NBER WORKING PAPER SERIES

RELATIVE-PRICE CHANGES AS AGGREGATE SUPPLY SHOCKS

Laurence Ball

N. Gregory Mankiw

Working Paper No. 4168

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 1992

We are grateful for research assistance from John Driscoll, Antonio Fatas, Stefan Opers, and Boris Simkovich, and for suggestions from Ben Bernanke, Alan Blinder, David Romer, and Richard Startz. Financial support was provided by the NBER, NSF, and Sloan Foundation. This paper is part of NBER's research programs in Economic Fluctuations and Monetary Economics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #4168
September 1992

RELATIVE-PRICE CHANGES AS AGGREGATE SUPPLY SHOCKS

ABSTRACT

This paper proposes a theory of supply shocks, or shifts in the short-run Phillips curve, based on relative-price changes and frictions in nominal price adjustment. When price adjustment is costly, firms adjust to large shocks but not to small shocks, and so large shocks have disproportionate effects on the price level. Therefore, aggregate inflation depends on the distribution of relative-price changes: inflation rises when the distribution is skewed to the right, and falls when the distribution is skewed to the left. We show that this theoretical result explains a large fraction of movements in postwar U.S. inflation. Moreover, our model suggests measures of supply shocks that perform better than traditional measures, such as the relative prices of food and energy.

Professor Laurence M. Ball
Department of Economics
Fisher Hall
Princeton University
Princeton, NJ 08544
and NBER

N. Gregory Mankiw
Department of Economics
Littauer 223
Harvard University
Cambridge, MA 02138
and NBER

I. INTRODUCTION

What determines the rate of inflation? Most macroeconomists agree that, in the long run, the primary determinant of inflation is growth in the money supply. The short-run behavior of inflation, however, is more controversial. Certainly monetary policy and other determinants of aggregate demand have important roles. Yet, since the 1970s, many economists have also emphasized the role of "supply" or "price" shocks. The purpose of this paper is to propose and test a new theory of supply shocks.

Fundamentally, supply shocks are changes in certain relative prices. For example, the famous supply shocks of the 1970s were increases in the relative prices of food and energy. As a theoretical matter, it is not obvious why such relative-price changes are inflationary. According to classical theory, real factors determine relative prices, and the money supply determines the price level. For a given money stock, adjustments in relative prices are accomplished through increases in some nominal prices and decreases in others. Writing after the first OPEC shock, Milton Friedman (1975) applied this logic to argue that this event should not be inflationary:

> It is essential to distinguish changes in relative prices from changes in absolute prices. The special conditions that drove up the price of oil and food required purchasers to spend more on them, leaving them less to spend on other items. Did that not force other prices to go down or to rise less rapidly than otherwise? Why should the average level of prices be affected significantly by changes in the price of some things relative to others?

This paper proposes an answer to Friedman's question. Friedman's analysis implicitly assumes that nominal prices are perfectly flexible. By contrast, we work with a model in which firms face menu costs when they adjust their prices and, therefore, have a range of inaction in response to shocks. We apply this model to the question of how the economy responds to shifts in relative prices that, in the absence of frictions, would leave the price level unchanged. When a firm experiences a shock to its desired relative price, it changes its actual price only if the desired adjustment is large enough to warrant paying the menu cost. That is, firms respond to large shocks but not to small shocks. Therefore, large shocks have a disproportionately large impact on the price level in the short run.

In this setting, shifts in relative prices can affect the price level. Specifically, the model has the novel implication that changes in the price level are positively related to the skewness of relative-price changes. Suppose, for example, that the distribution of desired changes in relative prices is skewed to the right. In this case, a few firms desire large price increases, which are balanced by small desired decreases by most firms. Since firms respond more quickly to large shocks than to small shocks, the desired increases occur more quickly than the desired decreases. Thus the average price level rises in the short run. Conversely, if the distribution of desired adjustments is skewed to the left, the decreases occur more quickly than the increases, and the price level falls.

This point is more than a theoretical curiosity: it explains a large fraction of the variation in inflation in the postwar United States. Using four-digit PPI data, we examine the cross-sectional distribution of price changes in each year from 1949 to 1989. We find substantial variation in the third moment of this distribution: in some years the distribution is fairly symmetric, whereas in others it is skewed sharply to the left or right. As our model predicts, innovations in aggregate inflation are associated with the skewness in relative-price changes. The OPEC oil shocks are episodes that fit our theory: the large increases in the prices of oil-intensive goods generated positive skewness, and aggregate inflation rose. Our empirical finding is, however, quite general: skewness and inflation are related throughout our sample, including the pre-OPEC era of the 1950's and 1960's.

After this introduction, the paper contains seven sections. Sections II and III present our theoretical model. Our theoretical results illustrate the ability of menu-cost models of price adjustment to generate novel empirical predictions. We also compare our model to previous theories of supply shocks.

Section IV describes our data and documents the variation in the cross-sectional distribution of price changes. Section V establishes the relationship between the first and third moments of price changes. We also briefly review previous studies of inflation and relative prices. Previous authors sometimes note a positive relation between the first and third moments, but generally they do not emphasize it. Instead, previous work focuses on the relationship between the first and <u>second</u> moments--that is, on the relationship between inflation and the variability of relative prices. We show that the inflation-skewness relationship is in fact stronger than the inflation-variance relationship.

Section VI explores the idea that asymmetric relative-price changes represent aggregate supply shocks--that is, shifts in the short-run Phillips curve. We experiment with alternative measures of supply shocks in simple Phillips-curve equations that relate innovations in inflation to detrended unemployment. We find that measures of asymmetries in price changes capture a large fraction of the shifts in the short-run Phillips curve. Most important, these variables outperform traditional measures of supply shocks, such as the changes in the relative prices of food and energy.

Section VII turns from time-series regressions to an examination of several historical episodes. Our model provides a theoretical foundation for traditional accounts of episodes such as the OPEC oil shocks. More important, our approach explains episodes that have previously been viewed as puzzling. One example is the sharp decrease in inflation between 1951 and 1952. Arthur Okun (1975) wrote that "inflation screeched to a halt in 1951--a development that still stands out in retrospect as an intriguing fortuitous mystery." Our model helps solve this mystery, because the fall in inflation coincided with substantial negative skewness in relative-price changes.

Finally, Section VIII offers concluding remarks.

II. THEORY: AN INFORMAL DISCUSSION

To build intuition, this section presents a heuristic discussion of our basic theoretical points. The next section shows how our theory can be formalized.

A. The Intuition

Our basic idea is illustrated in Figure 1, where we ask what happens when firms are hit with a distribution of shocks to their desired prices. We assume that the mean of the desired changes is zero; thus, if all prices were adjusted, the average price level would stay the same. We assume, however, that it is costly to adjust prices, so a firm adjusts only if its desired change exceeds a cutoff. That is, firms have a range of inaction in response to shocks. We assume that this range is symmetric around zero.

Figure 1 shows how the skewness of the distribution of desired price changes influences the price level. In Panel A, the distribution is symmetric. In this case, firms with desired changes in the upper tail of the distribution--those above the cutoff--raise their prices, and those in the lower tail lower their prices. Because the tails are symmetric, the net effect is zero. In Panel B, the distribution of prices is skewed to the right (but still has mean zero). In this case, the upper tail is larger than the lower tail. Thus more prices rise than fall, implying an increase in the overall price level. Finally, in Panel C, the distribution of shocks is skewed to the left, and the price level falls.

Our model also implies a relation between inflation and the variance of price changes, which is illustrated in Figure 2. If the distribution of shocks is symmetric, an increase in the variance of shocks magnifies the two tails proportionately, leaving the price level the same. If the distribution is skewed, a larger variance magnifies the asymmetry in the tails, and thus increases the change in the price level. That is, the variance has no independent effect on inflation, but it interacts positively with skewness: a larger variance is inflationary when the distribution is skewed to the right, and deflationary when it is skewed to the left. Thus our model has a rich set of implications about the interactions of the first, second, and third moments of price changes.

This argument takes shifts in the skewness of shocks as an exogenous feature of the economy. This approach distinguishes our analysis from recent theories in which asymmetries in the behavior of prices arise endogenously in the presence of menu costs, despite symmetry in the underlying environment. (For example, see Ball and Mankiw, 1992, or Caballero and Engel, 1992). A natural question is what might cause the distribution of shocks to be skewed. Most often, the answer is unusually large shocks to certain sectors. An OPEC shock, for example, can raise the relative prices of oil-intensive products by 50 or 100 percent. These increases are generally not balanced by equally large price decreases in particular sectors; instead, all other relative prices fall by small amounts. This pattern implies a skewed distribution of relative-price changes.

One limitation of this heuristic argument is that it concerns the relationship between inflation and the unobserved distribution of shocks. Empirically, one can only examine the relationship between inflation and actual changes in relative prices. Yet, our formal model in Section III shows that the relationship between first and third moments carries over to actual price changes under reasonable conditions.

B. Previous Theories of Supply Shocks

Informal Discussions: Although this theory of supply shocks is novel, we believe that it captures the spirit of some previous discussions. For example, in arguing that food and energy shocks explain the inflation of the 1970s, Blinder (1982) confronts the classical argument that these "special factors" are irrelevant and that inflation is a monetary phenomenon. He summarizes the argument as follows:

> There are "special factors" every year. In every year, some components of any price index are rising faster than the average. Thus, would it not be possible to use this methodology to brand all inflation as "special factor" inflation?

Blinder's answer is that the food and energy shocks of the 1970s were unusually large. He writes,

> The greatest year-to-year change in the energy index [between 1957 and 1973] was 4.5% in 1970. By contrast, the annual rate of increase of CPI energy prices from December 1972 to December 1979 was 15.2%.... Energy prices rose 21.6% during 1974 and 37.4% during 1979. The 1970s really _were_ different, and I fail to see why a theory of inflation is more "scientific" if it ignores this fact.

At first glance, Blinder's argument seems weak, for the classical distinction between relative and aggregate price changes applies with equal force to large and small changes. Our theory, however, suggests that Blinder is right in emphasizing the size of the energy shocks. Unusually large increases in prices are inflationary, because they occur more quickly than the smaller offsetting decreases.

Models with Nominal Rigidities: A number of previous authors have presented models of the inflationary effects of supply shocks based on frictions in nominal price adjustment. A typical approach is to assume that some nominal prices are flexible and others rigid. Some authors assume that oil or food prices are flexible and other prices rigid (for example, Gordon, 1975); others assume that nominal wages are rigid and output prices are flexible (for example, Phelps, 1978; Dornbusch and Fischer, 1990, p. 496). In these models, as in ours, a shift in relative prices can be inflationary. For example, if oil prices are flexible and other prices sticky, then an increase in the relative price of oil causes oil prices to rise while other prices remain constant, thereby raising the average price level.

This approach is similar to our model in including a combination of flexible and rigid prices. Indeed, one can view our model as providing a foundation for these earlier theories: oil prices often adjust flexibly because the oil industry has a history of large shocks. Our model modifies this approach in one important way, however. Rather than assuming that certain prices are always flexible and others always rigid, our model allows the flexibility of prices to be endogenous and to vary across periods as different industries receive large shocks.

The two approaches, therefore, suggest different ways to measure supply shocks. If certain goods have particularly flexible prices, then inflation depends on the changes in the relative prices of these goods. For this reason, it is common practice to include the relative prices of food and energy in Phillips-curve equations. (See, for example, Gordon, 1985). By contrast, in our model, particular relative prices matter only to the extent that they create skewness in the overall distribution of price changes; for example, moderate increases in oil prices are not inflationary. In our empirical work, we test between particular relative prices and overall skewness as measures of supply shocks.

Theories of Sectoral Shifts: The large literature on sectoral shifts provides an alternative way to explain how changes in relative prices influence the aggregate economy (for example, Lilien, 1982). These theories posit that workers require a period of unemployment when moving among sectors. Therefore, periods of high sectoral dispersion should tend to be periods of high unemployment and low output. A corollary of the fall in output (which is usually not emphasized) is that the price level rises for given aggregate demand.

In this paper we do not directly test between labor-reallocation and nominal-rigidity theories of the effects of sectoral shocks. Note, however, that the driving force in the labor-reallocation theories is the extent of labor reallocation--that is, the *variance* of sectoral disturbances. This variance seems well proxied by the variance of price changes across industries. By contrast, our theory gives a special role to the *skewness* of price changes, which has no obvious role in the labor-reallocation theories. We present evidence below on the relative importance of the second and third moments of price changes for explaining aggregate inflation.[1]

III. THEORY: A FORMAL MODEL

This section formalizes our theoretical ideas. Here, we emphasize the relationships among the moments of actual price changes rather than those of unobservable shocks. In addition, since our data are industry price indices rather than individual prices, our model focuses on price behavior at the industry level. We account for the fact that, within an industry, some individual prices change in a given period and others do not.

A. The Model

Our basic framework is a one-period model. The economy contains a continuum of industries, each with a continuum of imperfectly competitive firms. Within an industry, all firms have the same desired price. Initially, all nominal prices are set at the desired level, which, in logs, is normalized to zero for all industries. Then each industry experiences a shock: the desired nominal price for the industry changes to θ. One can interpret the shock as a shift in the industry demand or cost function. The shock θ has a density function $f(\cdot)$ across industries. The mean of θ is zero; that is, the shocks are sectoral disturbances and would leave the average price level

[1] A full survey of previous theories of supply shocks is beyond the scope of this paper, but we should mention one other theory. A common approach is simply to assume that a shock such as higher oil prices reduces full-employment output by acting like an adverse shift in the production function. If actual output equals full-employment output, then the price level rises for given aggregate demand. Our model is complementary with this simple theory. In particular, our model (and previous ones, such as Phelps's) seeks to explain why the increase in prices can be greater in the short run than the increase implied by the fall in full-employment output.

unchanged if all prices adjusted.[2]

A firm that adjusts its price must pay a menu cost C. If it does not adjust, its desired and actual prices differ by θ; we assume that the firm's loss from this divergence is θ^2.[3] This implies that a firm adjusts its price only if $|\theta|$ exceeds $\sqrt{C}$. Within an industry, firms are heterogeneous in menu costs: $\sqrt{C}$ is distributed across firms with distribution function $G(\cdot)$. Heterogeneity in menu costs implies that some firms within an industry adjust to a shock and others do not. If $G(\cdot)$ is well-behaved, the average price for the industry is a smooth function of θ.

We define an industry price change as the mean of the change in individual prices, and inflation as the mean of the industry changes (with all variables in logs). It is easy to see that the distribution of industry shocks influences inflation. For an industry with shock θ, the proportion of firms that adjust--those with $\sqrt{C}<|\theta|$--is $G(|\theta|)$. Since these firms adjust their prices by θ, the industry price index changes by $\theta G(|\theta|)$. Inflation π is the average of these price changes over industries:

---

[2] The menu-cost literature provides foundations for our model. (See, for example, Blanchard and Kiyotaki, 1987). Starting from tastes and technology, one can derive a firm's desired price as $\theta+vm+(1-v)p$, where θ is a relative shock, m is the log of the money stock, and p is the log of the aggregate price level. Our assumption that the desired price is simply θ is a special case in which the parameter v equals one and the money stock is constant. The assumption that $v=1$ means that we ignore interactions among price adjustments by different firms; the constancy of m means that we rule out aggregate shocks.

[3] This assumption is equivalent to taking a second-order approximation to a general profit function. See, for example, Ball and Romer (1989).

$$\pi = \int_{-\infty}^{\infty} \theta G(|\theta|) f(\theta) d\theta$$

$$= \int_{0}^{\infty} \theta G(\theta) [f(\theta) - f(-\theta)] d\theta .$$

If the density of shocks, $f(\theta)$, is symmetric around zero, then $f(\theta)=f(-\theta)$, and inflation is zero. If $f(\theta)$ is asymmetric, then π is generally non-zero.

B. Numerical Analysis

Here we present some calculations to show how inflation varies with the second and third moments of industry price changes. We first specify distributions for industry shocks and for menu costs.

For the distribution of $\sqrt{C}$, we choose an exponential distribution, $G(\sqrt{C}) = 1 - \exp[-a\sqrt{C}]$. For all our calculations, we set the parameter a equal to seven. This value implies that the mean of $\sqrt{C}$ -- the maximum deviation between desired and actual prices that the average firm will tolerate -- is $1/7 \approx 15$ percent. A 15 percent inaction range is consistent with microeconomic evidence on the frequency of price adjustment (Cecchetti, 1986; Blinder, 1991).

For the shock θ, we need a distribution $f(\theta)$ that permits either symmetry or skewness. A natural choice is the skew-normal distribution, which generalizes the normal distribution with a third parameter to capture skewness. As discussed by Azzalini (1985), the skew-normal distribution reduces to the normal when skewness is zero, and it approaches a half-normal when skewness approaches an upper bound of .995 or lower bound of -.995.

We continue to assume that the mean of θ is zero, and examine the effects of varying the standard deviation and skewness, which we denote by σ_θ and k_θ. For given values of these parameters, we numerically generate the distribution of industry price changes, $\theta G(|\theta|)$, and calculate the mean, standard deviation, and skewness of this distribution; these moments of actual price changes are denoted μ_p, σ_p, and k_p. Table I presents the results. The table includes only positive values of k_θ; for the corresponding negative values, σ_p is the same, and μ_p and k_p are negative and the same size.

We can see the effects of varying k_θ by looking down a column of the table. As emphasized in our informal discussion, average inflation μ_p rises monotonically with the skewness of θ. Equally important, the skewness of industry price changes, k_p, rises monotonically with the skewness of θ. That is, a large tail of desired price adjustments produces a large tail of actual adjustments, even though desired and actual prices can differ. These results imply that, as k_θ varies, the first and third moments of industry price changes move in the same direction. Finally, note that the standard deviation of price changes, σ_p, remains almost constant as k_θ varies: movements in k_θ do not induce a significant relationship between the first and second moments of price changes.

Looking across a row of Table I shows the effects of the standard deviation of shocks, σ_θ. Not surprisingly, a larger σ_θ implies a larger σ_p. The effect of σ_θ on μ_p has the same sign as k_θ. Thus, as σ_θ varies, a larger σ_p is associated with a larger μ_p if skewness is positive and a smaller μ_p if skewness is negative. Moreover, as suggested in our informal discussion, a larger standard deviation magnifies the aggregate price change arising from skewness.[4]

---

[4] Table I considers values of σ_θ that imply σ_p's of the same order of magnitude as the standard deviations in our data (see Table II below). For larger σ_θ's, the effect of σ_θ on $|\mu_p|$ becomes non-monotonic. As $\sigma_\theta \to \infty$, all firms adjust prices; with fully flexible prices, inflation is zero regardless of k_θ.

C. Sketch of Extensions

Although this model has the virtue of simplicity, it leaves out several important aspects of the short-run behavior of inflation. Here we briefly discuss three extensions of the model, which might be pursued in future research, and the additional results we expect to arise.

Dynamics: Our one-period model assumes that all prices are initially optimal. In a dynamic setting, initial prices for any period may differ from optimal prices, because firms have not adjusted fully to past shocks. Future research might consider a dynamic version of our model. In such a model, current price changes would depend on both the current distribution of shocks and the distribution of initial prices; in turn, the distribution of initial prices would depend on previous distributions of shocks. Hence, a dynamic model would likely yield a relationship between current inflation and the moments of past distributions, in addition to the contemporaneous relationship that we test here.

Trend Inflation and Asymmetric Adjustment: In an earlier paper (Ball and Mankiw, 1992), we examine the effects of sectoral disturbances in the presence of trend inflation. We show that an increase in the variance of shocks raises aggregate inflation, even with a symmetric distribution. The explanation is that, with trend inflation, price adjustment becomes asymmetric: the upper bound on a firm's range of inaction is smaller in absolute value than the lower bound. With asymmetric adjustment, greater dispersion in shocks raises prices on average, because the firms receiving positive shocks adjust more quickly than those receiving negative shocks.

A more general model could combine the asymmetric adjustment of our earlier paper with the asymmetries in shocks emphasized here. The results of both models would carry over: the skewness of shocks influences inflation, but there is also a direct effect of the variance. In our empirical work below, we test for a direct effect of variance.

<u>Monetary Shocks</u>: Finally, one could introduce monetary shocks, which would shift the mean of desired nominal prices over time. A positive monetary shock would raise aggregate inflation, as actual prices adjusted partially. In general, such a shock would also influence the skewness of price changes as some firms are pushed outside their range of inaction and others are not. Thus causality could run from monetary shocks to skewness, as well as from exogenous skewness to aggregate inflation.

In principle, this point suggests caution in interpreting our empirical finding that inflation and skewness move together: the direction of causality is unclear. In practice, however, reverse causality is not a serious problem. As detailed below, an examination of episodes with significant skewness makes clear that the driving force is exogenous asymmetries.

IV. THE DISTRIBUTION OF PRICE CHANGES

We now turn to our empirical analysis. We begin by documenting the asymmetries in the distributions of relative-price changes in the postwar United States.

Our sample consists of the annual Producer Price Index for each year from 1949 to 1989. We examine the PPI because it is available with a high degree of disaggregation. We use PPI components at the four-digit level: examples of four-digit industries are "cattle," "wheat," "cigars," and "lighting fixtures." This level of disaggregation is highly detailed yet is also reasonably complete and consistent over time. The number of four-digit industries in our cross-section is 213 in 1949 and is 343 in 1989. For each year, our summary statistics concern the distribution of the changes in these several hundred prices.

To give an initial sense of asymmetries, Figure 3 presents histograms of log industry price changes for several years. In constructing these histograms, each industry is weighted as in the official PPI. (Specifically, each industry price change is weighted by the "relative importance" of the industry in 1987).

The figure shows that there is considerable variation in the distribution of price changes. In 1987, the distribution is fairly symmetric. In 1973, it is skewed sharply to the right, and in 1986 it is skewed sharply to the left. These last two years correspond to OPEC shocks: oil prices rose in 1973 and fell in 1986. Substantial skewness also occurs in some pre-OPEC years, however, such as 1967.

Table II presents the standard deviation and skewness of the log industry price changes for each year in our sample. We compute these moments both with equal weighting of all prices and with the industry weights described above. The table also includes the inflation rate, measured as the change in the log of the PPI for all commodities.

The table shows that the basic empirical prediction of our model is apparent in the data. The skewness of price changes varies substantially over time, and it varies together with the inflation rate. Years of substantial negative skewness (1949, 1952, 1953, 1960, 1967, 1985, 1986) tend to be years of falling inflation, whereas years of substantial positive skewness (1950, 1965, 1970, 1972, 1973, 1977) tend to be years of rising inflation. A relationship between inflation and the standard deviation of price changes is less apparent.

V. BASIC STATISTICAL EVIDENCE

We now turn to a more systematic investigation of the data to see whether they confirm the informal impressions given by Table II. In all our regressions, the left-hand-side variable is the PPI inflation rate in Table II. On the right-hand side of the equations are variables describing the distribution of relative-price changes. All the regressions also include lagged inflation to capture persistence.

A. Inflation and the Moments

Table III tests our model's basic predictions about the inflationary effects of variance and skewness in relative-price changes. Table IIIA presents results using unweighted moments of relative-price changes, and Table IIIB uses weighted moments. In both tables, column (1) is a benchmark equation that uses only lagged inflation to explain current inflation. Columns (2) to (4) introduce the standard deviation of relative-price changes, the skewness, and both variables together.

These regressions confirm the relation between skewness and inflation. Skewness is always significant and contributes substantially to the $\bar{R}^2$; in the weighted case, the $\bar{R}^2$ is .265 when only lagged inflation is included, but rises to .584 when skewness is added. By contrast, the standard deviation is insignificant in the unweighted regressions. It is significant in the weighted regressions, but its contributions to $\bar{R}^2$ are modest, both when it is the only moment in the regression and when skewness is also included. Thus our results provide strong evidence that inflation is related to the skewness of relative-price changes, as predicted by our model, and somewhat weaker evidence that it is related to the standard deviation, as predicted by the model of asymmetric price adjustment in Ball and Mankiw (1992).

Finally, columns (5) and (6) of Tables IIIA and IIIB add the interaction between the standard deviation and skewness. Again, the data are consistent with the theory: the two moments interact positively. A large standard deviation magnifies the effect of skewness. Remarkably, when both weighted moments and their interaction are included, the $\bar{R}^2$ rises to .809. The moments of relative-price changes explain a large fraction of postwar innovations in inflation.

B. Alternative Measures of Asymmetry

Fundamentally, the theory says that inflation depends on the sizes of the tails of the distribution of changes in relative prices. It would be more parsimonious to measure the relevant asymmetry with a single variable--one that captures both the direct effect of skewness and the magnifying effect of variance. Here we experiment with such alternative variables.

The first variable that we consider is motivated by Figure 1. Specifically, for some cutoff X, define AsymX as

$$\text{AsymX} = \int_{-\infty}^{-X} rh(r)\,dr + \int_{X}^{\infty} rh(r)\,dr,$$

where r is an industry relative-price change (that is, an industry inflation rate minus the mean of industry inflation rates), and h(r) is the density of r, including the weighting for industry size. This variable measures the mass in the upper tail of the distribution of price changes minus the mass in the lower tail. The tails are defined as relative-price changes greater than X percent or smaller than -X percent. Note that AsymX is zero for a symmetric distribution of relative-price changes, positive when the right tail is larger than the left tail, and negative when the left tail is larger. Moreover, for any given skewness, AsymX rises in absolute value when a larger variance magnifies the tails.

The choice of the cutoff X is arbitrary, and so we experiment with a range of values between 5 percent and 50 percent. Our qualitative results are similar for all cutoffs. Table II presents the annual series for Asym10.

Table IV examines whether these asymmetry variables explain movements in inflation by regressing inflation on lagged inflation and AsymX for X=10 percent and X=25 percent. In both cases, the asymmetry variable is statistically significant. With Asym10, the $\bar{R}^2$ is .765, close to the level in the earlier regression that includes skewness, standard deviation, and their interaction.

We consider one final variation on our explanatory variable. The Asym variables capture the idea that large shocks have disproportionate effects by giving full weight to price changes above a cutoff and zero weight to other price changes. An alternative is to increase the weights linearly with the size of the adjustments. This approach yields

$$Q = \int_{-\infty}^{\infty} |r| \cdot rh(r)\,dr.$$

That is, Q averages the product of each relative-price change and its own absolute value. Like AsymX, Q is zero for a symmetric distribution, moves positively with skewness, and is magnified by a larger variance. Table IV shows that this variable, too, has considerable explanatory power for inflation. When inflation is regressed on lagged inflation and Q, the $\bar{R}^2$ is .777.

To summarize, there are various ways to measure the asymmetry in relative-price changes, and no strong grounds for choosing among them. Our results, however, are robust across the different measures.

C. Previous Evidence

One can gauge the robustness of our empirical findings by reexamining previous evidence on inflation and relative-price changes. A particularly useful study is that by Vining and Elwertowski (1976), who also compute unweighted moments of the distribution of industry price changes. Although their basic approach is similar to ours, there are important differences: their sample is mainly from the pre-OPEC era (1948-74); they use CPI as well as PPI data; and they use the 8-digit rather than 4-digit level of disaggregation. Nonetheless, running our basic regressions with Vining and Elwertowski's moments produces results similar to those reported in Table IIIA. As in our data, inflation is closely related to the skewness of relative-price changes.

Indeed, a review of the literature reveals that a number of authors have noted the wide variation in skewness and its relation to inflation. In addition to Vining and Elwertowski, examples include Batchelor (1981), Blejer (1983), Marquez and Vining (1984), and Mizon, Safford, and Thomas (1990). Thus the literature contains considerable support for our basic empirical results.

Given the strength of the relationship between inflation and skewness--and the fact that many authors have reported it--one might be surprised that it has received so little attention. More attention has been paid to the weaker relationship between inflation and the variance of price changes. (See, for example, Fischer's [1981] well-known study.) The apparent explanation for this emphasis is that the relationship between inflation and variance has fit more comfortably into the theoretical frameworks of past researchers. The inflation-skewness relationship has been an empirical oddity without an interesting interpretation. One contribution of menu-cost models of price adjustment is that they provide a theoretical framework in which this fact can be understood.

VI. WHAT SHIFTS THE PHILLIPS CURVE?

A. A New Measure of Supply Shocks

A large literature on the dynamics of inflation takes the Phillips curve as the starting point of analysis. In this literature, inflation depends on past inflation (which perhaps proxies for expected inflation), a measure of the business cycle, and supply shocks. From this perspective, our regressions above are like estimated Phillips curves, with the omission of a business-cycle variable. Moreover, they include an unusual measure of supply shocks, rather than the more traditional variables, such as the relative prices of food and energy.

To relate our regressions to this literature, we turn our inflation equations into Phillips curves by including detrended unemployment. Unemployment is detrended using the Hodrick-Prescott filter. Regression (1) in Table V presents a simple specification that yields the standard results: inflation is positively related to lagged inflation and negatively related to unemployment.

Regressions (2) and (3) add our new measures of supply shocks--the asymmetry variables. Regression (2) includes only Asym10. Regression (3) includes the full set of weighted moments--standard deviation, skewness, and their interaction. We interpret the coefficients on the asymmetry variables as showing how these variables shift the short-run inflation-unemployment relation.

Once again, the results support our model. Although unemployment is significant, both by itself and when asymmetries are included, the coefficients on our measures of asymmetry are close to the coefficients in the earlier regressions without unemployment. Thus, one can interpret our asymmetry variables as representing shifts in the short-run Phillips curve.

Finally, for completeness we include Gordon's (1990) dummy variable for the Nixon price controls in regressions (4), (5), and (6). The effect of the Nixon controls is negative, as expected. The coefficients on the other variables, however, are almost unchanged. The $\bar{R}^2$'s rise as high as .898: our Phillips curves explain most postwar movements in inflation.

B. Comparison to Traditional Measures of Supply Shocks

In previous Phillips-curve studies, notably the work of Gordon (1985, 1990), the most common measures of supply shocks are the changes in the relative prices of food and energy. These measures are empirically plausible, since the best-known shifts in the Phillips curve coincided with food and energy shocks. In addition, as discussed in Section II, these variables are theoretically correct measures of supply shocks if the nominal prices of food and energy are particularly flexible. We now compare our measures of supply shocks to these traditional measures. In addition to food and energy, we consider the change in the relative price of all raw materials.[5]

We first examine the relationships among the alternative variables. Our

[5] We measure food prices with the PPI for farm products, processed food and feed; energy prices with the PPI for fuels and related products; raw materials prices with the PPI for crude materials for further processing. All of these variables are divided by the PPI for all commodities to construct relative prices, and they enter the equations as log differences.

measures of asymmetry have fairly high correlations with traditional measures of supply shocks. For the period 1949 to 1989, the correlation of Asym10 with the changes in the prices of energy, food, and raw materials are .61, .21, and .61. Regressing Asym10 on both the food and energy variables yields an $\bar{R}^2$ of .71. These results are not surprising, since large food and energy shocks induce skewness in the distribution of price changes. To a large extent, our variables and traditional ones capture the same shocks.

Since the various measures of supply shocks have considerable comovement, it is not obvious which variables are responsible for innovations in inflation. To investigate this issue, we run horseraces, which are reported in Table VI. Regression (1) is a Phillips-curve equation including changes in the relative prices of food and energy. As in previous studies, these variables are highly significant. Regression (4) includes the change in the relative price of raw materials; this variable also performs well. The other regressions in this table are horseraces; in each, we include one version of our asymmetry measures (either Asym10 or the moments) and one version of the traditional variables (either food and energy, or raw materials). The results are striking. When our asymmetry measures are included, the coefficients on food and energy prices are close to zero, and are statistically insignificant. The coefficient on raw materials prices falls substantially, and is insignificant in one of two cases. In contrast, the inclusion of the traditional measures of supply shocks has little effect on the size or significance of the asymmetry variables.

These results suggest that the asymmetry variables are better measures of supply shocks than are the traditional variables. Particular prices such as food and energy matter only because they induce asymmetry in the distribution of price changes; they perform well in previous studies because they are proxies for asymmetries. Holding constant the overall distribution, rises in the relative prices of food and energy are not inflationary.

Another way that we compare measures of supply shocks is by examining subsample stability. In Tables VII and VIII, we split our sample into two periods, 1949-1969 and 1970-1989; these correspond roughly to the pre-OPEC and OPEC eras. For each subsample, we estimate Phillips curves using our asymmetry measures and using traditional measures. The coefficients on our variables are fairly stable. Thus our results do not depend on the special circumstances in the 1970s and 1980s. One of the traditional measures of supply shocks, the price of raw materials, also has a fairly stable coefficient. The equation with food and energy prices, however, is unstable. In particular, the effect of energy prices, which is significantly positive for the combined sample, is significantly negative for 1949-1969. This result appears to arise largely from the observations for 1949-1952, which exhibit the largest inflation movements of the pre-OPEC period. Inflation fell in 1949, rose in 1950 and 1951, and fell in 1952; in each case, the relative price of energy moved in the opposite direction.

These results suggest that the relationship between asymmetries and inflation holds across varying economic circumstances. In contrast, food and energy prices influence inflation only when they have a major effect on asymmetries, which is sometimes but not always the case.

VII. SOME HISTORICAL EPISODES

In this section, we examine some of the historical episodes that lie behind our statistical results. In doing this, we have two goals. First, we want to learn about the direction of causation between skewness and inflation. Our theory assumes that skewness in relative-price changes is an exogenous variable causing changes in inflation. As noted above, however, inflation could in principle generate skewness. Examining historical episodes with substantial skewness can shed light on which way causality runs.

Second, historical episodes are of interest in themselves. The goal of macroeconomics is to explain the evolution of the economy. In this section, we see which postwar developments our theory can illuminate.

To help choose the most significant years, Figure 4 presents a scatterplot with our Asym10 variable on the horizontal axis and innovations in inflation on the vertical axis. Innovations in inflation are generated using an AR(1) process for inflation. The figure confirms the strong relation between inflation and the asymmetry variable, and shows that the association is not driven by only a few years.

Several years stand out in this figure as being especially important in driving this relationship. Before examining these episodes, however, we look at two years in which the relationship does not hold.

The Two Big Recessions: Two observations that our theory cannot explain are 1975 and 1982. In 1975, inflation fell, even though Asym10 was positive. In 1982, inflation fell substantially, even though there was almost no asymmetry at all.

It is not surprising that our theory of supply shocks does not explain these two years. In both years, the economy experienced deep recessions that are usually attributed to tight monetary policy. The 1975 recession is attributed to the Fed's delayed reaction to the OPEC-induced inflation that began in 1973, and the 1982 recession to Paul Volcker's determination to disinflate at any cost. (See, for example, Romer and Romer, 1989.) These years are not outliers in our Phillips-curve regressions, in which inflation is explained by unemployment as well as asymmetries in relative-price changes. Indeed, these years can be viewed as evidence in favor of our interpretation of the asymmetry-inflation relationship. The failure of Asym10 to turn negative in these two disinflations suggests that causality does not run from inflation to skewness.

The Oil-Shock Years: The largest absolute values of Asym10 arise in 1973, 1974, 1979, 1980, and 1986; in each case, inflation also moves substantially. The explanation for these episodes is obvious: OPEC. In the first four of the years, OPEC caused large increases in the world price of oil. In 1986, political turmoil among OPEC members caused the price of oil to collapse. The direction of causality is clear: exogenous events in the Middle East induced skewness in the distribution of relative prices, which led to changes in the U.S. inflation rate.

The Mystery of 1952: As we noted in Section I, Arthur Okun called the sudden halt to inflation in the early 1950s "an intriguing fortuitous mystery." It is easy to see why this event appeared mysterious. Inflation fell from 10.7 percent in 1951 to -2.7 percent in 1952. The cause was not a demand contraction, for unemployment fell slightly. And traditional measures of supply shocks do not suggest that inflation should have fallen substantially: the relative price of food fell by only 1.3 percent, and the relative price of energy rose by 2.6 percent. The relative price of raw materials did fall 5.8 percent, but even this change is too small to explain a 12 point change in aggregate inflation.

From the standpoint of our theory, by contrast, the fall in inflation in

1952 is not at all mysterious. As Figure 4 shows, Asym10 was negative and substantial in 1952, indicating a significant, beneficial supply shock. And by other measures, the shock was even larger: the absolute value of weighted skewness, 6.78, is the largest in our sample. The product of the skewness and standard deviation is also the largest. By these measures, there was a larger supply shock in 1952 than, for example, in 1974, when the relative price of energy rose 26 percent.

The disaggregated data for 1952 reveal that the asymmetry in relative-price changes is attributable to various industries that exhibited large relative-price decreases, whereas almost no industries exhibited similarly sized increases. Cattle and hog prices fell over 10 percent. The prices of drugs and soft-surface floor coverings fell over 15 percent. The prices of crude vegetable oil and vegetable-oil end products fell over 20 percent. Crude rubber prices fell over 30 percent, and wastepaper prices fell over 60 percent. Moreover, each of these industries contributes substantially to the measured asymmetry. One cannot look to a single industry to identify the supply shock; instead, one must look to the overall distribution of relative-price changes.

VIII. CONCLUSION

Over the past decade, a large literature has studied menu-cost models of price adjustment.[6] The goal of this literature has been to explain rigorously the short-run effects of aggregate demand. In the most basic

[6] Some of the papers representative of this literature are the following: Mankiw, 1985; Akerlof and Yellen, 1985; Parkin, 1986; Blanchard and Kiyotaki, 1987; Caplin and Spulber, 1987; Rotemberg, 1987; Ball, Mankiw, and Romer, 1988; Ball and Romer, 1990; Caplin and Leahy, 1991; Caballero and Engel, 1992.

terms, this work has sought to explain why the short-run aggregate supply curve slopes upward.

This paper extends this theoretical framework to explain what causes the short-run aggregate supply curve to shift. We show that, when menu costs create a range of inaction in response to shocks, the distribution of relative-price changes influences the overall price level. When the distribution is skewed to the right, the economy experiences an adverse shift in aggregate supply: the price level rises for given aggregate demand. Conversely, when the distribution of shocks is skewed to the left, the economy experiences a beneficial supply shock. Our model shows that the menu-cost paradigm can provide a unified interpretation of short-run fluctuations, in which frictions in price adjustment explain the effects of both demand and supply shocks.

The results in this paper are significant for three reasons. First, we both document and explain an important stylized fact: the correlation between the first and third moments of industry price changes. This correlation is a robust feature of the data: other researchers have noticed it, and we confirm it using four-digit PPI data. Previously, this fact has not been widely emphasized, for it lacked a theoretical explanation. Our theory suggests that the fact is central to understanding the short-run dynamics of inflation.

Second, the empirical validation of our theory provides evidence for menu-cost models of price adjustment. A scientific theory gains credibility when it explains facts that it was not designed to explain. Menu-cost models were developed to explain monetary non-neutrality; they gain credibility from their ability to fit the facts regarding inflation and relative-price changes.

Third, and most important, our results provide an explanation for shifts in the short-run aggregate supply curve, or equivalently the short-run Phillips curve. Since the simple Phillips curve broke down in the early 1970s, many economists have sought to explain how food prices, oil prices, and other microeconomic factors influence the tradeoff between inflation and unemployment. This paper shows that menu-cost models offer a coherent explanation. Moreover, this approach suggests measures of supply shocks that perform better empirically than standard measures. These new measures fit better in sample, they exhibit greater stability across subsamples, and they can more easily explain various historical episodes.

REFERENCES

Akerlof, George, and Janet Yellen, "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia," Quarterly Journal of Economics 100, Supplement 1985, 823-838.

Azzalini, A., "A Class of Distributions which Includes the Normal Ones," Scandanavian Journal of Statistics 12, 1985, 171-178.

Ball, Laurence, and N. Gregory Mankiw, "Asymmetric Price Adjustment and Economic Fluctuations," NBER Working Paper #4089, 1992.

Ball, Laurence, N. Gregory Mankiw, and David Romer, "The New Keynesian Economics and the Output-Inflation Trade-off," Brookings Papers on Economic Activity 1988, no.1, 1-65.

Ball, Laurence, and David Romer, "The Equilibrium and Optimal Timing of Price Changes," Review of Economic Studies 56, April 1989, 179-198.

Ball, Laurence, and David Romer, "Real Rigidities and the Nonneutrality of Money," Review of Economic Studies 57, April 1990, 183-203.

Batchelor, R.A., "Aggregate Expectations Under the Stable Laws," Journal of Econometrics 16, 1981, 199-210.

Blanchard, Olivier J., and Nobuhiro Kiyotaki, "Monopolistic Competition and the Effects of Aggregate Demand," American Economic Review 77, September 1987, 647-666.

Blejer, Mario I., "On the Anatomy of Inflation: The Variability of Relative Commodity Prices in Argentina," Journal of Money, Credit, and Banking 15, November 1983, 469-482.

Blinder, Alan S., "The Anatomy of Double-Digit Inflation," in Robert E. Hall, Inflation: Causes and Effects, University of Chicago Press, 1982.

Blinder, Alan S., "Why are Prices Sticky? Preliminary Evidence from an Interview Survey," American Economic Review 81, May 1991, 89-96.

Caballero, Ricardo J., and Eduardo Engel, "The Output-Inflation Tradeoff Revisited," MIT, 1992.

Caplin, Andrew S., and John Leahy, "State-Dependent Pricing and the Dynamics of Money and Output," Quarterly Journal of Economics 106, August 1991, 683-708.

Caplin, Andrew S., and Daniel F. Spulber, "Menu Costs and the Neutrality of Money," Quarterly Journal of Economics 102, November 1987, 703-

725.

Cecchetti, Stephen G., "The Frequency of Price Adjustment: A Study of the Newsstand Prices of Magazines, 1953-1979," Journal of Econometrics 20, April 1986, 255-274.

Dornbusch, Rudiger, and Stanley Fischer, Macroeconomics, 5th ed., New York: McGraw-Hill, 1990.

Fischer, Stanley, "Relative Shocks, Relative Price Variability, and Inflation," Brookings Papers on Economic Activity 1981:2, 381-431.

Friedman, Milton, "Perspectives on Inflation," Newsweek, June 24, 1975, 73.

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

Gordon, Robert J., "Understanding Inflation in the 1980s," Brookings Papers on Economic Activity, 1985:1, 263-300.

Gordon, Robert J., "What is New-Keynesian Economics?" Journal of Economic Literature 28, September 1990, 1115-1171.

Lilien, David M., "Sectoral Shocks and Cyclical Unemployment," Journal of Political Economy 90, August 1982, 777-793.

Mankiw, N. Gregory, "Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly," Quarterly Journal of Economics 100, May 1985, 529-537.

Marquez, Jaime, and Daniel Vining, "Inflation and Relative Price Behavior: A Survey of the Literature," in Maurice B. Ballabon (ed.), Economic Perspectives: An Annual Survey of Economics, vol. 3, Chur, Switzerland: Harwood Academic Publishers, 1984.

Mizon, Graham E., J. Claire Safford, and Stephen H. Thomas, "The Distribution of Consumer Price Changes in the United Kingdom," Economica 57, May 1990, 249-262.

Okun, Arthur M., "Inflation: Its Mechanics and Welfare Costs," Brookings Papers on Economic Activity 1975:2, 351-390.

Parkin, Michael, "The Output-Inflation Trade-off When Prices Are Costly to Change," Journal of Political Economy 94, February 1986, 200-224.

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

Romer, Christina, and David Romer, "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," NBER Macroeconomics Annual, 1989.

Rotemberg, Julio, "The New Keynesian Microfoundations," NBER Macroeconomics Annual, 1987, 69-114.

Vining, Daniel R., and Thomas C. Elwertowski, "The Relationship Between Relative Prices and the General Price Level," American Economic Review 66, September 1976, 699-708.

Table I: Moments of Industry Price Changes

k_θ		σ_θ				
		0.05	0.10	0.15	0.20	0.25
0.00	μ_p	0.0000	0.0000	0.0000	0.0000	0.0000
	σ_p	0.0217	0.0657	0.1171	0.1708	0.2247
	k_p	0.0000	0.0000	0.0000	0.0000	0.0000
0.20	μ_p	0.0005	0.0011	0.0015	0.0017	0.0017
	σ_p	0.0218	0.0659	0.1174	0.1709	0.2248
	k_p	0.6414	0.4445	0.3454	0.2912	0.2596
0.40	μ_p	0.0010	0.0023	0.0031	0.0035	0.0035
	σ_p	0.0220	0.0662	0.1175	0.1710	0.2249
	k_p	1.2296	0.8651	0.6792	0.5762	0.5156
0.60	μ_p	0.0016	0.0036	0.0049	0.0055	0.0055
	σ_p	0.0222	0.0664	0.1176	0.1709	0.2247
	k_p	1.7668	1.2653	1.0046	0.8576	0.7701
0.80	μ_p	0.0021	0.0050	0.0067	0.0075	0.0076
	σ_p	0.0224	0.0664	0.1174	0.1705	0.2241
	k_p	2.2625	1.6545	1.3302	1.1431	1.0294
0.99	μ_p	0.0027	0.0062	0.0084	0.0094	0.0094
	σ_p	0.0226	0.0663	0.1169	0.1697	0.2233
	k_p	2.7068	2.0271	1.6532	1.4303	1.2906

Table II: Summary Statistics

Year	Inflation	Unweighted SD	Unweighted Skewness	Weighted SD	Weighted Skewness	Asym10
1948	0.0792	0.0964	-1.4168	0.0834	0.9413	0.008819
1949	-0.0509	0.1363	-1.9395	0.0934	-2.3891	-0.006000
1950	0.0385	0.0932	2.4456	0.0598	4.0738	0.004732
1951	0.1068	0.0770	-1.4957	0.0671	1.0843	0.003053
1952	-0.0275	0.1448	-2.9792	0.0620	-6.7753	-0.004370
1953	-0.0145	0.0845	-1.0656	0.0671	-2.8336	-0.005970
1954	0.0028	0.0762	-1.0980	0.0492	-1.5973	-0.002260
1955	0.0034	0.0817	-0.9428	0.0576	-1.6329	-0.001520
1956	0.0310	0.0607	-0.8482	0.0442	-0.2715	0.001885
1957	0.0290	0.0674	-1.5779	0.0503	-0.8251	0.003169
1958	0.0132	0.0698	0.2961	0.0518	1.5182	0.002733
1959	0.0023	0.0836	1.5174	0.0450	-1.3057	-0.003730
1960	0.0005	0.0625	-2.2801	0.0368	-2.1893	-0.001060
1961	-0.0034	0.0543	-0.2714	0.0338	-0.0987	-0.001310
1962	0.0023	0.0460	0.2393	0.0264	-1.5641	0.000287
1963	-0.0023	0.0660	-2.0541	0.0288	1.2287	-0.001930
1964	0.0018	0.0499	0.5542	0.0307	1.7726	-0.000092
1965	0.0198	0.0602	1.0144	0.0414	2.9306	0.004364
1966	0.0317	0.0520	1.6282	0.0336	1.9459	0.002626
1967	0.0274	0.0793	-3.6261	0.0369	-3.6282	-0.002540
1968	0.0246	0.0565	1.2269	0.0328	1.0439	0.000290
1969	0.0389	0.0512	1.4171	0.0380	1.3762	0.002547
1970	0.0361	0.0738	-2.3093	0.0500	2.3581	0.003011
1971	0.0322	0.0653	-1.2299	0.0482	0.0263	0.004274
1972	0.0432	0.0998	4.1443	0.0476	4.7456	0.005519
1973	0.1235	0.1517	2.0122	0.1123	2.9204	0.013661
1974	0.1721	0.1648	0.1646	0.1606	1.1848	0.009228
1975	0.0882	0.1548	-1.9980	0.1141	-0.7301	0.004681
1976	0.0454	0.1153	1.2631	0.0797	1.1117	0.001966
1977	0.0594	0.0753	1.2805	0.0776	2.1775	0.004240
1978	0.0751	0.0616	-0.9992	0.0614	0.7859	0.003342
1979	0.1182	0.0808	0.5507	0.0860	1.1513	0.008178
1980	0.1317	0.1193	-0.6348	0.1140	1.4271	0.009898
1981	0.0876	0.0748	-1.4884	0.0829	0.7054	0.005560
1982	0.0200	0.0782	-2.1894	0.0715	-1.0549	0.000173
1983	0.0122	0.0510	0.7041	0.0482	0.0272	-0.001780
1984	0.0236	0.0525	1.3320	0.0416	1.0955	0.001500
1985	-0.0050	0.0619	-3.1010	0.0500	-2.8140	-0.003550
1986	-0.0293	0.0871	-4.2430	0.1255	-3.1192	-0.013740
1987	0.0260	0.0548	1.1056	0.0548	0.1472	0.003082
1988	0.0394	0.0696	1.7304	0.0724	0.8086	0.000176
1989	0.0483	0.0449	0.8508	0.0415	1.0659	0.002397
Mean	0.0352	0.0807	-0.3407	0.0622	0.1625	0.001561
SD	0.0468	0.0312	1.8204	0.0296	2.1997	0.004910

Table IIIA: Inflation and the Distribution of Price Changes

Dependent Variable: Inflation

Unweighted Measures of Dispersion

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	.016 (.008)	.010 (.019)	.016 (.007)	.012 (.017)	.013 (.006)	.012 (.015)
Lagged Inflation	.527 (.134)	.490 (.176)	.619 (.121)	.597 (.158)	.736 (.110)	.728 (.142)
Standard Deviation		.087 (.264)		.053 (.233)		.019 (.202)
Skewness			.011 (.003)	.011 (.003)	-.020 (.009)	-.020 (.009)
Skew*SD					.357 (.097)	.356 (.098)
$\bar{R}^2$	.265	.248	.428	.414	.571	.559
D.W.	1.56	1.57	1.78	1.79	1.68	1.68
s.e.e.	.040	.041	.036	.036	.031	.031

Standard errors are in parentheses.

Table IIIB: Inflation and the Distribution of Price Changes

Dependent Variable: Inflation

Weighted Measures of Dispersion

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	.016 (.008)	-.014 (.014)	.013 (.006)	-.014 (.010)	.016 (.005)	-.010 (.008)
Lagged Inflation	.527 (.134)	.293 (.161)	.569 (.101)	.352 (.117)	.480 (.083)	.274 (.088)
Standard Deviation		.609 (.256)		.559 (.185)		.537 (.138)
Skewness			.012 (.002)	.012 (.002)	-.009 (.005)	-.009 (.004)
Skew*SD					.332 (.069)	.326 (.059)
$\bar{R}^2$	.265	.343	.584	.657	.737	.809
D.W.	1.56	1.53	1.55	1.64	1.53	1.58
s.e.e.	.040	.038	.030	.028	.024	.021

Standard errors are in parentheses.

Table IV: Alternative Measures of Asymmetry

Dependent Variable: Inflation

	(1)	(2)	(3)	(4)
Constant	.016 (.008)	.015 (.004)	.018 (.006)	.018 (.004)
Lagged Inflation	.527 (.134)	.252 (.082)	.235 (.109)	.246 (.080)
Asym10		7.33 (.80)		
Asym25			4.85 (.82)	
Q				10.0 (1.1)
$\bar{R}^2$	.265	.765	.609	.777
D.W.	1.56	2.01	1.91	1.80
s.e.e.	.040	.023	.029	.022

Standard errors are in parentheses.

Table V: Phillips-Curve Equations

Dependent Variable: Inflation

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	.015 (.007)	.015 (.004)	-.009 (.007)	.015 (.008)	.017 (.004)	-.005 (.006)
Lagged Inflation	.551 (.124)	.283 (.077)	.327 (.075)	.559 (.136)	.209 (.082)	.260 (.068)
Nixon Dummy				.006 (.041)	-.047 (.023)	-.058 (.017)
Unemployment	-2.10 (.75)	-1.15 (.44)	-1.49 (.36)	-2.06 (.79)	-1.35 (.43)	-1.78 (.33)
Asym10		6.84 (.77)			7.22 (.76)	
Standard Deviation			.491 (.116)			.471 (.102)
Skewness			-.004 (.003)			-.004 (.003)
Skewness*SD			.260 (.052)			.277 (.046)
$\bar{R}^2$	.376	.796	.884	.360	.812	.898
D.W.	1.70	2.12	1.98	1.71	2.18	1.85
s.e.e.	.037	.021	.017	.038	.020	.015

Standard errors are in parentheses. "Unemployment" stands for the Hodrick-Prescott filtered unemployment rate, and "Nixon Dummy" for Robert Gordon's dummy variable for the Nixon Administration's wage and price controls (.5 for 1972 and 1973, -.3 for 1974, and -.7 for 1975).

Table VI: Horseraces

Dependent Variable: Inflation

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	.026 (.006)	.016 (.005)	-.004 (.006)	.020 (.005)	.018 (.004)	-.004 (.005)
Lagged Inflation	.322 (.125)	.236 (.091)	.284 (.077)	.574 (.096)	.257 (.096)	.280 (.063)
Nixon Dummy	-.042 (.035)	-.052 (.025)	-.069 (.019)	-.110 (.034)	-.062 (.028)	-.082 (.018)
Unemployment	-1.08 (.64)	-1.44 (.46)	-1.74 (.35)	-1.57 (.56)	-1.35 (.43)	-1.60 (.31)
Food	.660 (.160)	-.019 (.162)	.117 (.101)			
Energy	.381 (.083)	-.061 (.096)	-.001 (.066)			
Raw Materials				.681 (.111)	.133 (.136)	.218 (.081)
Asym10		7.74 (1.31)			6.29 (1.22)	
Standard Deviation			.459 (.102)			.475 (.094)
Skewness			-.005 (.003)			-.005 (.003)
Skewness*SD			.284 (.062)			.245 (.044)
$\bar{R}^2$	.617	.805	.899	.679	.812	.914
D.W.	1.82	2.21	1.74	2.36	2.25	1.81
s.e.e.	.029	.021	.015	.026	.020	.014

Standard errors are in parentheses. "Unemployment" stands for the Hodrick-Prescott filtered unemployment rate, "Food", "Energy" and "Raw Materials" for the relative inflation rates for the prices of those goods, and "Nixon Dummy" for Robert Gordon's dummy variable for the Nixon Administration's wage and price controls (.5 for 1972 and 1973, -.3 for 1974, and -.7 for 1975).

Table VII: Subsample Stability, Part I

Dependent Variable: Inflation

	(1)	(2)	(3)	(4)
Sample	49-69	70-89	49-69	70-89
Constant	.014 (.005)	.021 (.006)	-.014 (.011)	-.002 (.009)
Lagged Inflation	-.046 (.135)	.382 (.112)	.328 (.132)	.337 (.102)
Nixon Dummy		-.032 (.021)		-.043 (.020)
Unemployment	-1.15 (.57)	-2.22 (.51)	-2.06 (.45)	-1.82 (.49)
Asym10	6.97 (1.40)	5.12 (.90)		
Standard Deviation			.642 (.239)	.419 (.127)
Skewness			-.017 (.006)	-.003 (.005)
Skewness*SD			.531 (.110)	.218 (.057)
$\bar{R}^2$	.608	.902	.775	.925
D.W.	2.26	2.32	2.02	1.90
s.e.e.	.019	.016	.015	.014

Standard errors are in parentheses. "Unemployment" stands for the Hodrick-Prescott filtered unemployment rate, and "Nixon Dummy" for Robert Gordon's dummy variable for the Nixon Administration's wage and price controls (.5 for 1972 and 1973, -.3 for 1974, and -.7 for 1975).

Table VIII: Subsample Stability, Part II

Dependent Variable: Inflation

	(1)	(2)	(3)	(4)
Sample	49-69	70-89	49-69	70-89
Constant	.012 (.005)	.031 (.005)	.019 (.005)	.016 (.008)
Lagged Inflation	-.185 (.114)	.407 (.081)	.052 (.142)	.762 (.120)
Nixon Dummy		-.028 (.015)		-.052 (.036)
Unemployment	-2.11 (.52)	-1.64 (.38)	-1.27 (.56)	-2.67 (.70)
Food	.249 (.146)	.540 (.084)		
Energy	-.728 (.171)	.354 (.040)		
Raw Materials			.645 (.130)	.397 (.134)
$\bar{R}^2$	.698	.953	.608	.804
D.W.	2.02	1.89	2.02	2.53
s.e.e.	.017	.011	.019	.022

Standard errors are in parentheses. "Unemployment" stands for the Hodrick-Prescott filtered unemployment rate, "Food", "Energy" and "Raw Materials" for the relative inflation rates for the prices of those goods, and "Nixon Dummy" for Robert Gordon's dummy variable for the Nixon Administration's wage and price controls (.5 for 1972 and 1973, -.3 for 1974, and -.7 for 1975).

Figure 1

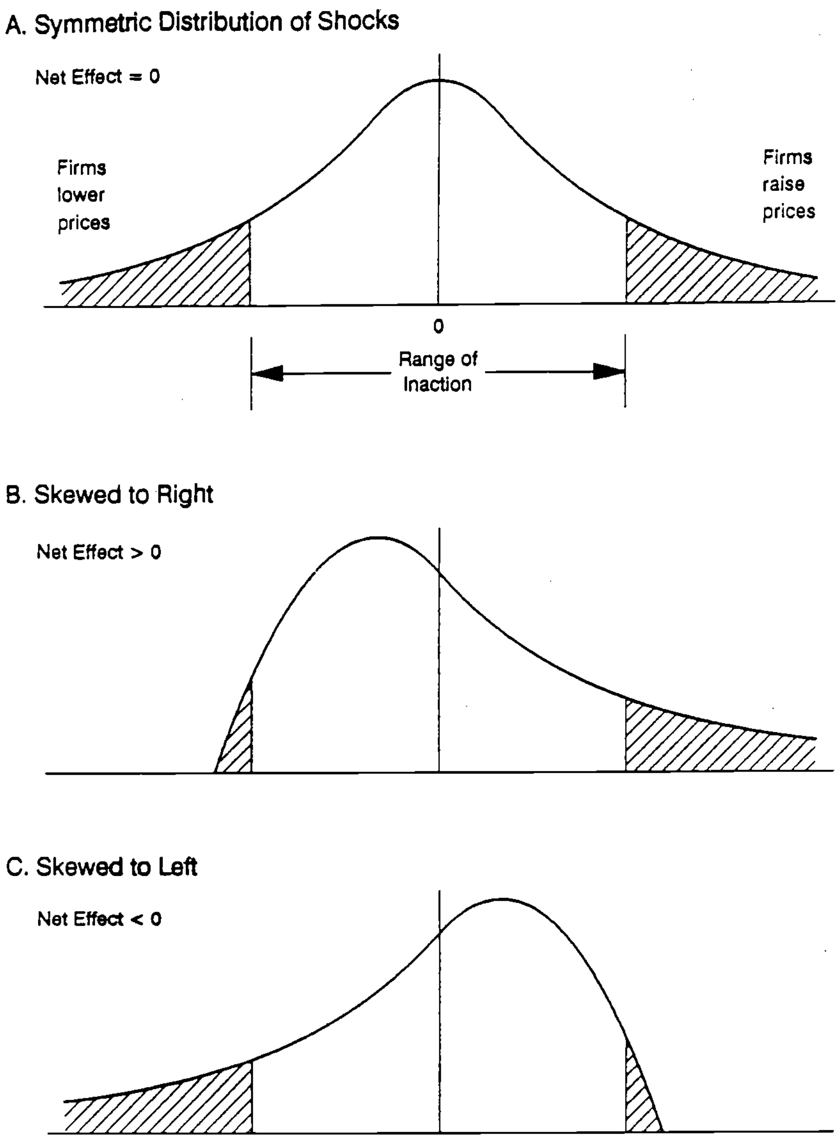
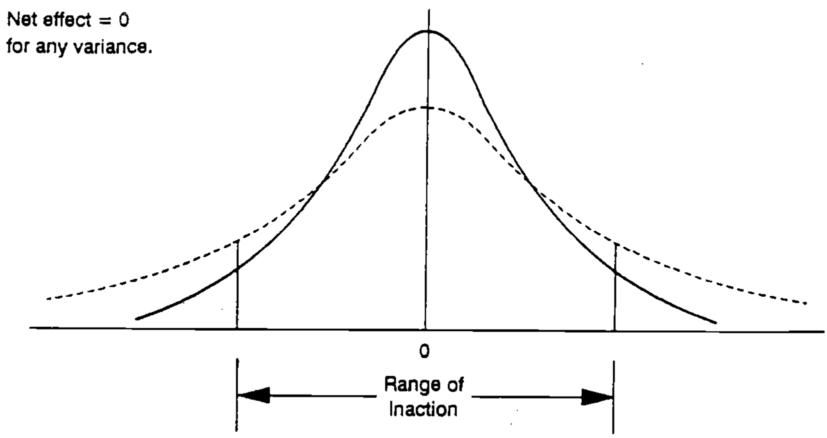

A. Symmetric Distribution of Shocks
Net Effect = 0
Firms lower prices
Firms raise prices
0
Range of Inaction
B. Skewed to Right
Net Effect > 0
C. Skewed to Left
Net Effect < 0

Figure 2

A. Symmetric Distribution



B. Skewed Distribution

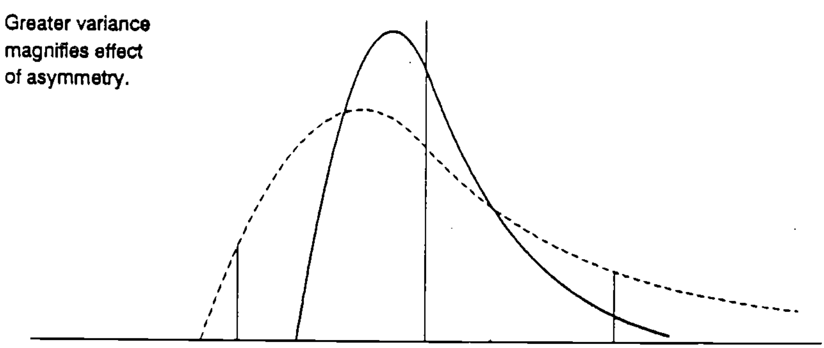


FIGURE 3

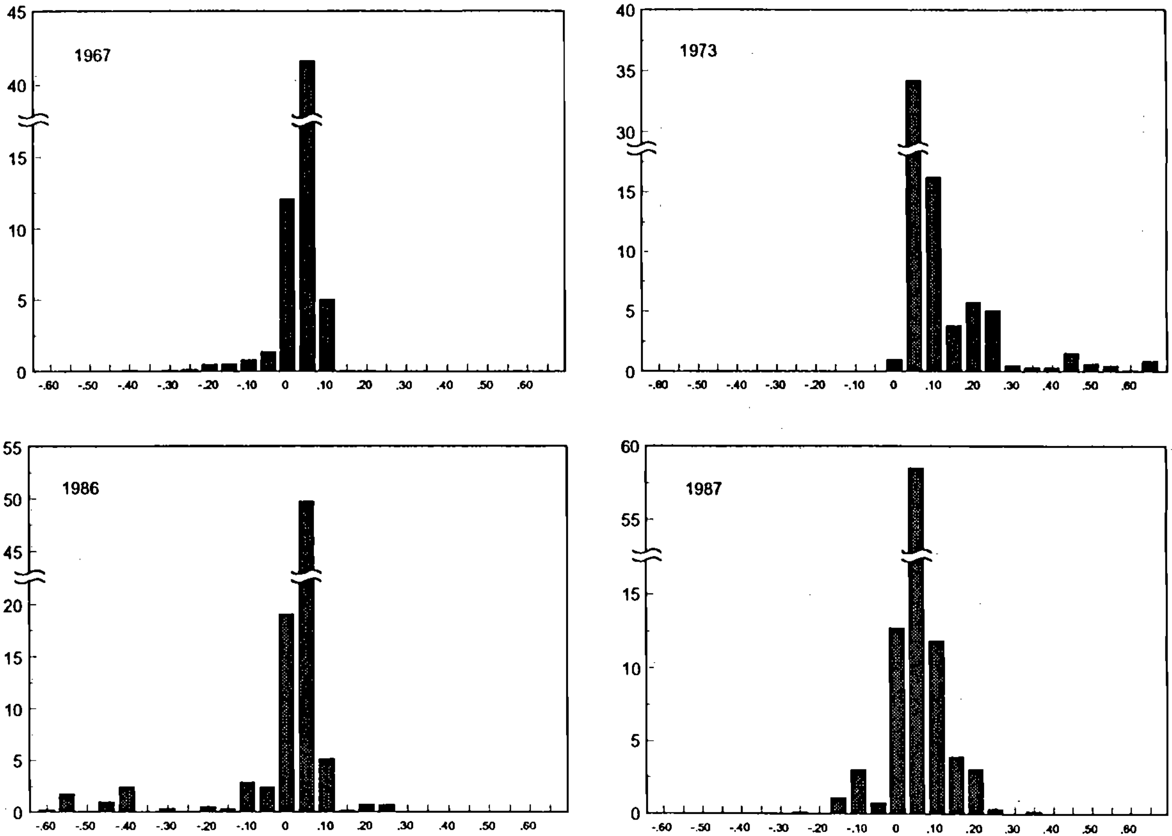
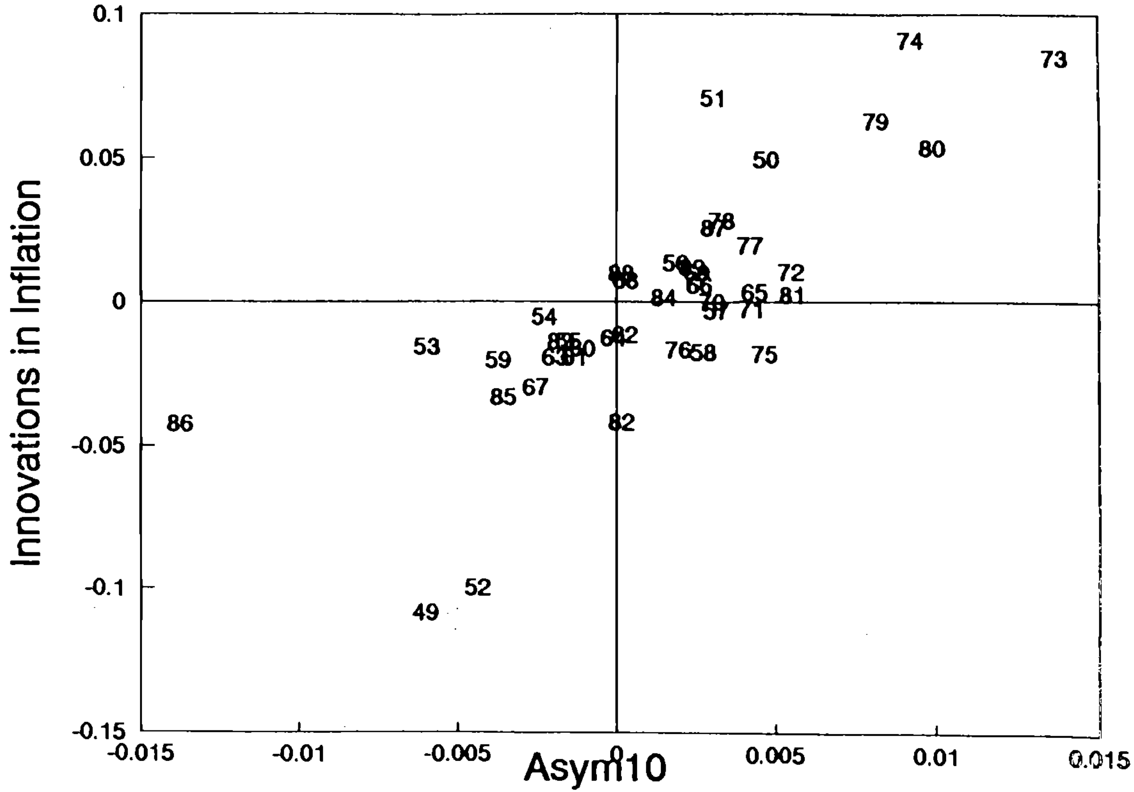

1967
45
40
15
10
5
0
-.60 -.50 -.40 -.30 -.20 -.10 0 .10 .20 .30 .40 .50 .60
1973
40
35
30
15
10
5
0
-.60 -.50 -.40 -.30 -.20 -.10 0 .10 .20 .30 .40 .50 .60
1986
55
50
45
20
15
10
5
0
-.60 -.50 -.40 -.30 -.20 -.10 0 .10 .20 .30 .40 .50 .60
1987
60
55
15
10
5
0
-.60 -.50 -.40 -.30 -.20 -.10 0 .10 .20 .30 .40 .50 .60

Figure 4


Innovations in Inflation
Asym10
0.1
0.05
0
-0.05
-0.1
-0.15
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
74
73
51
79
80
50
78
87
77
72
65
81
84
54
53
59
67
85
86
82
76
58
75
71
52
49