Sargent (1979, Chapter XVI), would lead to a policy of production-smoothing. In response to a price surprise in a Lucas-type setting, firms would raise production less than sales, accommodating a portion of the extra sales by a reduction in inventories of finished goods. Even if there is no price surprise in the second period, the stock of inventories would be below the initial level, and output would be raised above normal to allow restocking, thus introducing a positive correlation between output in the first and second periods. Since the restocking period could take any number of periods, the Blinder-Fischer model can incorporate any degree of positive serial correlation in output. Although promising as a theoretical device, this approach does not appear to have much payoff in making the equilibrium approach compatible with the observed facts of U.S. business cycles. Periods during which inventories are out of equilibrium in U.S. data have much shorter frequencies than business cycles, and for periods of many quarters the inventory-sales ratio has remained roughly constant while the log output ra-

¹¹ As Barro has pointed out (1979, footnote 1), the appearance of $E(P_t)$ in (8) is formally incompatible with the 1972 paper, where intertemporal substitution requires a comparison of the current relative price with the expected *future* price $E(P_{t+1})$.

tio (\hat{Q}_t) has remained substantially above or below zero (examples are 1961–64, 1967–69, and 1976–77). Inventory disequilibria may have contributed to the amplitude of cycles, of course, and may have been of central importance in minor recessions like those of 1924 and 1927.

3. *Sluggish Price Adjustment and the Demise of the Friedman-Lucas Supply Function*

In the minds of some critics of the new classical equilibrium models, problems of arbitrary information-exclusion and an inability to explain persistence are secondary to the most basic problem of all: the assumption of instantaneous market-clearing. Observers who believe that prices adjust sluggishly rather than instantly thus tend to dismiss the new classical models and to deny any practical relevance to the LSW policy ineffectiveness proposition. In a series of papers, McCallum has argued to the contrary: “recognition of price level stickiness does not, in and of itself, negate the Lucas-Sargent proposition” (1977, p. 633).

The essence of the argument in McCallum (1977) is that a model can be built incorporating a supply function like (7) above, a quantity-theory nominal-demand equation, and a price-adjustment equation of the form:

$$P_t = \eta P_t^* + (1 - \eta)P_{t-1} \quad 0 < \eta < 1, \quad (12)$$

where P_t^* is the market-clearing price that would set the log output ratio (\hat{Q}) at zero. The expectation of the price level $E(P_t)$ is simply (12) with the expected value $E(P_t^*)$ substituted for the actual market-clearing price P_t^* (the expected value of the lagged term P_{t-1} is, of course, equal to the true value). This means that output, which depends in (7) on $P_t - E(P_t)$, must, through (12), depend on $\eta[P_t^* - E(P_t^*)]$. But since P_t^* depends on the actual money stock while $E(P_t^*)$ depends on the ex-

pected money stock, their difference—and thus output—depends only on the unexpected component of the money stock, exactly the point of the LSW proposition.

Although this argument looks convincing, at first glance, its tight logic is based on a flawed model that implies absurdly irrational behavior on the part of businessmen and women. The Lucas supply function (7) cannot be combined with a gradual-price-adjustment equation like (12). This counterargument is easiest to see if we assume that $\eta = 0$ in (12), so that the price level is completely fixed. Then, as I have argued previously:

consider a policy which cuts nominal expenditure by half from E_0 to $.5E_0$. According to the McCallum argument, if prices are rigid the price level, unemployment, and output remain at their original level. . . . Production is double the level of sales, and so an involuntary accumulation of inventories occurs and continues as long as E remains low and P remains rigid. Retention of the Lucas supply function in the face of price rigidity thus leads to the counterfactual conclusion that businessmen never cut production in response to involuntary inventory accumulation! [Gordon, 1977, p. 132]

Roman Frydman (1981) has developed a formal statement of the same criticism of McCallum's argument and has shown that when production is allowed to adjust to deviations of inventories from their desired level, the LSW proposition loses its validity.¹² The nature of the flaw in McCallum's claim suggests two interesting

¹² When Frydman's paper was presented at the NBER conference on Rational Expectations and Inventory Behavior at Princeton in March, 1980, McCallum admitted, orally, that his 1977 and 1978 models were “flawed.” In his 1981 survey paper he has reconstructed a valid argument supporting the LSW proposition for prices that are rigid for a single period, but which are then free to jump by any amount in the next period. This type of one-period rigidity does not seem to have any empirical relevance to the aggregate U.S. economy, and one-period rigidity for a single firm would turn into a distributed-lag, aggregate-adjustment process when fed through an input-output table by the process proposed in Part VII below.

aspects of the dichotomy in macroeconomic theory during the past decade. First, the casual use of the Friedman-Lucas supply function in combination with an arbitrary price-adjustment formula neglects the fact that the supply function is not a universal statement about the behavior of optimizing agents. In fact it is a reduced form derived by Lucas (1972) on the basis of a restrictive set of assumptions, and it loses its validity if those assumptions—particularly instantaneous price flexibility and market clearing—are violated. A second and related point is that classical equilibrium theorists seem to have lost sight of the basic contribution of the work by Clower and Barro-Grossman. Even if those papers do not explain where price rigidity comes from, they are quite correct in showing where it leads—to quantities that are constrained rather than voluntarily chosen.

The new classical equilibrium models have generated a growing industry devoted to empirical testing of its main propositions, and a number of interesting econometric issues have emerged that are beyond the scope of this paper (see Barro, 1979*b*; McCallum, 1979; and Gordon, 1981*a*). But, recently, John Boschen and Grossman (1980) have devised an ingenious test based on the use of data on contemporaneously available money-stock estimates and subsequent revisions to the preliminary estimates. Their results appear to deny the underlying information structure built into Lucas (1972), and all subsequent theoretical models in the classical tradition, which assume that available data provide no information on current monetary aggregates but that they provide full and accurate information on past monetary policy. On this basis the models derive the result that monetary policy can influence aggregate output only if it is at least partly unperceived and they imply Boschen and Grossman's "hypothesis I," that the first preliminary estimate of U.S. money-stock data, which is

obviously perceived, must have no influence on output; this hypothesis is decisively rejected by Boschen and Grossman in postwar U.S. data. A parallel implication of the models is that the unperceived component of the current money stock—measured as the difference between the preliminary and final estimates of the money supply for a given period—should positively affect output, and this hypothesis II is rejected as well.

V. *Price Adjustment Models in a Non-market-clearing Setting*

In the conclusion to their empirical paper, Boschen and Grossman not only declare the equilibrium models to be empirically unconvincing, but they also reject non-market-clearing approaches as relying on "biased expectations or on the widespread failure of economic agents to realize perceived gains from trade." With nowhere to go, they conclude that "the business cycle, consequently, seems mysterious" (p. 30). Can the extensive literature on price adjustment in a non-market-clearing or "disequilibrium" setting be so easily dismissed? In this section we review a few of the major contributions in this area during the past decade, asking in each case whether an explanation has been found for price stickiness that is derived from maximizing behavior rather than from extraneous assumptions.

1. *The Legitimacy of the Non-market-clearing Paradigm*

Given the weak theoretical and empirical foundations of the classical equilibrium model based on incomplete information, it is hard to account for its popularity. The sticking point for its protagonists is that they have raised market clearing onto a pedestal of theoretical primacy that prevents them from thinking about other theoretical points of departure. In Barro's language, the appealing feature about market clearing is that "the equation of

supply to demand implies that market transactions have proceeded to the point where perceived mutually advantageous trades have been exhausted . . . the 'disequilibrium' literature postulates arbitrary dynamic processes for price formation and arbitrary rules for determining quantities in non-market-clearing situations. The modeling implies easily correctable ways in which private markets malfunction" (1979*a*, pp. 28–29).

Yet the "law" of supply and demand cannot be so easily accepted, and Kenneth Arrow's original doubts are worth repeating. Following Arrow (1959, pp. 42–43) we first write demand and supply functions for, respectively, competitive consumers and producers:

$$D = f(P); \quad S = g(P), \quad (13)$$

where D is the demand for the commodity, S its supply, and P its price. Since (13) is incomplete, with only two equations in the three unknowns (S , D , and P), the model is usually completed by adding the condition of equality between supply and demand:

$$S = D. \quad (14)$$

Equilibrium protagonists regard the *sine qua non* of an acceptable theory to be not only the absence of unrealized gains, but also the grounding of all decisions in "choice-theoretic foundations." The problem with (14) however, is that it is not derived from maximizing behavior and, instead, is assumed to be self-evident. One defense might be that (14) is regarded as the limit of a trial-and-error process in which the price adjusts by the following rule whenever (14) does not hold:

$$\frac{dP}{dt} = h(S - D) \\ \text{where } h' < 0, \quad h(0) = 0.^{13} \quad (15)$$

¹³ h' is the rate of change of the function h with respect to an increase in the excess supply.

This equation, describing a market in disequilibrium, states that the change in price is proportional to the gap between supply and demand. A market-clearing equilibrium occurs, with no unrealized gains from trade, only in the limit of a dynamic process in which (if it is stable) there is no pressure for any of the three magnitudes S , D , and P to change.

There are two problems with (15), sometimes called the "law of supply and demand." First, the dynamic adjustment may take a substantial length of time. During this interval of disequilibrium, the market-clearing equality (14) is not satisfied, and rational agents in forming their expectations about costs, prices, sales, and the rate of return on investment will not cling to the unrealistic belief that markets are continuously clearing, as they are forced irrationally to do in the new classical equilibrium models where the Friedman-Lucas supply function is postulated to describe behavior at every moment in time. The second difficulty is the "problem of the missing auctioneer," the failure of the model of (13) through (15) to explain whose decision it is to change prices, a lack that is at the heart of the issues discussed in this paper. It is crucial for economic theorists to develop better models of the dynamic process of price adjustment and to resist the temptation (to which so many have succumbed) of falling back on an unexplained permanence of the equality of supply and demand:

[The law of supply and demand] is inadequate in not supplying any mechanism by which prices are changed. Who or what changes them? But it would seem to be superior from this point of view to models which postulate a permanent equality between supply and demand, for which the mechanisms are even more mysterious (Arrow, 1980, pp. 141–42).

2. From Fixed Prices to Conjectures by Monopolistic Competitors

The insightful synthesis by Barro and Grossman (1971) of a general equilibrium

with fixed prices in labor and commodity markets set loose a horde of mathematical economists who attempted to formalize and push further the notion of a non-market-clearing equilibrium.¹⁴ Unfortunately they have not yet achieved a satisfactory formulation, because they have not yet squarely confronted the basic question of the relative adjustment speeds of prices and quantities. One approach prevents agents from changing prices or otherwise experimenting to escape perceived quantity constraints (Jacques Dreze, 1975). Another flounders on the implausible assumption of "manipulable rationing," that agents can influence their own constraints (Benassy, 1975). Still another requires that prices stay fixed until an equilibrium is established (Benassy, 1976). In Frank Hahn's analysis of conjectural equilibrium, agents facing sales constraints are assumed to have conjectures concerning the degree to which the price must be reduced to achieve their objectives. A "conjecture" thus seems to be little more than a new word applied to the old idea that monopolistic competitors are uncertain about their own demand curves. The explanation is shifted back one step to the formation of conjectures.

The central issue in the Hahn theory appears to be the rationality of conjectures; the mathematical proofs center around the correctness of conjectures in relation to the presumed behavior of both competitors and suppliers in response not only to a firm's own price-setting and other competitive actions, but also in response to the more general conditions they face. As yet, there have been few attempts to link the behavior of competing firms to the existence of aggregate in-

formation that might expose the subject-firm and its competitors to common knowledge about the evolution of aggregate demand. In his recent survey Allan Drazen suggests that attempts to demonstrate an unemployment equilibrium with rational behavior have:

met limited success at best. Either some crucial aspect of the economy is exogenously specified, or certain agents are severely restricted in behavior or information sets, sometimes perversely so [Drazen, 1980, p. 299].

It may seem discouraging that brilliant mathematical economists are able to prove little more than they assume in this area, but there may be a methodological problem that inhibits progress. No sooner is a mathematician let loose on non-market-clearing problems than he attempts to prove the existence of a static equilibrium in which there is no incentive for an agent to change prices. Perhaps the fixation on equilibrium is a crucial handicap. With continuous shocks to nominal demand, agents are forever being confronted with a new experimental decision process in which they must slowly discover the change in both prices and quantities that a full-information, rational adjustment requires. The explanation of gradual price adjustment may involve just what the name implies, a continuous dynamic adjustment, requiring an explanation of why prices adjust to perceived nominal disturbances gradually rather than fully and contemporaneously.

3. *Dynamic Models of Monopolistic Price Adjustment*

Unlike the papers that are concerned at least implicitly with the existence of a "non-Walrasian" or "conjectural" equilibrium, another set of contributions analyzes the dynamics of price adjustment in a partial equilibrium context. The failure of prices to adjust completely and instan-

¹⁴ Here we deal only with the literature on non-market-clearing disequilibrium. Weintraub (1977, p. 8-11) provides a summary of recent attempts by equilibrium theorists to extend the Arrow-Debreu model to account for the absence of futures markets in contingent commodities.

taneously to demand shocks is attributed to two types of frictions, adjustment costs and incomplete information. In this section we attempt to determine whether either of these grains of sand thrown into the frictionless classical wheel of commerce is necessary or sufficient to explain why our adjustment coefficient α in equation (4), above, is less than unity, and why its value varies over time.

Although Barro's recent advocacy of the market-clearing paradigm ignores Arrow's doubts about the market-clearing and adjustment equations (14 and 15, above), ironically, Barro earlier wrote an important paper (1972) that takes Arrow's analysis as a point of departure. There Barro claims to derive "the law of supply and demand" (equation 15, above) from the behavior of a profit-maximizing monopolist who faces a lump-sum cost of adjusting prices. The optimal strategy for the monopolist is shown to be the selection of "floor" and "ceiling" bounds for an additive shift in the demand curve, with the price remaining constant when the shift is within the bounds and changing fully when the shift is outside the bounds. The solution is analogous to models of the transactions demand for money in which lump-sum adjustment costs make the transfer of cash receipts to interest-yielding assets take the form of discrete rather than continuous transfers (William Baumol, 1952; Merton Miller and D. Orr, 1966).

Barro's final price-adjustment equation sets the expected value of price change equal to an adjustment coefficient times the additive demand-shift term. This is not equivalent to (15), above, which multiplies an adjustment coefficient times the difference between output supplied and demanded ($S-D$). As Katsuhito Iwai has pointed out (1974, p. 259), in Barro's model the shift term is simply the difference between current demand and the level of demand at the time of the last

price change, and this does not correspond to the difference between supply and demand, because Barro's model assumes that actual output supplied always equals the amount demanded. Instead Barro's adjustment equation seems to correspond more closely to our equation (4), above, which sets the rate of price change equal to a coefficient times adjusted nominal GNP growth; however his model does not appear to have much promise for explaining why that adjustment coefficient varies across countries and over time.

There have been few other attempts to base partial price adjustment on adjustment costs, probably because the magnitude of demand shifts in episodes like the Great Depression would seem to swamp any reasonable guess as to the magnitude of those costs. Most authors have based their analysis of dynamic price adjustment on some aspect of incomplete information. Following up on Stigler's suggestive analysis of dispersion as a manifestation of customer ignorance about current price quotations (1961), Armen Alchian argued that stable prices perform the role of reducing the need for search by potential customers (1969). If prices were constantly varying to achieve continuous market clearing, this might involve, for instance, a doubling of price for a restaurant on an unexpectedly busy night, forcing consumers to plan routinely on a period of search before dinner rather than a quick and direct trip to a pre-chosen spot. While stable prices reduce the search costs imposed by *random* demand shifts, any *expected* variation in demand can be offset by a posted price schedule (e.g., higher prices for theater seats or airline tickets on weekends).

The first formal analysis of optimal price-setting policy by a firm facing "customer flow dynamics" was presented by Phelps and Winter (1970). They show that competitive firms have transient monopoly power in product markets, just as Dale

Mortensen's (1970) firms have transient monopsony power in labor markets. The analysis involves a twist on Edward H. Chamberlin's famous distinction between firm and industry demand curves, "*dd*" and "*DD*" respectively. Whereas in Chamberlin's static framework the elasticity of "*dd*" was always greater than that of "*DD*," for Phelps-Winter the elasticity of "*dd*" initially equals that of "*DD*" but increases over time as a given discrepancy between a firm's price and the prevailing industry price results in a constant geometric growth or decline in its share of customers. Because the Phelps-Winter firm is a monopolist in the short run, but a perfect competitor in the long run, its present value is maximized when it produces beyond the point where marginal cost equals instantaneous marginal revenue, but at less than the point where marginal cost equals price. The Phelps-Winter version of the Phillips curve shares with Friedman's the assumption of adaptive expectations; Phelps-Winter firms raise output because they believe the price charged by competing firms will rise by less than the demand-shift. Their model cannot explain output fluctuations in response to perceived monetary disturbances if firms are endowed with rational expectations, since any nominal shock recognized as aggregate in origin will lead to an equiproportionate increase in the price that firms expect their competitors to charge.

Arthur M. Okun combined elements of the Alchian and Phelps-Winter contributions to provide a richer model of price-setting behavior. His 1975 article popularized a distinction between "auction" and "customer" markets, with price stickiness in the latter explained by Alchian-like considerations of intertemporal comparison shopping. Costly search makes customers willing to pay a premium to do business with customary suppliers, and intertemporal comparison shopping discourages

firms from changing prices in response to short-run changes in demand in order to avoid giving customers an incentive to abandon no-search relationships and to begin exploring. Okun argues that his customer-search model explains the full-cost pricing practices incorporated into so many theoretical discussions and econometric models. Customers appear willing to accept as "fair" an increase in price based on a permanent increase in cost, whereas transitory events, whether an increase in demand or a reduction in productivity, are not generally expected to last long enough to justify price increases. Okun's model shifts the locus of attention from "price rigidity" to "mark-up rigidity" and thus requires an auxiliary model of wage stickiness to explain why costs are not completely responsive to demand changes.¹⁵

Several recent papers have concentrated on inventories as a buffer that reduces the required response of both prices and output to a demand shock. We have already seen (Part IV, Section 2) that persistence can be introduced into the classical equilibrium model when firms meet part of a sales shock out of inventories and are required to restock in subsequent periods. In a model of quasi-monopolistic price-setting behavior, the buffer role of inventories for both output and prices seems intuitively clear and in fact was recognized in early commentaries on *The General Theory* (Lawrence Klein, 1947). A negative sales shock will be met partly by reducing production and partly by accumulating inventories, with the balance between the two responses depending on the costs of adjusting output and the costs of financing inventory stocks. As Alan Blinder (1980) has shown, intertemporal speculation will reduce the incentive to

¹⁵ Subsequently, Okun expanded and enriched his model of customer markets without changing its main thrust or conclusions (1981, Chapter IV).

cut prices now and will stimulate inventory additions in the expectation that future prices will return to normal, depending on the expected duration of the sales shock.

A pair of recent papers (Yakov Amihud and Haim Mendelson, 1980; Patricia Reagan, 1979) derives an asymmetry in price behavior when inventory stockouts occur. The buffer role of inventories dampens downward price adjustments but is able to dampen upward adjustments only as long as inventories remain positive. Eventually higher sales cannot be accommodated by selling out of inventory, at which point a standard classical price response must occur. Both authors ignore the symmetric role of unfilled orders in dampening price and production adjustments when demand is high. In a series of papers, Dennis Carlton analyzes markets with delivery lags (1978; 1979; 1980*a*), in which customers are willing to pay for instant availability, and in which allocation is achieved by a combination of price movements and changes in delivery lags. Both methods of allocation have costs, but the adjustment of availability may be a less costly way for many firms to respond to short-run fluctuations in demand than the adjustment of prices. In this sense delivery lags, like inventories, operate as a buffer and tend to moderate the responsiveness of prices to demand shocks.

This small selection from the large, recent literature on price adjustment has uncovered several convincing explanations for price stickiness, including the Alchian-Okun stress on stable prices as a source of information for searching customers, and the Blinder-Carlton analysis of inventories and unfilled orders as buffers that stabilize both production and prices relative to sales. Yet, there is a missing link in all of these contributions, because the agents are almost always specified as responding to a homogeneous

random shock and are not allowed to engage in a Lucas-like exercise to decompose the shock into its local and aggregate components. As Blinder has pointed out (1980, p. 26), his own model only explains stickiness in relative prices, not in nominal prices. Like Okun's model of mark-up pricing, Blinder's explains stickiness of a firm's nominal price only by assuming cost stickiness, thus pushing the puzzle back one step.

VI. *The Coexistence of Auction Markets with Price Setting*

Our survey of the present state of work on the relations between price adjustment and macroeconomic disturbances finds the present level of understanding to be inadequate. In what direction can we try to advance? Our task is to construct a simple model of price adjustment that explains as many as possible of the five outstanding questions that were listed in the introduction to this paper with the smallest possible set of assumptions. If the resulting framework is to have any appeal to proponents of the new classical equilibrium macroeconomics, two of these assumptions must be rationality and profit-maximizing behavior on the part of economic agents. A third essential assumption, however, plays no role in the new classical models. This is *pervasive heterogeneity* in types and quality of products, and in the location and timing of transactions. Heterogeneity is crucial for the theory of price adjustment, because it explains the coexistence of auction markets and price-setting markets; it thus undermines the new classical macroeconomic models based on a one-good economy populated by identical price-taking yeoman farmers.

1. *Why Every Product Market Cannot Be a Spot-Auction Market*

Heterogeneity would create overwhelming transactions costs for an econ-

omy that insisted on determining every price in an auction. This is easiest to see if we imagine the obstacles to selling by auction in the aisles of a supermarket. Any visitor from Mars would immediately notice a striking difference between the typical supermarket aisle and the floor of the Chicago Board of Trade—at a typical mid-day hour the former is almost empty, and the latter is crowded with traders. The empty aisle reflects the heterogeneity of time and space of retail transactions, with a large number of customers making brief individual visits to different aisles and stores, spread over many hours, in contrast to the Board of Trade where each trader remains continuously at his post throughout the day. In contrast to the empty supermarket, the essence of a spot-auction market is its liquidity, which can only be achieved if many buyers and sellers are present simultaneously (Carlton, 1980*b*). Time and space are both scarce resources, and real-world price-setting practices allow goods and services to be made available at convenient locations, with the purchase time at the discretion of the buyer and with multiple items available on fixed terms without a special time-consuming auction for each. The use of a price tag instead of a live trader or auctioneer can also be viewed as a substitution of cheap capital for expensive labor.

While heterogeneity is necessary to explain price-setting as a practice that economizes on scarce resources, it is not sufficient. The thousands of equities that are traded on organized auction markets are obviously not homogeneous, differing in dividend yields, expected capital gains, variance of return, and so on. Another key characteristic of auction markets is the absence of any need for instantaneous physical contact between buyer and seller. Because I never actually have to see or touch my shares of stock, I can entrust their purchase and sale to a specialist in a distant

centralized market, but I cannot similarly delegate the authority to buy my lunch-time hamburger. Most products traded in organized exchanges are either homogeneous products like wheat and corn, or heterogeneous stocks of financial assets that do not have to come in physical contact with the ultimate consumer. Durable goods are an intermediate category, because they can be purchased from a distance and subsequently brought into direct proximity for the consumption of durable services. Since each consumption activity involves a joint product of purchased goods or services and one's own time (Gary Becker, 1965), time-consuming auctions or bargaining are more likely for large transactions in houses or expensive antiques than for small transactions in tomato soup or haircuts.

Although most of these examples have involved sales of final products to consumers, the factors of heterogeneity, direct physical contact, and small transaction size all help to explain why price-setting practices are common in sales by manufacturers to wholesalers, and by wholesalers to retailers. Firms often have so many varieties and sizes of products that they must print the catalogues that we often see displayed on the counters of auto parts departments and wholesale electrical suppliers.

This is no new phenomenon. Ever since manufacturers first began to sell elsewhere than at the factory, and to employ travelling salesmen, and to contract with wholesalers and jobbers, it has been necessary for them to announce prices and to stick by their announcements, or if they diverted from them to do so secretly [Rufus S. Tucker, 1938, p. 53].

What is critical here is that the act of setting a price does not deny profit maximization or rationality, nor does it represent the failure to take advantage of "perceived gains from trade." On the contrary, any auto parts manufacturer who

insisted on selling only by auction to customers who were willing to travel to pre-announced locations at pre-announced times would be driven out of business by a competitor who had the bright idea of providing retail parts departments with catalogues offering items by mail or delivery at a pre-set price. There is nothing arbitrary about pre-set prices; they simply substitute for pre-set locations and times of hypothetical auction markets by allowing transaction locations and times to be freely chosen.

2. *Heterogeneity as a Source of Multiple Suppliers for Every Firm*

Next to its role in explaining why prices are so often pre-set, the second most important effect of heterogeneity is to create an input-output table of relations among firms. As we shall soon see, the input-output table is crucial in creating a source of friction in price adjustment. Adam Smith would have been dumbfounded by the one-good models of the new classical equilibrium models, for as early as Chapter II of *The Wealth of Nations* he was already attempting to explain the “propensity to truck, barter, and exchange one thing for another” (p. 13), i.e., to respond to the heterogeneity of goods and the advantages of specialization by producing many numbers of a few items and trading them for small numbers of many items. By the end of the same chapter Smith had discovered the central fact and necessity of input-output relations: no economic agent is on a Phelpsonian or Lucasian island but each, instead, requires as inputs the outputs of many other workers and firms:

The woollen coat, for example, which covers the day-labourer, as coarse and rough as it may appear, is the product of the joint labour of a great multitude of workmen. The shepherd, the sorter of the wool, the wool-comber or carder, the dyer, the scribbler, the spinner, the weaver, the fuller, the dresser, with many others, must all

join their different arts in order to complete even this homely production. . . . What a variety of labour too is necessary in order to produce the tools of the meanest of those workmen! [Smith, 1776 (1937 ed.), p. 11]

Devotees of one-good models often forget, also, how essential is heterogeneity to explaining the existence of three fundamental economic concepts: the industry, the firm, and the product. Stigler’s definition of industries rests not on concentration-ratios nor competitiveness but on “similarity of products or production processes of establishments” (1955, p. 3); i.e., on elements of homogeneity in the heterogeneous network of products and processes. Similarly, the existence of the firm has been explained as a way of economizing on transactions costs when numerous heterogeneous types of labor, capital, and materials must be brought together to produce a given range of products (R. H. Coase, 1937). Heterogeneity extends from the industry to the firm to the product. Lawyers specializing in the definitions of markets and products, like those involved in regulatory and antitrust cases, would be among those finding the one-good assumption to be an unacceptable abstraction (see, for instance, Victor Goldberg, 1976).

VII. *Sources of Gradual Price Adjustment in a Heterogeneous Input-Output World*

1. *Business Cycles and the Price of Lettuce*

The Okun, Blinder, and Carlton models are capable of explaining why the prices of some types of final goods exhibit a relatively low frequency of price change. Pre-announced prices convey information to customers, and changes in inventories and unfilled orders reduce the need to use price adjustments as a method of allocation. But the fact that some prices are pre-set does not, of itself, rule out either fre-

quent price changes or an insulation of aggregate real output from nominal demand changes. Price tags can be changed often, as when the pre-set price of lettuce in the supermarket changes each day to reflect changes in the market-clearing price in the wholesale produce exchange. In the German hyperinflation and in other severe inflations in South America and Israel, prices have been pre-set but for short periods. Some additional theoretical element needs to be introduced to explain the variety of responses of prices to nominal demand variations observed over time and across countries. The common thread that connects the lettuce and hyperinflation examples is the perceived behavior of business costs; when firms which pre-set prices know that their costs are changing frequently they will be prepared to change price tags frequently.

This part of the paper provides an analysis of the factors that influence the response to nominal demand changes of firms that pre-set their own product price and face pre-set prices for a multitude of intermediate inputs. First, we note that in the standard analysis of microeconomic theory, changes in the optimal price set by a monopolist depend on perceived changes in both marginal revenue and marginal cost. The quantity produced will vary in the same direction as a shift in demand unless changes in marginal revenue are completely offset by changes in marginal cost. Second, in predicting what will happen to marginal cost, and thus how much its product price should respond to a perceived demand shift, each firm must solve a Lucas-like inference problem, guessing how much marginal costs will change on the basis of some combination of available local information on revenue and aggregate information on nominal demand. The more variable is aggregate demand, the greater will be the likelihood that a firm's suppliers are experiencing the same demand shock ob-

served locally and, thus, that marginal costs will mirror shifts in marginal revenue. Finally, complete current data on the aggregate money stock and price index are not sufficient to guarantee that a firm's product price will instantly mirror aggregate demand shifts, because incomplete information about the circumstances of suppliers introduces a lag in the response of the product price.

2. *Price-Setting by a Textbook Monopolist*

Pervasive heterogeneity makes each firm into a monopolist in the short and medium run. "In disequilibrium the market consists of a number of monopolists facing a number of monopsonists" (Arrow, 1959, p. 47). Because the selling side of the market is more concentrated than the buying side, however, "the main force in changing prices will be the monopolistic behavior of the sellers." On these grounds we ignore monopsony elements and other issues involved in the response of costs to changing output, adopting, for convenience, the extreme assumption of a horizontal marginal-cost function, initially at the position MC_0 in *Figure 1*. Our monopolist faces a downward-sloping linear demand curve, initially at D_0 , with a corresponding linear marginal revenue schedule MR_0 . Initially marginal cost and marginal revenue are equal at point E_0 , the price charged is P_0 , and the output level is Q_0 , which we may take for convenience to be the firm's "natural" level of output, in the sense that if all firms were producing at this level the aggregate economy would be at its natural output level.

The diagram shows that a downward shift in demand from D_0 to D_1 , with a corresponding decline in marginal revenue from MR_0 to MR_1 , could be accompanied by two alternative responses (or any intermediate combination of the two). First, if the firm perceives the marginal cost schedule MC_0 to be fixed, then marginal

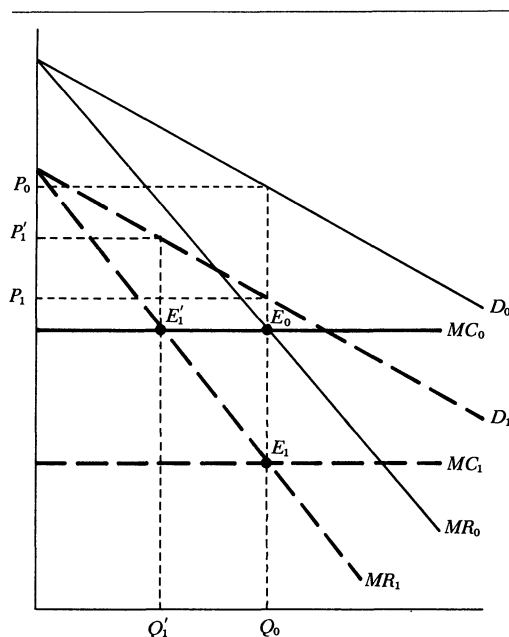


Figure 1

cost and marginal revenue are equal at point E'_1 , the price level declines from P_0 to P'_1 , and production will fall from Q_0 to Q'_1 . Second, if the firm has some reason to believe that the marginal cost schedule has declined vertically, by exactly the same distance as the demand curve, from MC_0 to MC_1 , then output will remain fixed at the original level Q_0 and prices will drop from P_0 to P_1 , i.e., by the same vertical distance as the demand shift itself.

Let us now imagine that the entire cause of the downward shift in the demand schedule is a negative aggregate demand shock. The diagram illustrates clearly the strong condition required for the firm to reduce product price by the same amount as the demand shift, leaving real output unaffected. Price adjustment will be complete if perceived marginal cost responds fully to the aggregate shock, but not otherwise. Thus the central ques-

tion becomes the determinants of the perceived response of input cost to actual changes in nominal aggregate demand.¹⁶

3. Forming Expectations about Input Costs

Changes in the demand and cost schedules faced by the firm contain both an aggregate and local component. Nominal demand and costs can be raised in tandem by a moderate aggregate inflation like that experienced in the U.S. recently, as well as by large aggregate shocks as during wars and hyperinflations. The local component of changes in demand consists of changes in tastes, real income, foreign competition, technology, and other factors that alter the share of an industry in aggregate demand, and the market-share of a particular firm in that industry. The local component of changes in marginal cost for a particular firm consists of changes in the production techniques of its myriad suppliers and in the pecuniary rewards of their factors of production, including changes caused by union bargaining triumphs and successful oil cartels. Since the local component of cost changes faced by a particular firm depends on conditions in other industries, it may be largely independent of the local component of demand changes, and under normal peacetime conditions both local components of change may be much more important as influences on day-to-day managerial decision-making than the common aggregate component.

Thus, we suggest that a fundamental reason for gradual price adjustment is the large local component of actual changes in demand and costs, together with the

¹⁶ If, in Figure 1, A is the vertical intercept of the demand curve and C is the intercept of the marginal cost schedule, then the optimal price is simply $P = \frac{1}{2}(A + C)$, and the optimal price change is $\Delta P = \frac{1}{2}(\Delta A + \Delta C)$. Only if the vertical shift in cost equals the shift in demand, $\Delta C = \Delta A$, does the change in price fully exhaust the change in demand, $\Delta P = \frac{1}{2}(\Delta A + \Delta A) = \Delta A$.

independence of those cost and demand changes. Price moves in exact proportion to local demand shocks, as from P_0 to P_1 in *Figure 1*, only if marginal cost changes by the same amount as the demand shock. But firms rarely have a reason to expect such a close correspondence between movements in demand and cost, and thus conventionally respond to a demand-shift partially by a change in price and partially by a change in the real quantity sold.

The conditions likely to lead to a close correspondence between cost and demand shifts can be formalized by applying Lucas' 1973 analysis of expectation-formation to a world of price-setting monopolists who are facing heterogeneous suppliers, in contrast to his use of that analysis in a world of price-takers and continuous market clearing. For our monopolist the percentage price change (p_i) will be a weighted average of actual changes in nominal revenue (a_i) and of expected changes in marginal cost ($E(c_j)$):

$$p_i = \psi a_i + (1 - \psi)E(c_j), \quad (16)$$

where the "i" subscript designates the individual firm, the "j" subscript signifies that its costs are determined by a different set of firms, "E" is the expectation operator, and the time subscript is suppressed. Following Lucas, we assume that the demand shift consists of a local component plus an aggregate component (\hat{y}), and that the aggregate shift is not observable and has an historical mean of \bar{y} . This allows us to write the expected aggregate change as in equation (9), above:

$$E(\hat{y}) = (1 - \theta)a_i + \theta\bar{y}. \quad (17)$$

As in the Lucas model, θ is the ratio of the variance of the local component of the demand shift to the sum of the local and aggregate variance. θ is close to unity when the variance of the local component is large relative to the variance of the aggregate component, and θ is close to zero

when the aggregate variance is dominant.

The key factor for price determination is the formation of expectations about cost behavior, which is also assumed to consist of an unobservable local component and the aggregate component (\hat{y}). If the mean of the local component is zero, then the expected value of the change in marginal cost is:

$$E(c_j) = (1 - \phi)E(\hat{y}), \quad (18)$$

where ϕ is analogous to θ and is defined as the ratio of the variance of the local component of the cost shift to the sum of the local and aggregate variance. If the aggregate variance dominates the local variance, then ϕ is close to zero and expected cost mimics expected aggregate demand, but if the local variance of cost is relatively large, then ϕ is close to unity and the expected cost change depends on unobservable local factors.

When (17) is substituted into (18), and then the result is substituted into (16), we obtain an expression for the response of the monopolist's product price to the observed demand shift (a_i):

$$p_i = \psi a_i + (1 - \psi)(1 - \phi)[(1 - \theta)a_i + \theta\bar{y}]. \quad (19)$$

It is clear from this expression that under normal conditions, with both of the "relative variance coefficients" θ and ϕ between zero and unity, the product price will not respond equiproportionately to changes in the demand shift observed by the firm. The same conclusion applies when (19) is aggregated over all firms in the economy. We can write an aggregate price-adjustment equation like (19) that replaces p_i by the aggregate price change (p) and a_i by the aggregate demand change (\hat{y}):

$$p = \psi \hat{y} + (1 - \psi)(1 - \phi)[(1 - \theta)\hat{y} + \theta\bar{y}]. \quad (20)$$

In the extreme case when the aggregate component of the variance of both demand and cost shifts is very large relative to the local component, as during wartime or a hyperinflation, $\phi = \theta = 0$, and (20) reduces to $p = \hat{y}$. But ordinarily the coefficient of adjustment of p to \hat{y} (designated α in equation (4), above), will be a number that is well below unity.

A frequent criticism of the Lucas model is that it has no explanation for fluctuations in output when data on current aggregate demand are available, since this is equivalent to setting θ equal to zero. Even if aggregate demand were observable in our model, expected costs are not, and this provides a separate source of incomplete price adjustment when the local component of cost changes is independent of both the aggregate and local components of demand shifts. In addition, the mere existence of current data does not mean that the current level of either local revenue or aggregate demand is observable in any precise sense. First, price-setting firms may know their own prices accurately and immediately, but not their revenue. Having set their price, they must wait to see how unit sales develop. Since seasonal, cyclical, and competitive factors are hard to predict, weeks and months can pass before a firm can make a close estimate of the revenues associated with a given set of prices. Even that sales volume does not reveal the associated marginal revenue. Second, published data on interest rates, the money supply, and commodity prices have not been sufficient to generate accurate three-month forecasts or even accurate assessments of where aggregate demand stands at the moment. Even though the economy peaked in January, 1980, and descended into recession in February, the *Wall Street Journal* was able to write on February 28 that "another indication of just how imperceptible the long-awaited recession seems to be at the moment can be found in prices of indus-

trial goods" (Ralph Winter, 1980).¹⁷ The inference problem can be formalized in terms of a simple IS-LM textbook diagram, with real GNP on the horizontal axis. Observations on current money, interest rates, and prices do not provide sufficient information to pinpoint one's location on the diagram, because critical data on the error term in the commodity demand and money demand equations, as well as on the expected rate of inflation, are missing. In sum, business firms may be able to deduce the aggregate component of a shift in their own sales only after a substantial delay, and they may be quite in the dark about the likely near-term evolution of their own marginal costs.

4. Sources of Delay in the Transmission of Demand Disturbances to Prices

The analysis of the preceding section, as summarized in equation (20), seems sufficient to explain why relatively small and short fluctuations in nominal GNP during normal peacetime conditions are accompanied by only a partial response of prices, but demand disturbances that are widely perceived to be large relative to the variance of local shocks, such as those that occur during wars and hyperinflations, are accompanied by a greater proportional price response. A more complete formal analysis of this input-output model of monopolistic price setting would take explicit account of time lags and dynamic adjustment. There are at least three sources of delay in this framework that make the process of price adjustment not only *partial*, but also *gradual*.

1. Expectation formation. Our monopo-

¹⁷ As another example, the December 3, 1980, forecast of real GNP change in the fourth quarter of 1980 by the Wharton Econometric Forecasting Associates was an annual rate of increase of 0.3 percent; the preliminary estimate announced only seven weeks later on January 21, 1981, was an increase of 5.0 percent (*Business Week*, January 26, 1981, p. 9).

listic firms are assumed to maximize profits and to be rational, but this does not rule out lags in expectation-formation, because experience is required to form opinions about the relative variances of local and aggregate shocks that go into the determination of the θ and ϕ parameters. A perceptive early paper by Moses Abramovitz shows an acute awareness of the problem faced by agents trying to disentangle the implications of currently-published data for their own demand and that of their suppliers in light of knowledge regarding the behavior of the same data in past episodes: "Perhaps the most general and far-reaching characteristic of trade cycles is that they are complex intermixtures of differences with similarities" (1938, p. 200). Imagine, for instance, that firms in 1929 believed that θ and ϕ were relatively close to unity, based on the small size of minor recessions in the 1920s and on the presumption that the large shocks of 1915-22 were special and would not be repeated. As the Great Depression developed during the period between 1929 and 1933, expectations must have gradually shifted to reflect the growing variance of aggregate demand, and indeed both prices and wages showed a greater tendency to drop after 1930 than in the first year of the contraction.¹⁸

2. *News comes first to producers of final goods.* All firms are engaged in a constant effort to guess what will happen to aggregate demand and to their costs on the basis of a combination of information on cur-

rent local sales and on recently-published aggregate data. A decline in demand will be observed, first, by price-setting final-goods producers as a decline in unit sales. Intermediate-goods producers, however, will learn about the decline only with a delay. They must wait either for aggregate data on sales and orders to be published, or for final-goods producers to transmit reduced real orders for intermediate goods. Since rational final-goods producers know that a delay will occur before intermediate goods prices can respond to the demand shock, they will take this sluggishness of response into account when guessing the near-term evolution of marginal cost. While it might seem a trivial act for a final-goods producer to telephone a single supplier to inform him of a shift in demand and to ask him for a price reduction, inter-firm coordination and communication becomes impossibly costly when each firm deals with thousands of suppliers, each of whom has its own thousands of suppliers. The high variance of local shocks and the role of inventories and unfilled orders as buffers all contribute to the delay in price adjustment by intermediate-goods suppliers, since a negative shock to sales may not, initially, lead to a decline in orders for supplies, and such a reduction in orders by a particular final-goods industry may be initially interpreted by suppliers as a manifestation of a local, rather than an aggregate, disturbance.

3. *FIFO and LIFO pricing practices.* Until now we have assumed that firms compute marginal costs on a replacement-cost basis, which requires a guess about the level of costs in the future period when the replacement goods are obtained. Many firms, however, appear to base prices on actual costs paid in the past, so-called "FIFO" (first-in-first-out) pricing practices. If marginal cost is calculated on the basis of historical cost, and each supplier applies a historical cost basis to its own operations, then current marginal

¹⁸ According to the data used in TABLE 1, during the first four quarters of the great contraction (ending in 1930:Q3) the decline in the GNP deflator absorbed only 24 percent of the decline in adjusted nominal GNP. In the next four quarters 54 percent was absorbed, and in the subsequent four quarters 34 percent (in 1932 the rate of decline of spending accelerated but that of price decline did not). The greatest absorption of spending change by price change (64 percent) occurred in the four quarters ending in 1934:Q2, perhaps reflecting the widespread knowledge that the National Recovery Act had both encouraged and caused prices to increase.

cost embodies the demand conditions of an infinity of past periods. A continuing mystery among accounting professors is the prevalence of FIFO accounting in an inflationary age, thus causing firms to pay unnecessary taxes on inventory profits. While FIFO accounting does not necessarily imply FIFO pricing practices, the two may go together. Okun (1981, p. iv-33) has suggested that FIFO pricing may be partly explained by the unwillingness of top management to delegate the job of estimating future costs, as would be required by full replacement-cost pricing practices in a firm producing multiple products with multiple inputs. Delegation of such guesswork to lower-level managers raises problems of managerial control and accountability which many firms want to avoid, leading to preference for a cost concept based on actual billings over one based on guesses about hypothetical transactions. While LIFO (last-in-first-out) pricing reduces the adjustment lag, it imposes managerial decision-making costs, since individual goods in each replacement shipment must be compared with those in the preceding shipment.

We have assumed thus far that firms base prices only on marginal costs. Yet to the extent that fixed costs are considered as well, an additional FIFO-type element enters that delays the transmission of demand disturbances into the price system. The slowness of U.S. business firms to shift from straight-line to accelerated depreciation, following the tax reforms of the 1950s and 1960s, is well documented. In addition to depreciation, interest costs must be met as well and may put pressure on firms to hold prices up if their demand is perceived to be inelastic.

VIII. *Conclusion: Decentralization, Indexing, and Labor Markets*

Are business cycles due to "easily correctible malfunctions" in private market arrangements (Barro, 1979a)? An easy an-

swer is: if the malfunctions were so "easily correctible," some clever entrepreneur or politician would already have performed the required correction. A more complete answer is that business cycles in real variables rest upon the incomplete and gradual extent of price adjustment which, in turn, results from fundamental aspects of market arrangements that have been recognized at least since the time of Adam Smith. Heterogeneity across time, space, products, and processes leads to specialization, which in turn leads to decentralized decision-making.

Once decentralization and the multiplicity of supplier-producer relationships are recognized, no single firm can perform an action that would eliminate the aggregate business cycle. Each manager may recognize when emerging from his night-school economics class that a recession in real output may be avoided by a uniform and instantaneous drop in all prices in exact proportion to a decline in nominal GNP (as long as he is willing to rule out expectations effects that might cause the price decline to depress nominal spending further). Yet, he cannot see any way that he can "easily correct" the situation by his own isolated action, for he does not even know the identity of all the other agents in the input-output table of supplier-producer relationships. An isolated price decline by a single producer in exact proportion to a perceived decline in nominal demand will lead not to the elimination of business cycles but, rather, to bankruptcy if suppliers of intermediate inputs do not simultaneously adjust their prices. Each agent is caught in a "prisoner's dilemma," aware of an aggregate inefficiency but without any private incentive to bear the enormous transaction cost of trying to correct it.

It is often alleged that business cycles could be avoided if only all firms (and workers) were to enter into contracts indexed to the aggregate price level. Joanna

Gray (1976) and Alan Blinder (1977) have persuasively argued that complete indexation is not generally optimal when there are shocks to both demand and supply. For instance, full wage indexation rigidifies the growth rate of the real wage over the period of the contract and interferes with the adjustment of real wages to unexpected productivity shifts caused by supply shocks. The same argument applies with even more force to product markets where, instead of a single relative price of labor, there is a multiplicity of relative prices to be considered. Any unexpected disturbance could cause capricious windfall gains and bankruptcies in a world of universal-product-market contracts, indexed to a single aggregate price index. It is highly ironic that the same economists who sometimes claim that universal indexation would eliminate business cycles almost uniformly condemn governmental price controls for interfering with exactly the same unanticipated demand-and-supply shifts that make indexed contracts sub-optimal!

The introduction to this paper stressed five facts that a theory of output fluctuations and price adjustment should be able to explain. Section VI of the paper explained the co-existence of auction markets with markets where prices are pre-set, as the result of heterogeneity in the time and place of transactions that makes markets with pre-set prices more efficient than auction markets for many types of products. The greater variability of some pre-set prices than others, as well as the greater extent of price responsiveness of the U.S. economy during World War I and in countries during hyperinflations than during normal peacetime situations, is attributed to the ability of firms which pre-set prices to know that their costs are changing frequently. Changes over time and across countries in the perceived responsiveness of costs is, in turn, explained by shifts in the perceived variance of ag-

gregate demand, relative to the local component of demand and cost.

Economic theory in the past decade has adopted a number of analytically convenient assumptions that have obscured rather than clarified the fundamental nature of business cycles. Agents are assumed to be identical, producing a single good, and isolated on "information islands," whereas the essence of the problem comes from differences in the circumstances faced by producers and suppliers, from the heterogeneity of goods, and from the costs of communication and coordination through a complex input-output network of relations among agents. Some economists have lost sight of their fundamental goal, an understanding of the real world, through a narrow-minded pursuit of the will-of-the-wisp of formal analytical tractability.

This paper has stressed characteristics of product markets that contribute to gradual price adjustment, while ignoring an explicit analysis of aspects of labor markets that make an additional contribution. In our analysis the input costs that are perceived to respond incompletely to aggregate demand shocks include, of course, nominal wage costs. Just as firms have no reason to believe that their multiplicity of suppliers will adjust the prices of intermediate goods instantly in response to demand shocks, so workers purchase a multiplicity of items in their market basket and have no reason to believe that the prices of those items will respond instantly to demand shocks. Each worker may believe that a uniform wage reduction would help boost output in a recession, yet no single worker has the power to convince all employed workers to accept an immediate wage cut. Nor can unemployed workers substitute for employed workers at a lower wage rate without cost, because innate heterogeneity and investments in training confer a degree of monopoly power on each employed worker. Okun,

in his "extended toll model," has provided a complex and subtle analysis that explains many aspects of real-world labor-market behavior, as resulting from differences in ability and from hiring and training costs (1981, Chapters II and III). The phenomena of gradual price and wage adjustments long antedate the specific form of labor contracts that has been the subject of much recent analysis; the observed historical behavior of wages and employment seems to be compatible with our analysis of price and output adjustment for firms purchasing a multitude of intermediate inputs.

The suggestions about the nature of price adjustment to which, I believe, this paper leads are consistent, alike, with our experience of recurrent fluctuations in output and employment, and also with the observed responsiveness of prices and wage rates in wartime, hyperinflations, and during the prolonged postwar inflation experienced by the U.S. and other countries. If we can now accept the systematic nature of gradual price adjustment, together with the quantity movements that such price adjustment implies, several tasks remain before us: to extend our understanding of the incomplete responsiveness of prices and to study, again, the cumulative processes by which price and quantity movements interact in the course of business expansions and contractions.

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