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INFLATION, UNCERTAINTY AND CAPACITY UTILIZATION

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Inflation, Uncertainty and Capacity Utilization

Editorial committee for this issue:
Hang-Sheng Cheng, John Judd, Yvonne Levy

Inflation, Uncertainty and Capacity Utilization

The economy has expanded substantially since the dismal days of early 1975; indeed, this expansion may be characterized as the longest and the strongest peacetime recovery of the past generation. At this stage of the business cycle, therefore, we are interested in determining the extent of the pressures (if any) developing in the labor and capital markets. In other words, how far can the expansion go without aggravating the already severe inflationary pressures existing in the economy? But in addition, we are interested in determining the shifts (if any) in factor utilization created by the increased uncertainty characteristic of the inflationary 1970's. Other studies have examined these questions in terms of labor-force utilization. The three papers in this issue extend the discussion, however, by analyzing also the utilization of capacity in the industrial sector of the economy.

Joseph Bisignano, in his paper, focuses on the role that inflation plays in determining labor and capital demand in manufacturing, especially when price changes are unexpected. To help analyze this question, he considers two measures of inflation variability—"unanticipated inflation," obtained from errors of forecasts of the wholesale-price index six months into the future, and "relative price variability," measured as the variance of the rate of change in business capital-goods prices. He incorporates these inflation-variability measures into a model of the demand for two "stock" variables, capital and workers, and two "flow" variables, capacity utilization and average weekly hours.

Bisignano's study suggests that, over the 1959-75 period, unanticipated inflation has tended to reduce the demand for investment goods in manufacturing, and to increase labor demand and the rate of capacity utilization. "Our tentative evidence suggests that unanticipated inflation can affect the demand for factors of production as well as the utilization of these factors. This type of inflation thus may slow the process of capital growth. Moreover, unanticipated-inflation shocks, and their persistent effects over a prolonged period, help explain why investment demand has been sluggish since the early-1975 cyclical trough."

Bisignano raises an important question—whether unanticipated inflation affects labor demand differently than capital demand. He notes that unanticipated inflation creates additional uncertainty regarding a firm's future output prices. The firm when expanding output thus will attempt to minimize the future cost of its forecasting errors by using more of its variable factor, labor, and less of its fixed factor, capital. The risk-averse firm, encountering greater uncertainty over the real value of future streams of income, will attempt to minimize those investments that are least reversible, such as long-term investment in plant and equipment. Unanticipated inflation thus causes changes in factor-demand response by inducing the substitution of labor for capital.

Rose McElhattan develops a combined price equation, connecting inflation and capacity utilization, analogous to the inflation/unemployment relation so often discussed in the literature. Her study suggests the existence of a full-capacity utilization rate which is consistent with the "natural rate of unemployment" concept. (According to that view, there is only one full-employment unemployment rate, towards which the economy tends over time.) Attempts to maintain a capacity-utilization rate above the estimated full-capacity equilibrium rate appear to be associated with a steadily increasing inflation rate.

At what specific point in the use of the nation's industrial capacity are inflationary pressures likely to increase? Many economists believe that the yardstick is provided by the historical peak of capacity utilization—that is, the 87-to-88 percent level of the 1973 period. McElhattan's analysis suggests, however, that the full-capacity utilization rate is reached at a somewhat lower level, so that there is less non-inflationary slack in the present economy than is commonly believed.

She argues that inflation tends to accelerate when the operating rate surpasses 82 percent—or more generally, the range of 80 to 83½ percent. "Once beyond that range, excess demand generates inflationary pressures as less efficient labor and capital resources are called into use. Thus, since utilization rates recently have approached 85 percent, we could expect mounting inflationary pressures from the domestic, nonfarm business sector of the economy."

Her estimates also indicate that for every percentage-point increase in capacity utilization above 82 percent, the rate of inflation should increase .12 percentage points on average. For example, if the yearly operating rate averages 88 percent—the historical peak value—the annual inflation rate should increase .72 percentage points on average. "Once capacity utilization exceeds the range indicated, the increased inflation tends to become imbedded in future inflation, with the current period's higher prices being reflected in the next period's expectations. When the operating rate rises above the full-capacity range, its return to that range will be accompanied by a higher rate of inflation."

Larry Butler analyzes the apparent conflict between the unemployment rate and the capacity-utilization rate—the two measures of the available economic capacity at the nation's disposal. He recognizes the argument that the conflict may be apparent rather than real, because structural changes in the economy—such as labor-force shifts—have made it difficult to compare the measures over time. He claims, however, that it is not necessary to resort to structural arguments to explain the current divergence of the two rates. "Rather, the two markets need not reach full-resource use at the same point in the business expansion, because capital and labor supplies exhibit different cyclical patterns. New additions to the capital stock are concentrated in the mature-recovery portions of cyclical expansions, while new additions to the labor force are concentrated in the brief periods following cyclical troughs."

Butler deals with this problem by developing a two-factor model—one which includes the capital market as well as the labor market used in the standard (single factor) aggregate-demand model. The single-factor model adequately describes such mature-recovery periods as 1956-57 and 1967-69, which were capital-constrained with high levels of capacity utilization, and also labor-constrained with quite low levels of unemployment. However, the two-factor model provides a much better explanation of three brief but important periods of transition to full employment—in 1955, 1965 and 1973. "More importantly, that model may be relevant to the period immediately ahead, which is likely to be marked by capital constraints but also by adequate supplies of labor."

Inflation Expectations and Factor Demands in Manufacturing

Joseph Bisignano*

Since the business-cycle trough in the first quarter of 1975, economists have frequently noted the rapid growth in aggregate employment and the rather sluggish growth in real business fixed investment. From March 1975 to July 1978, total employment grew at a 3.5-percent annual rate, compared with a 2.4-percent average annual rate of growth for the previous four business cycles. In contrast, real fixed investment grew at a 5.5-percent annual rate over roughly the same time-span, compared with a 7.3-percent average growth rate in the previous four recoveries.

Against that background, this paper focuses on the role inflation plays in determining the demand for labor and capital in manufacturing. Will inflation tend to increase or reduce the demand for these factors of production, and under what conditions? To help answer the question, we shall consider two measures of inflation variability. The first is a measure of "unanticipated inflation," obtained from errors of forecasts of the wholesale-price index six months into the future. The second measure, referred to here as "relative price variability," is the variance of the rate of change in business capital-good prices, derived from the disaggregated components of the price deflator for business fixed investment. These inflation-variability measures are incorporated into a model of the demand for two "stock" variables, capital and workers, and two "flow" variables, capacity utilization and average weekly hours worked. The demands for these factors of production are considered "interrelated," with the adjustment in one factor affected by the state of the other factors. We statistically estimate the factor demands to determine the impact of inflation variability, and then ask whether the results are consistent with the observed growth in labor and capital in the recovery period beginning in early 1975.

This study suggests that, over the 1959-75 period, unanticipated inflation has tended to reduce the demand for investment goods in manufacturing, and to increase labor demand and the rate of capacity utilization. In addition, anticipated (trend) inflation has had no statistically significant impact on either labor or capital demand. The latter findings lend support to the "natural-rate hypothesis" that there is no permanent beneficial trade-off between anticipated inflation and unemployment.

I. Output Expansion With Known Relative Prices

To understand how inflation may affect the demand for, and utilization of, capital and labor, we must first distinguish between short-run and long-run firm behavior in an environment without any price uncertainty. The "short run" typically is defined as a period with fixed supplies of at least one factor of production, usually capital in the form of physical plant and equipment. The labor force is usually considered variable in the short-run; within certain limits, the labor force can be expanded or contracted to meet the requirement to produce a given amount of output.

The "long-run" is conceptually defined as a period with variable supplies of both factors of production, labor and capital; that is, both are decision variables capable of being expanded to meet desired levels of output.[1] A firm's long-run production problem consists of determining the desired physical plant size and the desired perm-

*Director of Economic Analysis, Federal Reserve Bank of San Francisco. Research assistance for this article was provided by Jayant Kalawar, Jackie Kau and Steve Zeldes.

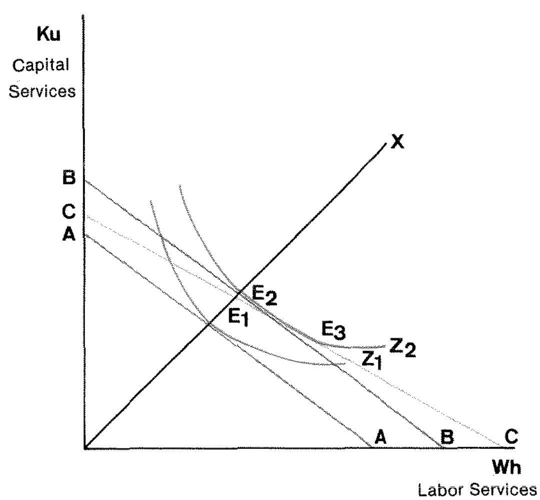
anent work force, while its short-run production problem consists of determining the optimal utilization of capital and labor, with some variation permissible in the size of the work force.

The firm's production process may have two dimensions, a stock and a flow dimension, with output being produced by the flow of services from capital and labor. The stock of capital, K (plant and equipment), times its utilization rate, u, determines capital services; the stock of labor, W (production workers), times its utilization, h (average hours worked) determines worker-hours, or the service flow from labor.

Chart 1 depicts the interaction of capital services Ku and worker services Wh. In the short-run we consider K fixed, while W, u and h are allowed to vary. In the long-run, with u and h set at their long-run "full utilization" levels, both the capital stock and the work force can vary to achieve a higher level of output.

The "constant output" curves Z_1 and Z_2 depict the combinations of capital and labor services that can produce the same output level. (Z_2 represents the higher output level of the two). The line AA is a "constant-cost" line, meaning that the same cost to the firm is incurred by varying expenditures on capital and labor anywhere along line AA. Equilibrium for the firm is achieved at point E, the most efficient combination of capital and labor given the prices of labor and capital. At point E, the ratio of the marginal return to labor to the marginal return to capital is exactly equal to the ratio of their respective prices.

Chart 1
Capital and Labor Services



"Relative factor prices," that is, the ratio of the price of capital to the price of labor, is equal to the absolute value of the slope of the AA line. Hence, since equal-cost line BB is parallel to AA, line BB represents a greater expenditure on capital and labor but at the same relative prices as exist at constant-cost line AA.

The two equal-output curves Z_1 and Z_2 represent technical (or engineering) relationships between capital and labor. These equal-output curves are shown as "smooth", under the assumption that very small incremental substitutions between capital services and labor services can produce the same output level. The firm's most economical expansion path, with unchanged relative prices, would be along the ray OX, which technically is a straight line for a wide variety of production functions.[2] The ray, OX, depicts those points of minimum production costs, at constant relative factor prices, as the firm expands to higher output levels.

Relative factor prices play an important role, first, in determining the most economical combination of factor inputs for producing a given output level, and, secondly, in determining the ratio of capital to labor as output expands. Chart 1 shows that as output expands from level Z_1 to Z_2 at constant factor prices, with constant utilization rates of capital and labor, capital and labor stocks should expand in fixed proportion. This constant proportionality cannot, of course, be expected to hold over every point throughout a business cycle. However, we should expect long-run factor-expansion proportionality if relative factor prices do not change considerably. Given a significant—and permanent—increase in the cost of capital relative to labor, the firm and the industry will economize on the more costly factor by employing relatively more labor. For example, with the equal-cost line CC, the firm faced with higher capital costs will produce output level Z_2 by moving from E_2 to E_3.

When the firm plans to expand plant size and work force, it does so presumably under the assumption that it knows what relative prices will be during the period when that expansion takes place. Thus, to the extent that inflation (i.e., the rise in the aggregate price *level*) affects long-run factor demands, the firm presumably knows how inflation affects *relative* factor prices over the planning horizon, when initial planning begins. As Chart 1 illustrates, relative factor prices will determine the most economical combination of factor inputs. Anticipated changes in the aggregate price *level* affect factor demands only to the extent that they alter relative factor prices. The relevant question is how inflation might affect relative factor prices, and what response firms are likely to make to both changing relative factor prices and variability in such prices.

Given current corporate accounting procedures, relative factor prices are sensitive to the aggregate rate of inflation even where the future inflation rate is known with certainty. This effect of *anticipated* inflation is analyzed in a recent article by Feldstein, Green and Sheshinski.[3] In their view, the real after-tax return to debt and equity reflects changes in the rate of inflation, because the U.S. tax system taxes the *nominal* income from investment (i.e., nominal interest and nominal capital gains) but permits borrowers to deduct *nominal* interest costs. The firm typically minimizes its total cost of capital by choosing an "optimal" debt-equity ratio, which ratio depends on the schedule of corporate tax rates and the rate of inflation. The shift in the debt-equity ratio due to inflation alters the firm's total cost of capital and, in turn, alters the firm's "implicit rental price of capital," defined as the incremental cost to the firm of a marginal increase in its real capital stock.[4]

The authors further argue that historical cost depreciation causes an implicit taxation of cash flow which increases with the rate of inflation. Quite simply, inflation reduces the real after-tax cash value of a dollar's worth of depreciation generated in the future.[5] This implicit taxation of cash flow is borne by both debt and equity holders. In addition, inflation aggravates a firm's tendency to extend debt in lieu of equity because of the deductability of nominal interest costs. Anticipated inflation, they argue, tends on balance to decrease the net rate of return to capital (which would *increase* the rental price of capital) and, in turn, to reduce the ratio of capital to labor.

These effects of fully anticipated inflation, by increasing the relative price of capital vis-a-vis the price of labor, should be captured in the relative price variable. If inflation causes the rental price of capital to rise more than the inflation-induced rise in wage rates, the firm will expand along a new expansion path, to the right of OX in Chart 1.

Fully anticipated inflation should have no effects independently of the relative price of capital, since it is relative prices which determine demands for factors of production. That is, fully anticipated inflation, and its consequent effects on the debt-equity ratio and the tax value of depreciation, presumably are captured in our measure of the firm's "rental price of capital."[6] Unanticipated inflation, on the other hand, must be incorporated in our model to capture the independent effect of this variable on factor demands in manufacturing.

II. Factor Demand and Unanticipated Inflation

Before considering how firms will respond to measures of inflation variability, we must first consider the aggregate relationship between inflation and employment, specifically, what has come to be called the "natural rate of unemployment" hypothesis. This hypothesis states that employment is a "real" phenomena and can therefore be determined only by other "real" phenomena—that is, it should be independent of any "nominal" phenomena. (Nominal factors, unlike real factors, depend on a monetary unit of account.) The natural-rate hypothesis basically states that there is no relationship (trade-off) between the rate of inflation and the unemployment rate in the long-run. This hypothesis is important because we are interested in the relationship of inflation to manufacturing employment, as well as to manufacturing capital demand and the utilization of capital and labor in that industry. Thus we should consider whether our results are consistent with the natural-rate hypothesis.

The natural-rate hypothesis does not necessarily preclude the existence of a relationship between employment and inflation in the short-run. One recent explanation of this short-run relationship concerns the way individuals form their expectations of inflation—the "rational expectations" argument. According to this argument, individuals have reasonably good knowledge in forming their inflation expectations. While those expectations may be wrong, they are not *consistently* wrong. Hence, there is no *systematic* error in the marketplace's expectations of inflation. (In other words, individuals' expectational errors average out to zero.) Given the basic premise that labor and capital demand is dependent on relative prices, and not on the level or rate of change of prices, the rational-expectations argument implies that any relationship between inflation and factor demand must result from individuals' short-term errors in forecasting inflation. These forecasting errors cause firms to temporarily misjudge current and future relative prices, thereby inducing a *temporary* relationship between inflation and employment. Yet because these errors are not systematic but rather fluctuate around zero, there is no systematic *long-run* relationship between employment and inflation.

Why do firms misperceive the rate of inflation, and thereby create a temporary misperception of relative prices? One possible explanation is simply incomplete information. Specifically, firms may have better present and future knowledge of their input prices, the prices of capital and labor, than of the future aggregate price level which will influence their output price. Thus if firms underestimate inflation, they may be led to believe that their output prices will rise in the future, so that they will then increase their demand for factors of production. This "paradigm of incomplete information"[7] implies that firms have better "local" price information, affecting their input prices, than "global" price information, affecting the aggregate price level. Yet under the rational-expectations model, only aggregate inflation-expectation errors trigger a factor-demand response. This argument thus suggests that factor demand can be affected by only one "inflation stock"—unanticipated inflation—and not by either the variability of input prices or by anticipated inflation acting by itself (independent of relative factor prices).

By including both the relative price variability in investment goods (local information) and unanticipated inflation (global information), we are able to test directly the natural-rate, rational-expectations argument. In the context of the manufacturing industry, this argument states that factor-demand adjustments are triggered by the effects of unanticipated inflation in the aggregate price level, rather than by the variability of inflation in input prices.

Other analysts have considered the aggregate economy impact of unanticipated inflation, but we are interested in an additional question which deserves more empirical investigation[8]—namely, whether unanticipated inflation affects labor demand differently from capital demand. We argue that since unanticipated inflation creates additional uncertainty regarding a firm's future output prices, the firm when expanding output will attempt to minimize the future cost of its forecasting errors by using more of its variable factor, labor, and less of its fixed factor, capital. A similar argument can be found in Albert Gailord Hart's 1940 book *Anticipations, Uncertainty, and Dynamic Planning.*

> "The fact that uncertainty—specifically, a high dispersion of anticipations around the expectation—favors processes under which durable equipment will be held to a minimum lends color to the widely held view that an increase in uncertainty will act upon the firm like an increase in interest rates."[9]

Hart's argument would suggest that, because of greater uncertainty in aggregate inflation, firms will not expand output along the expansion path shown in Chart 1. This variability, as measured by unanticipated inflation, causes greater uncertainty over the real value of future streams of income, so that the risk-averse firm will choose to minimize those investments that are least reversible, such as long-term investment in plant and equipment. This argument complements the Feldstein-Green-Sheshenski argument, which states that a reduction of fixed investment minimizes the implicit taxation of the firm's cash flow due to the use of historical-cost depreciation in an environment of uncertain inflation. Our hypothesis thus states that unanticipated inflation causes changes in factor-demand response by inducing the substitution of labor for capital.

III. Price Variability Data

Two measures of price variability are used in this study. The first measure consists of the variance of the rates of change of prices for individual components of business fixed investment from the average rate of change for the group as a whole.[10] For example, if P_{it} is the price of investment good i in period t, and P_t is the aggregate investment-goods price index, our relative price variance, RPV, measures the nonproportionality of price changes across the entire class of business-investment expenditures. It should be noted that RPV is a measure of *relative* price variability for investment goods.

The second measure of price variability consists of the forecast errors of projections of the wholesale-price index six months in the future. The forecasts have been compiled by Joseph Livingston, the Philadelphia Inquirer's business editor, and have been analyzed and cleansed for computational errors by John A. Carlson.[11] We used simple linear interpolation in order to obtain quarterly data from the semi-annual Livingston-Carlson series. These forecast errors provide a measure of "unanticipated inflation," since they are obtained from actual survey forecasts of wholesale-price inflation. The Livingston-Carlson forecasts can be said to be "rational," in that they utilize past inflation data to produce efficient and consistent inflation forecasts.[12] Thus the unanticipated rates of wholesale-price change utilized in our study appear to provide adequate representations of actual price-forecast errors that would take place in factor markets.

Chart 2

Relative Price Variance of Investment

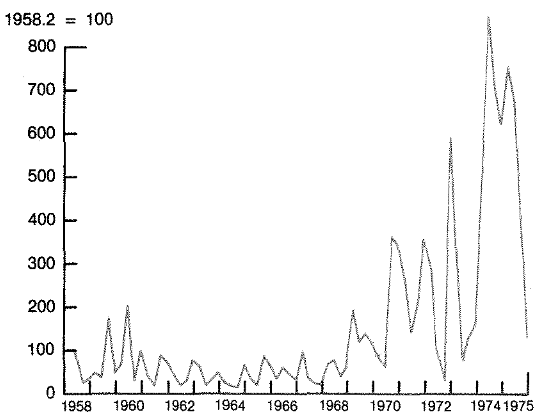
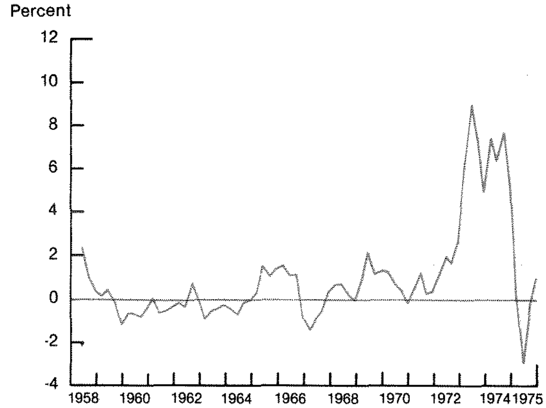


Chart 3

Unanticipated Price Change in Wholesale Price Index*



*6-month Horizon Forecast Error: Actual Less Forecast/Actual

Our data clearly show that relative prices of investment goods displayed a good deal of stability for the 1958-69 period, but considerable variability thereafter (Chart 2). The wholesale-price forecast errors apparently fluctuated around zero during the 1958-72 period, with no prolonged cycle or trend, but they provided substantial underforecasting thereafter (Chart 3). The forecast errors were calculated as the actual price level less the forecast level, divided by the actual level.

IV. Model of Factor Adjustment Behavior

The factor-adjustment model estimated in this paper assumes that the demand for a factor is dependent on the difference between the desired and actual stock (or utilization) of the particular factor *and* the difference between desired and actual stocks of related factors of production. For example, the demand for labor will depend not only on the difference between the desired and actual stock of labor, but also on a similar differential for the stock of capital. Utilization rates may also affect the demand for stocks. For example, the demand for capital— and also the demand for labor—may rise because a firm is fully utilizing its current capital stock.

Factor demands are divided into four separate categories. Two of them are stocks—physical capital, K, and total manufacturing production workers, W. The other two are flows—the utilization rate of capital, U, and the average workweek in manufacturing, H.[13] At the conceptual level, output, Q, is described as a function of all factor stocks and utilizations, or

$$Q = F(K,U,W,H)e^{\gamma t} \qquad (1)$$

The γ term measures the exponential rate of technical progress in the production function for the firm and, via aggregation over firms, for the industry. If in the short-run the firm considers output as given, and then minimizes costs associated with the production of this output level, it will obtain a "desired factor-demand" equation which is dependent on output, relative input prices and a time trend.

$$Y^*_{it} = f_i(Q,\frac{C}{W},t) \quad i = 1,2,3,4 \qquad (2)$$

where Q is output, C/W the relative user price of capital (i.e., the rental price of capital, C, divided by the wage rate, W), and t a time trend. By substituting (1) into (2) and assuming lagged adjustment, we obtain

$$Y_{it} - Y_{it-1} = \sum_{j=1}^{4} \beta_{ij} \left[Y^*_{jt} - Y_{jt-1} + \lambda_1 w_{1_t} + \lambda_2 w_{2_t} \right] + \gamma\pi_t + \epsilon_t \quad i=1,2,3,4 \qquad (3)$$

where Y_{it} is the ith factor (e.g., workers), Y^*_{jt} is the "desired" level of the jth factor. Equation (3) is the interrelated adjustment model, previously estimated for the manufacturing industry by Nadiri and Rosen.[14] Appended to the adjustment process are the random price-shock terms w_i, which are the price-forecast error and the variance of the relative prices of investment goods. The anticipated rate of wholesale-price inflation, π_t, is included to test the hypothesis that there are no independent effects of *anticipated* inflation aside from the relative rental price of capital. Hence the null hypothesis is that π should have no statistically significant effect on factor demands.

There has been little empirical work measuring the effect of price uncertainty, first, on the firm's optimal long-run capital stock, and secondly, on the adjustment path of capital-stock accumulation. Some theoretical work suggests that output price uncertainty should reduce the optimal capital stock of the firm. But these results, unfortunately, are very sensitive to the a priori specification of the firm's underlying production function.[15]

One important question relates to the differential impact of the two measures of inflation variability on manufacturing factor demands. Does the rise in unanticipated inflation have a significantly different impact on the demand for labor than on the demand for capital? If so, we could obtain a better understanding of the behavior of capital and labor demand in the recent economic recovery.

V. The Estimated Model

To repeat, the desired factor levels, denoted by Y^*_{jt} in equation (3), are assumed to be determined by output, the relative rental price of capital, and a time trend.[16] The relative price variance of investment goods and the unanticipated inflation variable are appended to this factor-adjustment equation. In addition, anticipated inflation (the Livingston series) is included as a independent variable to test the hypothesis that "surprise" or unanticipated inflation provides the major inflation impact on factor demands (aside from the relative user price of capital). All variables except the time trend and the anticipated and unanticipated inflation variables are entered as natural logarithms. The equations for capital, production workers, the average workweek and the capacity-utilization rates were estimated over the period 1959.III to 1975.IV.

As shown in Table 1, the "own rate of adjustment," that is, the portion of the discrepancy between desired and actual stocks or utilization of factors, is measured by one minus the estimated own-adjustment coefficient (e.g., the coefficient on K(t−1) in the K(t) equation). This computation shows that capital adjusts the slowest, as expected, and the average workweek adjusts the most rapidly. These results need to be qualified somewhat, because adjustment in any one factor is constrained or augmented by the gap between desired and actual stocks and utilization rates in other equations. For example, the average workweek and the capacity-utilization rate affect the capital-stock adjustment very little, that is, the coefficients for H(t−1) and U(t−1) are statistically insignificant. However, an increase in the discrepancy between desired and actual production workers will slow this capital adjustment. (In equation (3), lagged factor variables enter with a negative sign, indicating a negative cross-adjustment coefficient on lagged workers in the capital equation.) Similarly, the adjustment in workers, equation (2) in Table 1, is similarly constrained by the gap between the desired and actual capital stock. Interestingly, the estimated capital utilization equation implies that the greater the gap between desired and actual production workers, the greater the utilization of the existing capital stock.

Because of the dynamic specification of our factor-adjustment model, the estimated coefficients on the exogenous variables can only be considered short-run (first period) coefficients. The short-run output elasticities are all statistically significant and reasonable in size except in the capital equation. The relative rental price of capital should, a priori, yield a negative coefficient in the capital equation and positive coefficients in the remaining equations. However, this variable is statistically significant only in the capital equations with the expected negative sign.

As for our three inflation variables, we hypothesized that unanticipated inflation effects ought to predominate over relative price-variance effects if firms respond to "global" price shocks—that is, price shocks over which the firm

Table 1
Estimated Factor Adjustment Equations in Manufacturing (1959III-1975IV)

Explanatory Variables	Dependent Variables* (1) Capital (K)	(2) Workers (W)	(3) Hours (H)	(4) Utilization (U)
Constant	-.005	-.734	2.635	1.974
	(0.0)	(1.0)	(6.3)	(1.6)
K(t-1)	.871	.204	.040	-.098
	(20.6)	(3.1)	(1.1)	(.9)
W(t-1)	.165	.271	-.264	-.464
	(2.3)	(2.5)	(4.5)	(2.6)
H(t-1)	.034	.005	.091	-.071
	(.2)	(.02)	(.6)	(.2)
U(t-1)	.032	.048	.154	.377
	(.4)	(.5)	(2.8)	(2.3)
$\left(\frac{C}{W}\right)_t$ Relative rental price of capital	-.009	.001	-.003	-.008
	(2.9)	(.3)	(1.1)	(.9)
Output (t)	-.042	.448	.158	.767
	(1.3)	(11.0)	(7.1)	(11.3)
Time trend	.0016	-.0050	-.0012	-.0052
	(4.1)	(7.6)	(3.3)	(4.9)
Anticipated inflation (t)	-.0007	.0027	-.0006	.0038
	(.8)	(1.9)	(.8)	(1.7)
Unanticipated inflation (t)	-.0015	.0031	.0010	.0043
	(3.1)	(3.8)	(2.2)	(3.3)
Relative capital price variance (t)	.0002	-.0008	-.0020	-.0018
	(.2)	(.6)	(2.8)	(.9)
$\bar{R}^2$	.9992	.990	.928	.963
D.W.	1.78	1.88	1.99	1.65
RHO	-.30	.41	.39	.36
SER	.0064	.0069	.0038	.0115

* t-statistics in parentheses

has incomplete information. (This hypothesis fits in with that of some rational-expectations theorists.) This result, indeed, is implied by the estimated coefficients. The unanticipated-inflation variable is statistically significant in all of the four factor-demand equations, while the relative price-variability variable is only significant in the average-workweek equation. An increase in unanticipated inflation is found in the short-run to decrease the demand for capital but to increase the demand for workers, the capacity-utilization rate and the average workweek. Also, as hypothesized, anticipated inflation has no independent effect on any of the four factor demands, as this variable is statistically insignificant (at the 95-percent confidence level) in all the equations.

The estimated coefficients represent only the initial-period responses to a change in the exogenous variables. But we are also concerned with "long-run elasticities" (Table 2), which represent the total response of the factors to changes in output, unanticipated inflation and the relative rental price of capital. The long-run coefficients should be used with the estimated coefficients to determine the "reasonableness' of the estimated model.

For the long-run effect of the relative rental price of capital, all signs are as expected except in the workers equation. As expected, a rise in this variable is seen to decrease the demand for capital. The long-run output effects are also of correct (positive) sign in all the equations. And as expected, the largest long-run output elasticities are on capital and labor stocks.

The long-run effects of unanticipated inflation are seen to be negative on capital demand, but positive on worker demand and capacity utilization. There is no long-run effect on average hours worked. These results imply that the overall

Table 2
Long-Run Elasticities

	Exogenous Variable		
Factor	Relative Rental Price of Capital	Output	Unanticipated Inflation
Capital	-.0956	.942	-.0062
Workers	-0.235	.905	.0028
Hours	.0024	.021	.0000
Utilization	.0198	.407	.0057

effect of unanticipated inflation has been to reduce the long-run demand for capital, but to increase the long-run demand for labor and the utilization rate of the capital stock. This would thus imply a decline in the capital-labor ratio in manufacturing. These empirical results are consistent with the theoretical argument of Feldstein, Green and Sheshinski—that inflation reduces the demand for capital—although their argument stems primarily from a rise in steady-state or permanent inflation.

The results displayed in Tables 1 and 2 appear to confirm the hypothesis that inflation affects factor demand in manufacturing through unanticipated inflation, and not through the increased variability in the relative price of investment goods or independently through anticipated inflation. Our results also imply that there may indeed be a persistent long-run increase in labor demand because of unanticipated inflation, but that this positive response in labor demand is compensating for the reduced demand for capital from the same cause. These results would suggest that, in order to reach a better understanding of inflation's long-run impact on the economy, we should consider its effect on capital-investment demand as well as its short-run effect on the demand for labor.

VI. Dynamic Response to Inflation

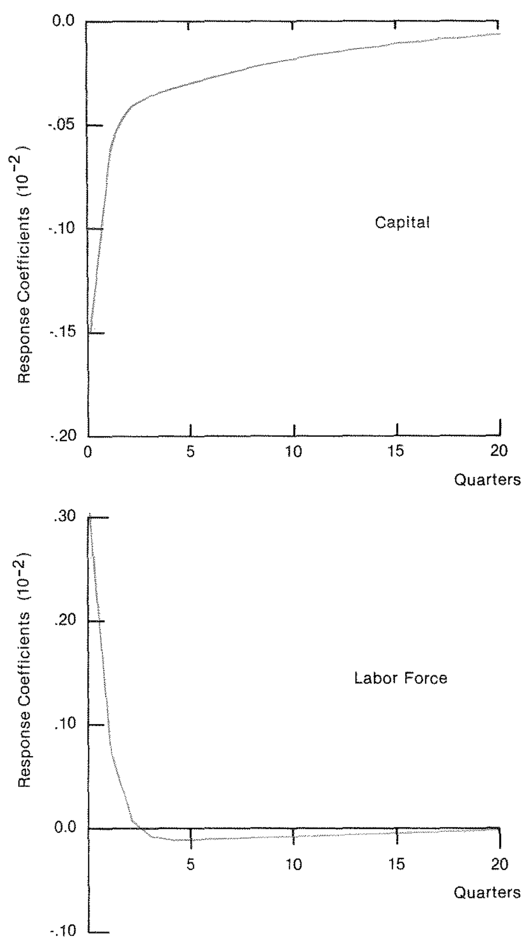
To understand the dynamic behavior of factor demands in manufacturing, we need to ask two questions. First, is the interrelated lagged-adjustment model stable? Technicalities aside, the answer is yes.[17] That is, a unit change in any exogenous variable will cause the factor demand to respond over time, and as time goes on, the level of the factor stock or utilization will return to its long-run equilibrium value.

Secondly, how do factor demands respond over time to a unit change in unanticipated inflation? Because of the interrelated nature of the adjustment process (where, say, the labor adjustment is affected by the current level of capacity utilization) we must use the entire adjustment matrix to see how any one factor demand changes over time.[18] As Chart 4 indicates, the capital stock in manufacturing adjusts suprisingly quickly to unanticipated inflation. Although the response is distributed over twenty quarters, 75 percent of the impact occurs after ten quarters. Again, the demand for workers responds very rapidly to unanticipated inflation, with almost all of the adjustment complete after five quarters.

Most importantly, a rise in unanticipated inflation leads to significant offsetting behavior, with a reduced demand for capital being offset by an increased demand for production workers. Unanticipated inflation, in effect, acts like a rise in the relative price of capital vis-a-vis the price of labor.

"Surprise inflation" thus can have a statistically significant short-run impact on the process of adjustment of factor demands, especially capital and labor. But because of the substitutability of the factors considered here, aggregate inflation shocks can affect their interaction as well. As we have seen, the capital stock tends to be reduced while capital utilization tends to be increased over the long run. Our results contradict the "complete inflation neutrality" proposition that inflation has no long-run impact on real variables. Our results, in contrast, indicate that if significant unanticipated inflation continues over a lengthy period, the capital stock in manufacturing will grow more slowly. Persistent unanticipated inflation thus could lead over time to a fall in the capital-labor ratio in manufacturing.

Chart 4
Response Pattern to a Unit Increase in Unanticipated Inflation



VII. Forecasting the 1976-77 Recovery

To evaluate the forecasting value of our interrelated factor-adjustment model, we performed two types of forecasts for the period 1976.I-1977.IV. The first (static) forecast utilized actual values for all of the explanatory variables. The second (dynamic) forecast utilized known values for all exogenous variables except the lagged values of the endogenous variable for capital stock, workers, hours and utilization. These latter values were set at their previous forecasted values, where the lagged values for 1975.IV were the fitted values obtained in the estimation.

The dynamic forecasts consistently overforecast the capital stock in manufacturing but underforecast workers and the utilization rate. The dynamic forecast was significantly worse than the static forecast only for the capital equation (Table 3). However, the root-mean-square percentage errors indicate that the worst forecasts surprisingly did not occur in the capital equation, but rather in the capacity-utilization equation. The capital and workers equations had almost equal root-mean-square percentage errors, but this statistic was almost double in size for the utilization forecasts.

Since our dynamic forecasts were consistently *less* than the actual rates of capacity utilization, we should not be asking why the aggregate capacity-utilization rate was so *low*, but rather why it was so *high*. Given the interrelated nature of the demand for stocks and utilization of capital and labor, our forecasts indicate that the capacity utilization rate was *higher* during the 1976-1977 recovery period than expected. In isolation, the rate may appear relatively low when compared with previous recovery periods. But this observation ignores the way the utilization of capital interacts with the utilization of labor and the growth in the capital stock and manufactuing labor force.

We used Theil's "U-Coefficient" to further judge the overall forecasting accuracy of the period 1976 I-1977 IV. A U-coefficient which exceeds unity indicates that the ex ante forecast of factor demands does not provide more useful information than a simple "no change" forecast.[19] As Table 3 indicates, the U-coefficient is less than unity for capital and workers, but greater than unity for the average hours and utilization equations. This suggests that the estimated interrelated factor-adjustment model was quite useful in forecasting the demand for capital and workers, but not of much use in forecasting average hours and capacity utilization for the 1976-77 period. Indeed, the U-coefficient is lowest for the capital-stock forecasts. These results support the use of the estimated model in explaining the demand for capital and labor, but they cast doubt on the forecasting properties for the capacity-utilization rate.

We also decomposed Theil's U-coefficient into three components, to analyze further the source of error in the utilization forecasts. The first two terms capture systematic errors that should be avoided in the forecasts, while the last (imperfect covariation) involves nonsystematic random error.[20] As Table 3 indicates, the largest source of forecast error in capacity utilization occurs because of nonsystematic random movements in the capacity-utilization rate. The utilization forecasts have the largest ratio of imperfect covariation to bias. These forecast errors indicate that, during the 1976-77 recovery, relatively greater nonsystematic random behavior occurred in capacity utilization than in capital demand, labor demand or the average workweek. The forecast performance also indicates that the recovery surprisingly was characterized by a greater-than-anticipated rate of capacity utilization.

Table 3
Forecast Performance 1976 I-1977 IV*

	Capital	Workers	Hours	Utilization
RMSE—Dynamic	$1.60 bil.	210 thous.	.263 hrs.	2.144 % points
RMSE—Static	$0.80 bil.	196 thous.	.286 hrs.	1.962 % points
RMS%E—Dynamic	1.3%	1.5%	0.65%	2.63%
RMS%E—Static	0.66%	1.4%	0.71%	2.41%
Theil Inequality Coefficients (Dynamic Forecasts)				
U-coefficient	.422	.904	1.955	1.248
Unequal Central Tendency	.06517	.00176	.00163	.00002
Unequal Variation	.00048	.00137	.00300	.33163
Imperfect Covariation	.16330	.87318	1.1379	1.4493

* RMSE = root mean square error; RMS%E = root mean square percentage error.The RMSE statistics were obained by first taking the antilogs of the forecasted variables.

VIII. Conclusion

Economists only recently have come to consider the effects of price uncertainty on the behavior of the firm, either in output markets or in factor markets. Yet this question must be answered if economists are to be able to explain how inflation affects the real economy. Our tentative evidence suggests that unanticipated inflation can affect the demand for factors of production as well as the utilization of these factors. This type of inflation thus may slow the process of capital growth. Moreover, unanticipated inflation shocks, and their persistent effects over a prolonged period, help explain why investment demand has been sluggish since the early-1975 cyclical trough. While our evidence is obviously tentative, it provides an avenue to a more complete understanding of the inflation-induced factor-demand adjustments in U. S. manufacturing.

Appendix
Deviation of a Risk-Adjusted Rental Price of Capital

Jayant Kalawar and Joseph Bisignano

The procedure used to derive the rental price of capital used in the text is similar in spirit to most other definitions of this variable seen in the investment literature. Basically, the rental price of capital is defined as

$$C = \frac{(1-k)\,(1-wz)}{(1-w)}\,P_k(r+\delta) \qquad \text{(A1)}$$

where:

- C = rental price of capital
- k = investment tax credit[1]
- w = tax rate for manufacturing corporations, computed as (provision for federal income taxes ÷ income before taxes)[2]
- z = present value of depreciation allowance, computed as

  $$[(1-e^{-dt})/dt]$$

  where:

- d = (Aaa corporate-bond rate) $(1-w)$[3]
- t = tax lifetime of investment goods = $1/\delta$
- δ = depreciation rate = .054511 (constructed by F. Brechling);
- P_k = implicit capital-stock price deflator (constructed by F. Brechling)
- r = total cost of capital in manufacturing, defined as

  $$r = (1-\phi)r_e + \phi(1-w)r_{Aaa}$$

where ϕ =

$$\frac{\text{long-term debt}}{\text{long-term debt + stockholders' equity}}\text{[4]}$$

- r_{Aaa} = Aaa corporate-bond rate
- r_e = cost of equity

It is quite common in investment studies to use some readily available measure of r_e, the cost of equity, such as the dividend-price ratio. This measure for r_e was used here, but the implied rental price of capital was not found to be significant in the capital equation. In fact, utilizing alternative derivations of the rental price of capital, we found the most significant measure of c to be simply P_k ($r_{Aaa} + \delta$). However, this variable was not used because it ignores important tax and equity cost considerations.

One of the authors (Kalawar) suggested constructing a risk-adjusted cost of equity for use in our final derivation of the rental price of capital. This was done by inferring the return demanded on equity from the returns on bonds, the returns on a "risk-free" asset, and measures of the "riskiness" of bonds and equity. To do so we utilized the Sharp-Lintner capital-asset pricing model, assuming that portfolios exist (consisting of all Aaa corporate bonds outstanding and a portfolio of Standard and Poor's 500 common stocks) which are efficient; that is, the risk-return characteristics can be simulated by holding the "market portfolio" in the appropriate proportions. Under this assumption the following relationship holds, (Sd indicates standard deviation):

$$r_e = r_f + \frac{(r_{Aaa} - r_f)}{Sd(r_{Aaa})} * Sd(r_e) \qquad (A2)$$

The above equation describes the "capital market line," with an intercept of r_f (the risk-free rate), and, since both the bond and equity portfolio lie on this straight line, the slope is given by $(r_{Aaa} - r_f) / Sd(r_{Aaa})$. Using this relationship, we can construct a series of expected rates of return on common stock which, in equilibrium, give us the cost of equity. Specifically:

r_e = expected return on equity for S&P 500 stocks;

r_f = yield to maturity, annualized, on 3-month Treasury bills outstanding, quarterly averages;

r_{Aaa} = yield to maturity, annualized, of Aaa corporate bonds outstanding, quarterly averages;

$Sd(r_{Aaa})$ = standard deviation of one-month holding-period returns on all corporate bonds outstanding (industrial and utility) with Moody's Aaa and Aa rating;

$Sd(r_e)$ = standard deviation of one-month holding-period returns on S&P 500 common stocks.

Twelve monthly observations were used to construct the standard deviations defined above, and were computed from the data developed by R. A. Ibbotson and R. A. Sinquefield.[5] The construction of our measure of the cost of equity requires one strong assumption, namely, that the covariance between equity and bond returns is zero. This assumption was made to ease the empirical derivation of the cost of equity.

The derived cost of equity and the ultimate rental price of capital are shown in Charts A1 and A2, respectively.

Chart A1

Derived Cost of Equity Capital

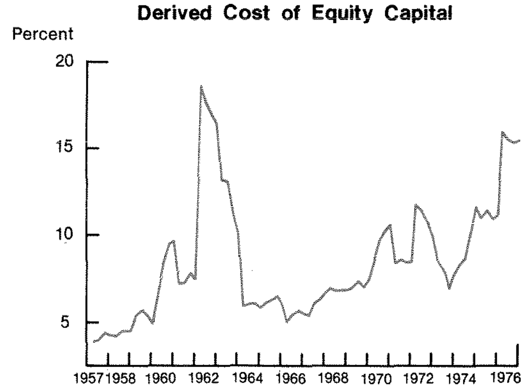
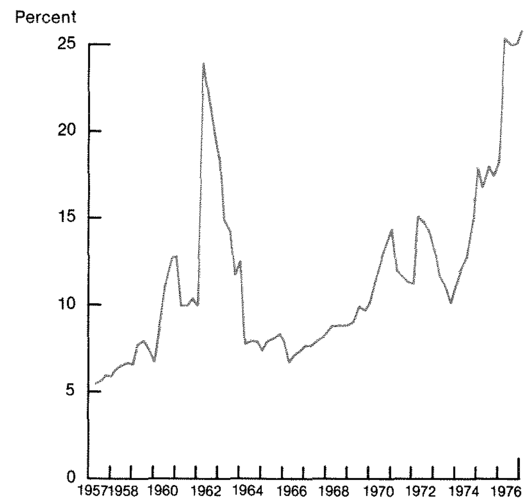


Chart A2

Derived Rental Price of Capital



FOOTNOTES

1. For a concise summary of the important properties of firms' long-run behavior, see Eugene Silberberg, "The Theory of the Firm in 'Long-Run' Equilibrium," **American Economic Review** (September 1974).
2. The expansion path will be linear for any homogenous production function. The intertemporal maximization of the net wealth of the firm usually assumes known fixed prices. See, for example, Dale W. Jorgenson, "Technology and Decision Rules in the Theory of Investment Behavior," **Quarterly Journal of Economics** (November 1973).
3. Martin Feldstein, Jerry Green and Eytan Sheshinski, "Inflation and Taxes in a Growing Economy with Debt and Equity Finance," **Journal of Political Economy,** Part 2 (April 1978).
4. For a derivation of the "rental price of capital" see Dale W. Jorgenson and James A. Stephenson, "Investment Behavior in U.S. Manufacturing, 1947-1960," **Econometrica** (April 1967).
5. See T. Nicolaus Tidemand and Donald P. Tucker, "The Tax Treatment of Business Profits Under Inflationary Conditions," in **Inflation and the Income Tax,** Henry J. Aaron, ed., Brookings Institution, Washington, D.C. (1976). An analysis of the erosion of capital-recovery allowances by inflation is considered for different inflation rates and for different tax-depreciation methods in Eric Schiff, "Inflation and the Earning Power of Depreciable Assets," Domestic Affairs Study 25, **American Enterprise Institute** (November 1974).
6. See the appendix to this paper for the derivation of our "rental price of capital."
7. For a review of the "paradigm of incomplete information" see Herschel I. Grossman, "Why Does Aggregate

Demand Fluctuate?" paper delivered at the August, 1978, meeting of the American Economic Association, Chicago, Illinois.

8. For aggregate studies of the unemployment rate and unanticipated inflation, see R. E. Lucas, Jr., "Some International Evidence on Output-Inflation Trade-offs," **American Economic Review** (June 1973), and Thomas J. Sargent, "Rational Expectations, the Real Rate of Interest and the Natural Rate of Unemployment," **Brookings Papers on Economic Activity** (1973). Regarding the effect of inflation on the employment of fixed and variable factors, Sheshinski and Weiss have shown, in a model of costs of adjustment associated with varying nominal output prices, that a firm will reduce the employment of fixed factors if there is an increase in inflation expectations. See Eytan Sheshinski and Yoram Weiss, "Demand for Fixed Factors, Inflation and Adjustment Costs," Discussion Paper No. 3, Stanford Workshop on the Microeconomics of Inflation (March 1976).

9. Albert Gailord Hart, **Anticipations, Uncertainty, and Dynamic Planning,** University of Chicago Press (1940).

10. The relative price variance, or RPV, is defined as the measurement of the nonproportionality of price movements across a group of expenditure classes. Here the group is business fixed investment. Specifically,

$$RPV_t = \sum_{i=1}^{n} W^*_{it}(DP_{it} - DP_t)^2 \qquad (a)$$

where: $DP_{it} = \log P_{it} - \log P_{i,t-1}$

P_{it} = price index of good i in period t

$$W^*_{it} = \frac{W_{it} - W_{it-1}}{2}$$

W_{it} = expenditure share of good i in period t

$$DP_t = \sum_{i=1}^{n} W^*_{it} DP_{it} \qquad (b)$$

The expression $(DP_{it} - DP_t)$ is seen as the rate of change in the ith relative price, i.e., the logarithmic difference in the relative price P_{it}/P_t, where P_t is the aggregate price level for the group of n goods. Thus the rate of change of the index is defined as the weighted average of the rates of change of the individual goods. Similarly, the relative price variance is defined as the weighted sum of squared deviations of the individual rates of price change around the average rate of change. The rate-of-change price index is recognized as a Divisia price index. The use of such an index was suggested by Richard W. Parks in "Inflation and Relative Price Variability," **Journal of Political Economy** (February 1978). On the use and construction of Divisia indices, see Henri Theil, **Economics and Information Theory,** Rand McNally (1967).

The aggregate investment class used in construction of the RPV series was business fixed investment, composed of structures and producers' durable equipment. Producers' durables equipment was broken down into 27 durable-equipment investment classes. The producers' durable-equipment category is composed of household furniture, other furniture, fabricated metals, steam engines, internal-combustion engines, construction tractors, agricultural machinery, farm tractors, construction machinery, mining and oil-field machinery, metalworking machinery, special industrial machinery, general industrial machinery, office and stores machinery, service industrial machinery, communications equipment, electrical transmission and distribution, household appliances, miscellaneous electrical, trucks, passenger cars, aircraft, ships and boats, railroad equipment, instruments, photographic equipment, and miscellaneous.

11. The data and comments on their construction and interpretation may be found in John A. Carlson, "A Study of Price Forecasts," **Annals of Economic and Social Measurement** (1977).

12. See Donald J. Mullineaux, "On Testing for Rationality: Another Look at the Livingston Price Expectations Data," **Journal of Political Economy,** Vol. 86, No. 2 (1978), and Carlson, cited above. Carlson could not reject the hypothesis at the 5-percent significance level that the consensus WPI forecasts are rational. Mullineaux conducted tests on the Carlson-Livingston consumer price-index forecasts and found that these forecasts were also "rational."

13. One of the early papers incorporating the interrelationship between factor-demand adjustments was M. I. Nadiri and S. Rosen, "Interrelated Factor Demand Functions," **American Economic Review** (September 1969). For an excellent review and extension of the cost-of-adjustment approach to dynamic firm behavior, see Frank Brechling, **Investment and Employment Decisions,** Manchester (England) University Press (1975).

14. See M. Ishag Nadiri and Sherwin Rosen, "Interrelated Factor Demand Functions," **American Economic Review** (September 1969). Their model, based on cost minimization, is more fully described and disaggregated in **A Disequilibrium Model of Demand for Factors of Production,** National Bureau of Economic Research (1973). Two general points should be noted about the estimated interrelated model. In matrix form the model may be written as

$$Y_t = \beta A x_t + (I-\beta)Y_{t-1}$$

where Y_t is the vector of factor levels, β the matrix of adjustment coefficients, A the matrix of behavioral coefficients on exogenous variables (e.g., output, relative prices, etc.) where $Y^*_t = Ax_t$, and x_t the vector of exogenous variables. I is the identity matrix. The matrices of estimated coefficients are βA and $(I-\beta)$. Long-run desired demand coefficients are obtained from

$$[I - (\widehat{I-\beta})]^{-1}\, \widehat{\beta A}.$$

The dynamic stability of the system of factor demands depends on the characteristic roots of $(I-\beta)$. Stability is obtained if the modulus of the largest root, in absolute value, does not exceed unity. The sequence of distributed-lag coefficients in response to a unit increase in any of the exogenous variables is given by $(I-\beta)^k\, \beta A$ for k = 1,2.... . Note that Nadiri and Rosen assume that firms are at each moment in time on their production functions. This can only be insured by imposing production-function coefficient constraints, usually nonlinear, across the estimated factor equations, which is a non-trivial exercise. The importance of such constraints can be seen in R. M. Coen and B. H. Hickman, "Constrained Joint Estimation of Factor Demand and Production Functions," **Review of Economics and Statistics** (August 1970).

15. Kenneth R. Smith has shown that if the firm produces with a Cobb-Douglas production function, uncertainty with respect to the demand for the firm's output (i.e., when the demand curve is random) will have

the effect of reducing the firm's optimal capital stock. See "The Effect of Uncertainty of Monopoly Price, Capital Stock and Utilization of Capital," **Journal of Economic Theory** (1969). One of the most interesting empirical studies on the role of price expectations in investment demand is Albert K. Ando, Franco Modigliani, Robert Rasche, and Stephen J. Turnovsky, "On the Role of Expectations of Price and Technological Change in an Investment Function," **International Economic Review** (June 1974).

16. The output series used is the sum of manufacturers' shipments and the changes in manufacturers' inventory, both for finished goods and work in progress. This series is then deflated by the wholesale price index for manufacturing to obtain the final real output series. The source of this data is U.S. Department of Commerce, **Manufacturers' Shipments, Inventories and Orders.** See the appendix to this paper on the derivation of the rental price of capital. Capital stock data were provided by Professor Frank Brechling of Northwestern University. These capital-stock data utilize benchmarks of 1948 and 1966. The benchmarks are derived from the **net** capital stocks based on double-declining-balance depreciation (at 1958 dollars) regularly published in the **Survey of Current Business.** Professor Brechling also supplied the estimated price index of investment goods in manufacturing. The utilization rate is the capacity-utilization rate published by the Federal Reserve. Total production workers in manufacturing and the corresponding average workweek may be found in **Employment and Earnings, 1909-75,** U.S. Bureau of Labor Statistics.

17. Stability of the dynamic system is determined by examining the characteristic roots of $(I-\beta)$, where I is the identify matrix and β the (4×4) adjustment matrix. Stability requires that the absolute value of the modulus of the largest root be less than unity. The characteristic roots of the $(I-\beta)$ matrix shown in Table 1 are .901, .129, .290 ± .098i. Since no root exceeds unity the interrelated adjustment system is stable. The hypothesis that the estimated coefficients remained the same over the entire sample period was tested by estimating the model over 1959.3-1968.4 and 1969.1-1975.4, and using an F-test (Chow test) for equality of coefficients during the two sub-sample periods. These F-tests appear below, where

$$F = \frac{(SSR(H_0)-SSR(H_1))/k}{SSR(H_1)/(T_1+T_2-2k)}$$

where SSR = sum of squared residuals
H_0 = hypothesis that coefficients are the same over the two sub-sample periods
H_1 = hypothesis that coefficients are not the same over the two sub-sample periods
T_1, T_2 = number of observations for sub-sample periods
k = number of estimated parameters

F-Tests for Equality of Coefficients

Factor	**Calculated F-statistic**	**Critical F^{12}_{42}(.05)**
Capital	1.698	1.99
Labor force	0.673	1.99
Hours	0.887	1.99
Utilization	1.270	1.99

The F-tests indicate that we cannot reject the hypothesis that the coefficients remained the same over the two sub-sample periods.

18. The adjustment paths, or more correctly, the impulse-response functions, are calculated as $(I-\beta)^k \beta A$, for k = 0,1,2,..., where β is the adjustment matrix and βA the matrix of estimated coefficients on the exogenous variables.

19. Let F_i and A_i be the forecast and actual percent changes, respectively, for period i, where the forecasts range from 1 to m. Theil's U (inequality) coefficient is here defined as

$$U = \frac{\sqrt{\frac{1}{m}\sum_{i=1}^{m}(A_i - F_i)^2}}{\sqrt{\frac{1}{m}\sum_{i=1}^{m}A_i^2}}$$

The numerator is seen to be the root-mean-square error of the forecast (in percentage change), while the denominator is the root-mean-square error assuming zero forecasted change. Perfect forecasts would yield a U = 0, while U = 1 implies a status quo (no change) forecast. A U greater than 1 implies that the forecasts are worse than the status-quo forecasts. See H. Theil, **Economic Forecasts and Policy,** North-Holland Publishing Company (1965).

20. Theil's U-coefficient was decomposed into three components as follows. The first component, called "unequal central tendency," measures the squared difference in the mean of the actual percentage change to the mean of the forecasted percentage change; it is a measure of forecast bias. The second component, described as "unequal variation," measures the squared difference in the standard deviations of the actual percentage changes and forecasted percentage change. The third component utilizes the correlation between the actual and forecast percentage changes and measures "imperfect covariation" between the two. The first two terms capture systematic errors that should be avoided in the forecasts, while the last involves nonsystematic random error. As we have computed them, the three components do not sum to the aggregate U-coefficient.

APPENDIX FOOTNOTES

1. R. W. Kopcke, "The Behavior of Investment Spending during the Recession and Recovery, 1973-76," **New England Economic Review**, November/December 1977.

2. Securities and Exchange Commission, **Quarterly Financial Reports.**

3. **Federal Reserve Bulletin,** Table 1.36.

4. Securities and Exchange Commission, "Balance Sheet of Manufacturing Corporations," **Quarterly Financial Reports.**

5. R. A. Ibbotson and R. A. Sinquefield, "Stocks, Bonds, Bills and Inflation: Year-by-Year Historical Returns, 1926-1974," **Journal of Business,** January 1976.

Estimating a Stable-Inflation Capacity-Utilization Rate

Rose McElhattan*

Since Phillips' seminal paper in 1958,[1] the economics profession has devoted considerable effort to the study of the linkage between inflation and unemployment rates. That linkage, popularly known as the Phillips Curve, is the result of combining a price and a wage equation. Because wages are related to the unemployment rate, that approach establishes a direct link between unemployment and final-product prices, which are considered to be a variable markup on unit labor costs. Other variables, of course, also appear in the combined price equation. One of these—the capacity-utilization rate—reflects aggregate-demand pressures on existing capacity, and thus is included in the equation because these pressures determine the value of the price/labor-cost markup. Consequently, the combined price equation will contain two excess-demand variables—the unemployment rate, reflecting excess demand in labor markets, and the capacity-utilization rate, reflecting excess demand in final-product markets. This result presents both a problem and an opportunity for those interested in estimating the impact of these variables upon inflation.

First, there is a problem because, with the close historical association between unemployment and capacity utilization, we may not be able with one equation to separate statistically the effects of these two variables upon inflation. The high historical correlation is in part related to the fact that labor demand is a derived demand, so that excess demand in the final-product market tends to produce excess demand in the labor sector. In addition, as recent empirical studies suggest, there may be limited substitutability between capacity and labor utilization. More intensive use of plant and equipment requires more intensive utilization of labor. In general, this results in higher employment (hence, lower unemployment) when capacity utilization rates are rising. In one recent study, Modigliani and Papademos stated that because of the high correlation between the two excess-demand variables, they were unable to estimate separate influences.[2] They therefore dropped capacity utilization from consideration, because they were primarily interested in measuring the inflationary impact of alternative unemployment rates. In this paper, in contrast, we focus upon the inflationary impact of alternative capacity-utilization rates.

Thus, we have the opportunity with our combined price equation, which connects inflation and capacity utilization, to make some interesting comparisons with the inflation/unemployment relation so often discussed in the literature. Two schools of thought may be distinguished in the literature. The "natural rate of unemployment" school believes that there is only one full employment-unemployment rate, towards which the economy tends over time. If government policy attempts to maintain a rate lower than the natural rate, inflationary pressures will accelerate as long as that lower rate is maintained. According to this school of thought, there is no long-run tradeoff between inflation and unemployment. In contrast, the "non-accelerating-inflation rate of unemployment" school takes an eclectic approach to the question of a trade-off. In this view, there may be several equilibrium points, and there may also be unstable inflationary conditions at relatively low unemployment rates, so that no permanent trade-off exists.

Our study suggests the existence of a full-

*Economist, Federal Reserve Bank of San Francisco. Deborah Anderson provided research assistance for this paper. Professor John Scadding of Stanford University provided detailed comments on an earlier draft of this paper.

capacity utilization rate which is consistent with the "natural rate of unemployment" concept. We can detect no permanent, stable relation between inflation and capacity utilization existing in this country since the early 1950's. Attempts to maintain a capacity-utilization rate above the estimated full-capacity equilibrium rate appear to be associated with a steadily increasing inflation rate.

This raises the question of the actual level of the stable-inflation capacity-utilization rate. In other words, at what point in the use of the nation's industrial capacity are inflationary pressures likely to increase? The recent rate of capacity utilization—still below 85 percent in August, according to the Federal Reserve series—would seem to indicate some slack when compared with the 87-88 percent post-World War II peacetime peaks. Indeed, according to Senate Banking Committee Chairman Proxmire, most witnesses at a recent committee hearing felt that inflationary pressures would not build until those previous peak operating rates had been surpassed.[3] But our historical experience since the early 1950's does not substantiate such a conclusion. Inflation has tended to accelerate well before previous peak rates have been reached; a utilization rate compatible with price stability appears to be a good deal lower than those peak rates.

Our statistical estimates suggest that the equilibrium rate of capacity utilization consistent with a stable rate of inflation falls around 82 percent, or within the range of 80-83½ percent. (In other words, 80 and 83½ percent represent the 95-percent confidence limits of our 82-percent point estimate.) Historically, the rate of inflation increases when capacity utilization rises above 83½ percent, while the rate of inflation declines when capacity utilization falls below 80 percent.

One point should be clarified at the outset. The relationship that we examine between inflation and capacity utilization is one in which overall inflationary pressures are closely linked with those in the U.S. manufacturing sector. If unusual pricing behavior occurs in the farm or import sector, our model will not capture all of the initial inflationary response, and we can observe increasing inflation although capacity utilization rates are within the full capacity limits. In other words, recent increases in inflation which have been attributed to increases in food prices have occurred regardless of aggregate demand pressures on available capacity. Nonetheless, should capacity-utilization rates continue above the 83 ½-percent upper limit of utilization, we could expect additional inflationary pressures to be generated by the nonfarm business sector of the U.S. economy.

The next section of this paper provides a simple testable model relating inflation and capacity utilization. The following sections present the statistical results and the conclusions of our analysis.

I. Relationship Between Inflation and Capacity Utilization

We are accustomed to think about inflation in terms of the inflation/unemployment relation, referred to as the Phillips Curve.[4] The association between capacity-utilization rates and inflation can be viewed within the context of that relation. As an illustration, we derive here a modified Phillips Curve, which is a general form of those incorporated in most large structural econometric models and recently in several monetarist models of the U.S. economy.[5]

The Phillips Curve is derived from the interaction of two basic structural equations: (1) a price equation relating prices to a markup on unit labor costs and (2) a wage equation relating wage changes to labor-market excess demand and expected inflation. Aggregate-demand pressures—as represented by capacity-utilization rates—affect the markup by which prices are related to unit labor costs. As demand builds and utilization rates increase, for example, the markup on costs may increase as final product prices adjust to eliminate excess demand. An increase in the markup during periods of increasing demand may also reflect noncompetitive pricing behavior by some firms who feel they can raise prices without a serious loss in sales.[6]

A general form of the price equation which incorporates this behavior may be written:

$$IR_t = a_{12}\dot{W}_t - a_{13}\dot{T}_t + f(CU_t - CU_t^e) \quad (1)$$

where a_{12} and a_{13} are estimated coefficients and "f" denotes a functional relationship. The inflation rate (IR) in the current period (t) is related to the rate of change in nominal wages ($\dot{W}$), the trend rate of productivity growth ($\dot{T}$), and a function (f) of the actual measured rate of capacity utilization (CU) relative to its expected normal or equilibrium value (CU^e). The value of f(CU-CU^e) will be zero when measured capacity utilization is equal to its equilibrium rate; rates of utilization above CU^e will lead to higher inflation and rates below equilibrium will lead to reduced inflation.

A general form of the wage equation may be written:

$$\dot{W}_t = a_{21}IR_t^* + a_{23}\dot{T}_t - h(u - u^e)_t \quad (2)$$

where a_{21} and a_{23} are estimated coefficients and "h" denotes a functional relationship. IR* represents the expected inflation rate, u is the measured unemployment rate and u^e is its equilibrium value. The difference ($u - u^e$) represents that part of unemployment most responsive to changes in excess-demand pressures. Here, as in the rest of the paper, excess demand may be positive (reflecting greater quantity demanded than supplied) or negative (reflecting greater supply). The unemployment rate, or more exactly, ($u - u^e$), enters the wage-adjustment equation as a proxy variable representing excess labor demand. According to the equation, when excess demand for labor is zero, inflation-adjusted wages ($\dot{W}_t - a_{21}IR_t^*$) will rise in proportion to the trend rate of growth in labor productivity, $\dot{T}$.[7]

We may derive a semi-reduced-form relationship for the inflation rate by substituting equation (2) into (1):

$$IR_t = a_{12}a_{21}IR_t^* + (a_{12}a_{23} - a_{13})\dot{T}_t - a_{12}h\,(u - u^e) + f(CU - CU^e) \quad (3)$$

Equation (3), the general form of the Phillips relation, provides the framework for the statistical tests in this paper. But before we can estimate that equation, we must first specify the functional forms "h" and "f" and the variables in the equation. We assume that the functions "h" and "f" are linear, and we define the variables as follows:

$IR_t^* = IR_{t-1}$

Last period's inflation rate, measured by the percentage change in the GNP implicit price deflator, represents this period's expected rate.

$\dot{T}$ = TIME.

The trend rate of labor productivity (output per worker hour) is represented initially by a simple linear time trend; and alternatively by a two-year and a three-year moving average of output per worker-hour.

CU = Federal Reserve capacity-utilization series for total manufacturing.

u = unemployment rate of prime-age males (25-54)

This rate appears to be a better cyclical indicator of demand pressure than the overall unemployment rate, which has tended in the past decade to reflect the changing structure in labor markets.[8]

All estimates use annual data. We further assume that the equilibrium rates of unemployment for prime-age males (u^e), and capacity utilization (CU^e), have been constant over the 1953-77 sample period. Regarding the prime-age unemployment rate, available data suggest that the rate averages roughly 3 percent at peacetime cyclical peaks, with no discernible trend. Regarding the capacity-utilization rate, recent theoretical studies suggest that the equilibrium rate of utilization is dependent upon economic costs and the degree of labor-capital substitutability, and therefore may vary over time.[9] However, we maintain the hypothesis of a constant CU^e on the basis of our initial estimates of the impact upon that rate of such economic variables as the relative cost of capital to labor which were statistically insignificant. (This point is reinforced by Joseph Bisignano's article in this *Review*.) With these specifications, and with the incorporation of both equilibrium values in a constant term, equation (3) may be written:

$$IR_t = b_o + b_1 IR_{t-1} + b_2 TIME - b_3 u_t + b_4 CU_t \quad (3')$$

where

$$b_o = (b_3 u^e - b_4 CU^e)$$

$$b_1 = a_{12} a_{21}$$

$$b_2 = (a_{12} a_{23} - a_{13})$$

Economic theory and statistical results reported in the literature suggest the values of some of the coefficients in equation (3′). We expect that the coefficient of the trend term in labor productivity, b_2, will not differ significantly from zero. This can be seen from the elements of b_2. The values a_{12} and a_{13}, derived from the price markup equation (1), are the coefficients associated with the change in nominal wages ($\dot{W}$) and productivity ($\dot{T}$), respectively. In statistical tests of the price equation, these coefficient values generally are equal and are close to unity.[10] This indicates that the relevant measure for pricing decisions is a measure of standard unit labor costs ($\dot{W} - \dot{T}$); consequently, changes in money wages and trend productivity would have the same quantitative impact (but in the opposite direction) and would be completely passed through to final prices. In addition, we expect $a_{23} = 1$. This reflects the assumption that, in equilibrium, the rate of change in real wages is equal to the rate of change in labor productivity.

We expect to find a close, although not perfect, association between changes in unemployment (u) and capacity utilization (CU), since both reflect pressures originating from excess demand in product markets.[11] In addition, recent empirical evidence suggests that there is limited substitutability between capacity and labor utilization. The high correlation between the two may prevent our obtaining independent estimates of the impact of either one on the inflation rate in equation (3′).[12]

Our estimate of equation (3′) did, in fact, substantiate our expectations concerning the significance of the independent variables. In particular, the trend coefficient, b_2, was not significantly different from zero, and neither excess-demand variable added significantly to the determination of inflation. Each was significant, however, when equations were estimated with only one or the other included. These results are shown in Appendix 1.

Given the above conclusions, we may drop the time trend from equation (3′) and include capacity utilization as the sole proxy for excess demand in the model. Other analysts, more interested in the unemployment/inflation relation, have dropped capacity utilization from their models.[13] Our interest, however, lies with the capacity-utilization variables, which leads us to replace equation (3′) with the following general form:

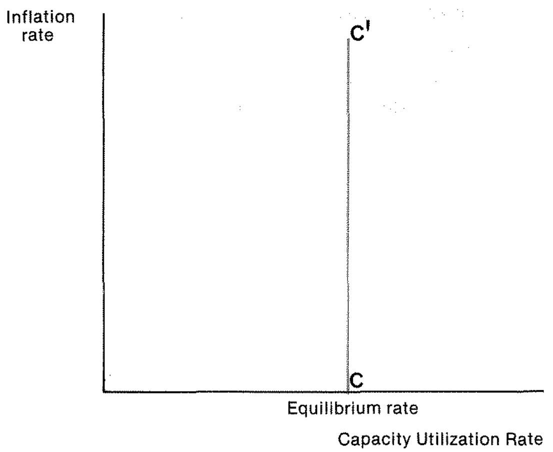
$$IR_t = d_1(CU_t - CU^e) + d_2 IR_{t-1} \quad (4)$$

According to this specification, capacity utilization and inflation rates are linked in the current period through the value d_1, but it is not a unique contemporaneous relationship, since current inflation depends also on past inflation through the lagged inflation-rate term. Our ability to associate a certain inflation rate with a certain level of capacity utilization depends upon the value of $d_1/(1-d_2)$, and crucially upon the value of d_2, the coefficient of past inflation.[14] If d_2 is less than unity, past inflation rates will become less and less important over time, and eventually will tend to have no impact on current inflation. Under such circumstances, we will observe in the long-run a unique, stable relationship developing between capacity utilization and inflation. A higher rate of capacity utilization will become associated with a higher rate of inflation, and conversely. It would be possible, then, for an economy to lower its inflation rate by maintaining over time a lower average rate of capacity utilization.[15]

On the other hand, when d_2 is equal to one, the expression $d_1/(1-d_2)$ is infinite, so that no unique association exists, even in the long-run, between capacity utilization and inflation. A long-run curve relating the two variables is vertical, as illustrated by the line cc′ in Chart 1. Under these circumstances, a given operating rate will be consistent with any rate of inflation, and the equilibrium inflation rate will be determined by other factors.[16]

In statistical tests of equation (4)—under a variety of specifications for the lagged structure, the sample period and the inflation aggregate—

Chart 1
Inflation–Capacity Utilization Equilibrium Relationship When Coefficient on Past Inflation is Unity



we found that the coefficient on past inflation, d_2, was not significantly different from unity. These results are reported in Appendix 2 for U.S. data since the early 1950's. It appears, therefore, that the level of capacity utilization is not uniquely related with any particular rate of inflation. On the other hand, when d_2 is equal to unity, there is a permanent and stable relationship between *changes* in the inflation rate and capacity-utilization rates. Inflation thus tends to accelerate when capacity utilization surpasses a particular level. To illustrate this, we may write equation (4) in terms of the change in the inflation rate, CIR, by moving past inflation to the left-hand side since its coefficient value is one:

$$CIR_t = a(CU_t - CU^e) \qquad (5)$$

Thus, if actual utilization (CU_t) is maintained above the equilibrium rate, the rate of inflation will steadily increase; the inflation rate will rise each period by "a" percentage for each percentage point the current operating rate exceeds the equilibrium rate. Conversely, at utilization rates below CU^e, inflation will generally decline over time. Only at the equilibrium operating rate will the change in inflation be zero, with stability in the inflation rate.

II. Estimating a Stable-Inflation Capacity-Utilization Rate

Equation (5), which is in terms of the change in the inflation rate (CIR), is our basic model for estimating the equilibrium rate of capacity utilization.

$$CIR_t = a(CU_t - CU^e) \qquad (5)$$

By incorporating the CU^e in the constant term, the equation can be written:

$$CIR_t = -k + aCU_t \qquad (5')$$

where $k = aCU^e$. Once we obtain an estimate of "a" , an estimate of CU^e may be derived by dividing the constant term by that value, i.e.,

$$\hat{CU}^e = \frac{\hat{k}}{\hat{a}}$$

The equilibrium rate is the full-capacity utilization rate associated with stability in the inflation rate; that is, the change in the inflation rate will be zero, on average, when $CU_t = CU^e$. All statistical tests, unless otherwise stated, utilize annual data.

We first developed a regression for the 1954-73 sample period (Line 1 of Table 1). We omitted the more recent years from this first estimation because of the unusual price factors which surfaced during this period, such as the oil price hike, agricultural shortages, and the overall effects of imported inflation.[17] The estimate of CU^e is 81.95 for the 1954-73 period.

For the entire 1954-77 period, we would expect greater variance because of the unusual price factors just cited—and this is exactly what we see (Line 2). The standard error has about doubled, yet the estimate of the CU^e (81.92) remains virtually unchanged. The constant term is negative, as posited by our model, and the estimate of the "a" coefficient is statistically significant at the 5-percent level. We made alternative specifications of the basic model in order to test the robustness of the CU^e estimate, yet in each case the estimate remained close to 82 percent.

Again, our estimates generally remained unaffected when we substituted a manufacturing wholesale-price index in the price series, and when we substituted fourth-quarter to fourth-quarter for annual-average price data.

We introduced dummy variables into our equations to adjust for the unusual price behavior of the 1974-76 period and for the price controls of the 1972 period (Lines 5 and 6). These adjustments led to a substantial drop in the standard error, to a point about equal to that reported for the original (1954-73) regression, and with coefficient estimates similar to the earlier period also.

Our preferred regression (Line 6) indicates that for every percentage-point increase above 81.9 percent of capacity utilization, the inflation rate tends to increase by .12 percentage points. For example, with an increase in utilization from 81.9 percent to 83.9 percent, we would expect the inflation rate to increase by .24 percentage points. If capacity utilization rose to 83.9 percent in year 2, the inflation rate would rise from (say) 6.00 percent to 6.24 percent—and if capacity utilization remained at 83.9 percent in year 3, the inflation rate would rise further to 6.48 percent. This result also held in the shorter (1954-73) period, and therefore appears stable over different time spans.[18]

We also tried various lag structures for the variables CU and IR. However, the results for the additional lagged values were not significant at the 5-percent level.[19]

We next estimated the 95-percent confidence interval for the CU^e,[20] realizing that policymakers obtain little benefit from knowing the average utilization rate which leads to increased inflation if there is a wide band of uncertainty associated with that average estimate. The 95-percent confidence interval is 79.6-83.5 percent for the 1954-73 period (Line 1). Relatively wide confidence intervals are associated with the extension of the estimating period to cover the 1973-77 period, but we can obtain a narrower confidence interval by incorporating dummy variables to account for the special price factors which dominated those years. With those adjustments, the 95-confidence interval for the CU^e for the 1954-77 period is 79.8-83.4 percent (Line 6). This range appears narrow enough, relative to historical utilization rates, to provide a meaningful signal of potential inflationary pressures.

Table 1
Estimates of Change in Inflation Rate‡
(Annual Data, 1954-77)

Change in Inflation Rate	Constant	Capacity Utilization CU (t)	D^1	D^2	D^3	Stable-Inflation Capacity-Utilization Rate CU^e	95-percent Confidence Limits for CU^e	Standard Error	D.W.	p	R^2	Estimation Procedure
CIR* (1)	-9.88369	.120612				81.95	79.62-83.53	.59	2.2	-.46	.55	CORC
	(-4.76)	(4.85)										
CIR (2)	-13.7149	.167421				81.92	74-86-86.02	1.33	2.0		.21	OLSQ
	(-2.67)	(2.70)										
CIRW (3)	-36.2811	.439590				82.53	75.70-88.57	2.98	1.8	.12	.27	CORC
	(-2.96)	(2.99)										
CIR** (4)	-18.8944	.230581				81.94	77.94-84.81	1.43	1.9		.32	OLSQ
	(-3.40)	(3.44)										
CIR (5)	-9.84463	.12079	-.755	4.334	-3.796	81.50	79.16-83.15	.57	2.1	-.42	.86	CORC
	(-5.22)	(5.35)	(-1.36)	(7.84)	(-6.60)							
CIR (6)	-9.9206	.12119		4.448	-3.698	81.86	79.79-83.39	.58	2.2	-.48	.85	CORC
	(-5.33)	(5.44)		(8.09)	(-6.45)							

‡ t-statistics in parentheses
* Estimation period is 1954-73
** Fourth quarter to fourth quarter
CU Capacity utilization for total manufacturing
CIR G.N.P. implicit deflator used for change in inflation rate
CIRW Wholesale-price index (manufacturing) used for change in inflation rate
D^1 1 in 1972 and 0 elsewhere
D^2 1 in 1974 and 0 elsewhere
D^3 1 in 1976 and 0 elsewhere

III. Instability Between Inflation Rate and Capacity Utilization

The relationship which we estimated between the change in the inflation rate and capacity utilization can be written in the following terms. To simplify the discussion, we have not included any dummy variables.

$$IR_t = .12(CU_t - 82.0) + IR_{t-1} \qquad (6)$$

This relationship may also be illustrated graphically (Chart 2). At the capacity-utilization rate equal to equilibrium, CU^e, the vertical line illustrates the lack of a long-run stable relationship between the rate of inflation and the capacity-utilization rate. Essentially this means that once an economy departs from its equilibrium value, it may return to it, but at a rate of inflation different from its initial value.

If the capacity utilization rate is above CU^e, the inflation rate is expected to increase steadily. If last year's rate of inflation remained constant, the relationship between capacity utilization and the current inflation rate would trace the path denoted by SS′ in the chart, where "a" represents the point where this year's inflation is equal to last year's rate.

But according to equation 6, a deviation of capacity utilization from CU^e will in fact change this year's inflation rate, which will alter next period's rate, and so on—so that the line SS′ keeps shifting as long as the inflation rate keeps changing. Consequently, we expect the relationship to trace a counterclockwise loop. This behavior is analogous to what we find in the inflation/unemployment relation, as rising inflation expectations shift the inflation/unemployment curve over time.

Consider an initial equilibrium at point a. Suppose there is a disturbance which results in capacity utilization increasing relative to CU^e. The rate of inflation will then follow the path a to b. If capacity utilization begins to decline from point b back towards its equilibrium value, the inflation rate will follow the path b to c. Note that the equilibrium inflation rate consistent with a return to CU^e is higher than its initial rate. This is because the economy maintains a capacity-utilization rate always greater than CU^e; hence, the current year's inflation is always greater than last period's. To return to the initial inflation rate, a, capacity utilization must fall relative to CU^e; for example, tracing the path c to d, and then returning to a. Inflation need not, however, ever return to its initial equilibrium value if events prevent capacity utilization from remaining less than CU^e for a sufficient *time or amount* to lower the inflation rate to point a.

Chart 2

Capacity Utilization Rate and Change in Inflation Rate

Graphical Illustration

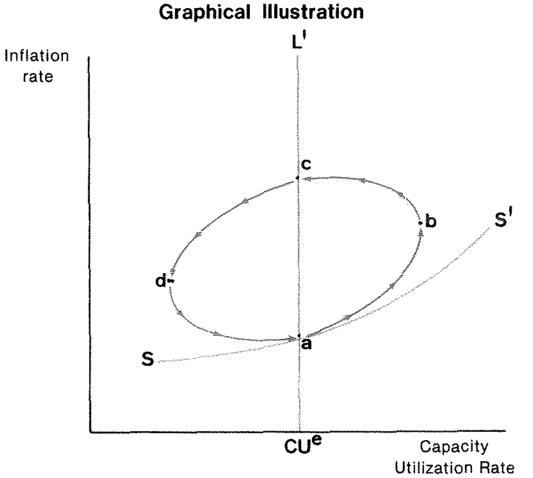
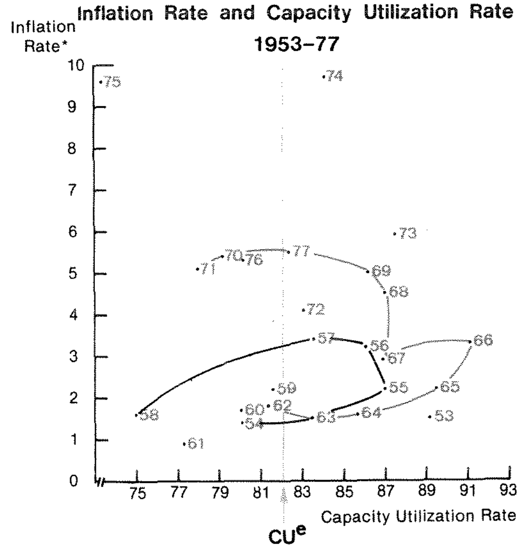


Chart 3

Inflation Rate and Capacity Utilization Rate

1953–77



*Annual Percent Change in GNP Implicit Deflator

These counterclockwise loops may be illustrated with recent U.S. historical data (Chart 3). The colored line first traces the recovery which began in 1954, with an inflation rate averaging less than two percent. During the recovery, the inflation rate increased as capacity utilization rose and remained above equilibrium, so that the return towards 82 percent was accompanied with a higher inflation than at the start of the recovery. The business contraction in 1958 resulted in inflation returning to about the 1954 value.

Again, the long recovery of the 1960's started out with a relatively low inflation rate. Between 1969 and 1970, the economy turned down and crossed the 82-percent capacity-utilization line with more than double the initial rate of inflation. The contraction which followed was relatively short lived, and consequently the inflation rate dropped very little.

The current recovery is apparently beginning its counterclockwise loop. The price movements of 1976 and 1977 appear closely associated with the imbedded inflation from the pressures generated in the previous years of high capacity utilization. If 1978 carries the economy to utilization rates beyond equilibrium, we may find the next return to equilibrium at higher inflation rates than we are now experiencing.

IV. Summary and Conclusions

In this paper, we have combined a wage and a price equation to derive a semi-reduced-form model of inflation. Our equation for the CU^e relates changes in the inflation rate to deviations of capacity utilization from its equilibrium value. According to that equation, a stable inflation rate is consistent with a full-capacity utilization rate of 82 percent—or within the 80-to-$83\frac{1}{2}$ percent range provided by our 95-percent confidence limits. These results were robust under changes in the estimation period, the lag structure and the chosen inflation rate.

Many economists believe that the yardstick for full use of the nation's productive resources is provided by the historical peak of capacity utilization—specifically, the 87-to-88 percent level of the 1973 period. Our analysis suggests, however, that the full-capacity utilization rate is reached at a somewhat lower level, so that there is less non-inflationary slack in the present economy than is commonly believed. Indeed, inflation tends to accelerate when the operating rate surpasses 82 percent—or more generally, the range of 80 to $83\frac{1}{2}$ percent. Once beyond that range, excess demand generates inflationary pressures as less efficient labor and capital resources are called into use. Thus, since utilization rates recently have approached 85 percent, we could expect mounting inflationary pressures from the domestic, nonfarm business sector of our economy.

Once capacity utilization exceeds the range indicated, the increased inflation tends to become imbedded in future inflation, with the current period's higher prices being reflected in the next period's expectations. Our analysis suggests that when the operating rate rises above the full-capacity range, its return to that range will be accompanied by a higher rate of inflation. For the inflation rate to decline, therefore, capacity utilization would have to fall below its equilibrium value, such as generally happens in a business recession.

We may conclude that, in the 1978 economy, there is no more non-inflationary slack available. The important policy task, therefore, is to steer a steady course which does not permit output growth to exceed its long-run potential. Under such circumstances, a stable rate of inflation can be maintained with both capital and labor at their full utilization rates.

Appendix Table I
Estimates of Equation (3′) ‡
(Annual Data, 1953-77)

Dependent Variable	Constant	IR(t-1)	TIME	XM^2	XM^3	URM(t)	$\frac{1}{URM(t)}$	CU(t)	$\bar{R}^2$	Standard Error	DW	Estimation Procedure
IR (1)	4.004	.692	.075			-.507		-.024	.71	1.28	1.82	OLSQ
	(.35)	(3.29)	(1.20)			(-1.15)		-.20)				
IR* (2)	1.109	.718		.401		-.472		-.017	.70	1.31	1.82	OLSQ
	(.09)	(3.31)		(.974)		(-1.025)		(-.137)				
IR* (3)	1.566	.752			.324	-.506		-.016	.69	1.32	1.86	OLSQ
	(.13)	(3.49)			(.79)	(-1.09)		(-.12)				
CIR (4)	.018					-.537		.024	.19	1.28	2.11	OLSQ
	(.002)					(-1.25)		(.218)				
CIR (5)	-11.698							.143	.17	1.30	2.11	OLSQ
	(-2.40)							(2.44)				
CIR (6)	2.305					-.617			.22	1.26	2.09	OLSQ
	(2.91)					(-2.82)						
CIR (7)	-1.345						4.655		.12	1.34	2.09	OLSQ
	(-1.73)						(2.09)					

‡ t-statistics in parentheses
* Estimation period is 1954-77
IR Annual rate of change in GNP implicit deflator
CIR Change in IR
TIME Linear time trend
XM^2 Two-year moving average of output-manhours ratio. (Output includes nonfarm business sector and households; manhours includes private domestic nonfarm business sector, including proprietors and unpaid family workers.)
XM^3 Three-year moving average of output-manhours ratio
URM Unemployment rate of males aged 25-54
CU Federal Reserve capacity-utilization series

Appendix Table 2
Estimates of Inflation Rate‡
(Annual data, 1954-77)

Inflation Rate	Constant	Capacity Utilization CU(t)	Inflation Rate, Lagged	D^1	D^2	D^3	Stable-Inflation Capacity-Utilization Rate (CU^e)	Standard Error	D.W.	$\hat{\rho}$	R^2	Estimation Procedure
IR (1)	-11.9213	.149276	.919				79.86	1.34	1.96		.68	OLSQ
	(-2.00)	(2.16)	(7.15)									
IRW (2)	-29.3233	.364912	.781				80.36	2.97	1.81	.22	.56	CORC
	(-1.95)	(2.10)	(4.12)									
IR (3)	-10.6478	.12875	1.051	-.958	4.015	-4.250	82.70	.578	2.15	-.40	.94	CORC
	(-4.91)	(5.14)	(16.24)	(-1.57)	(5.92)	(-5.22)						
IR (4)	-10.0484	.122435	1.008		4.393	-3.77	82.07	.599	2.20	-.48	.94	CORC
	(-4.75)	(4.99)	(16.64)		(6.54)	(-4.71)						

‡ t-statistics in parentheses
IR (t) G.N.P. implicit deflator used for inflation rate
IRW (t) Wholesale-price index (manufacturing) used for inflation rate

D^1 = 1 in 1972 and 0 elsewhere
D^2 = 1 in 1974 and 0 elsewhere
D^3 = 1 in 1976 and 0 elsewhere

1. See Phillips (1958).
2. See Modigliani and Papademos (1976).
3. "Required Reading," **American Banker,** May 3, 1978, page 4.
4. In the literature, the term Phillips curve refers to the relation between the unemployment rate and the rate of change in wages, but also to the relation between the unemployment rate and the rate of change of final-product prices. We shall use the term only in the latter sense.
5. See Eckstein (1972), Stein (1978) and Laidler (1973).
6. Numerous studies in the literature relate demand pressures to the inflation rate and use capacity utilization as a proxy for demand pressures within the context of a price-markup equation. See the articles in Eckstein (1972) and Hirsch (1977). One of the earliest studies is Eckstein and Fromm (1968).
7. For wage equations of this general form, see those incorporated in the models discussed in Eckstein (1972).
8. The unemployment rate of males, (25-54) is relatively insensitive to cyclical business conditions, so that changes in their unemployment rate basically reflect changes in job opportunities and in the demand for labor in general. For a review of the use of unemployment rates in labor market studies, see Mincer (1966). The aggregate unemployment rate, on the other hand, reflects the changing composition of the labor force, so that it may change even when demand pressures in labor markets do not. For example, teenagers and women historically have higher than average unemployment rates; thus, although their group unemployment rate may not change, an increase in their percentage in the labor force will increase the overall measured unemployment rate. Since the mid-1960's, both these groups have increased their labor-force participation substantially; consequently, the measured total unemployment rate has tended to overstate the amount of slack in labor markets. The reader will note that since equation (3) uses the variable $(u - u_e)$, the aggregate unemployment rate could be used as a proxy for excess demand provided we also included the equilibrium unemployment rate. Recent research indicates that the equilibrium rate has been increasing since the early 1950's, although there is a good deal of professional debate about its actual value. I have used the unemployment rate of males (25-54) in the text, since that group's equilibrium unemployment rate may be represented as a constant.
9. See Winston (1974) for a review of this literature.
10. See Tobin (1972).
11. For an analysis of the unemployment and capacity-utilization relationship over the business cycle, see Butler (1977).
12. Because the demand for labor is derived from the demand for final output, we may expect a high correlation between excess demand in the two markets. In addition, we may assume that once capital stock is in place, there is limited substitutability between capacity utilization and labor employment. Recent empirical evidence appears to substantiate this assumption (see Malcomson). This limited substitutability may be the major reason why we observe a high correlation between labor and capacity utilization in U.S. data.
13. Modigliani and Papademos (1976), using a quasi-reduced form similar to equation (3), dropped capacity utilization because of the high correlation between the unemployment-rate measure used in their equation and capacity utilization. Modigliani and Papademos then went on to measure the nonaccelerating inflation rate of unemployment.
14. Equation (4) states:

$$IR_t = d_1(CU_t - CU^e) + d_2 IR_{t-1} \quad (4)$$

Lagging equation (4), we obtain

$$IR_{t-1} = d_1 (CU_{t-1} - CU^e) + d_2 IR_{t-2} \quad (4')$$

Substitute (4') into (4), to derive

$$IR_t = d_1 (CU_t - CU^e) + d_1 d_2 (CU_{t-1} - CU^e) + d_2^2 IR_{t-2} \quad (5)$$

Continuing this process, current inflation is seen to be a distributed-lag of capacity utilization. Assuming a given level of CU through time, we obtain the infinite geometric series-

$$IR_t = d_1 \sum_{i=0}^{\infty} d_2^i (CU - CU^e) \quad (6)$$

$$\text{where } d_1 \sum_{i=0}^{\infty} d_2^i = \frac{d_1}{1-d_2} - \frac{d_1 d_2^{\infty}}{1-d_2} \quad (7)$$

If $d_2<1$, expression (7) converges to a finite number resulting, according to (6), in a stable, equilibrium association between IR and CU. If $d_2>1$, no stable solution exists; any gap between actual and expected inflation continually widens. If $d_2=1$, there is no long-run solution of equation (6); the equilibrium inflation rate is independent of the rate of capacity utilization.
15. The terms permanent, long-run and equilibrium are used interchangeably in his paper, in the sense of a situation that would exist indefinitely if not disturbed by "exogenous" forces, such as mandated energy-price increases or changes in fiscal and/or monetary policy.
16. For a similar derivation of the long and short-run impact of unemployment upon inflation, see Tobin (1972).
17. For an analysis of inflationary pressures over this period, see Keran and Riordan (1976).
18. One other estimate of the stable-inflation capacity-utilization rate was derived by Otto Eckstein and Gary Fromm in their 1968 article, "The Price Equation". Using quarterly data, 1954.1-1965.4, and the wholesale-price index, they estimated a price equation of the form (1) above. They found an equilibrium value for the capacity-utilization rate of 82 percent. The capacity-utilization index was the Klein-Summers estimate, which at the time of their study averaged about 2 points higher than the Federal Reserve Board Index used in this paper. They also found that every additional point of the operating rate raises prices by .03 percent a quarter, or .12 percent a year as we have found.

Eckstein and Fromm's results, however, are not strictly comparable to ours, since they used the wholesale-price index instead of the GNP implicit deflator as a measure of inflation. In addition, the capacity-utilization series have undergone substantial revisions since the time of their study, which could affect their estimates.

Nevertheless, both studies, using different but consistent models of pricing behavior—theirs a structural price equation and mine a reduced form equation—both similarly concluded that the stable-inflation full capacity utilization rate is substantially less than the estimated historical peak would indicate.

19. The reader will note that our estimation equation is but one relation in a complete model of the U.S. economy. In our estimations, we treat capacity utilization as an exogenous variable. In the context of a complete model, the operating rate would be determined by other economic variables including inflation. Consequently, our estimates may be subject to simultaneous-equation bias. We therefore estimated equations similar to those reported on lines 1 and 2, Table 1, using a two-stage least squares procedure where capacity utilization was a function of past money supply growth. Our results did not differ from those reported in Table 1; therefore, we continued to use ordinary least squares or Cochrane-Orcutt procedures.

20. The formula for calculating the confidence limits was supplied by John L. Scadding. The procedure for obtaining the formula is described in "The Sampling Distribution of the Liviatan Estimator of the Geometric Distributed Lag Parameter," by Scadding in **Econometrica**, May 1973.

The formula for the lower and upper confidence limits is

$$\frac{(2ab - 2t^2Sab) \pm \sqrt{(2ab - 2t^2Sab)^2 - 4(b^2 - t^2S_b^2)(a^2 - t^2S_a^2)}}{2(b^2 - t^2S_b^2)}$$

where

a = estimate of constant

b_2 = estimate of coefficient of capacity utilization

S_a^2 = square of standard error of estimated constant

S_a^2 = square of standard error of b

t = student t variable, $t_{n-2}^{\alpha/2}$

Sab = estimate of covariance between a and b

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Room for Growth: Speeds of Adjustment of Labor and Capital

Larry Butler*

Unemployed labor and unused capital stock provide two measures of the available economic capacity at the nation's disposal. In the past, the two have generally followed the same path, and most analysts have treated them as roughly interchangeable measures of the amount of pressure on resources. In recent years, however, that relationship has come to appear considerably weaker than before.

In the summer of 1978, capacity utilization approached 85 percent of the nation's capital stock—relatively tight in terms of the post-World War II average of 81 percent—while the unemployment rate stood at 5.9 percent of the labor force—relatively slack in terms of the postwar average of 5.3 percent. Thus the two measures have been providing different signals of the amount of resource pressure in the economy. The recent level of capacity utilization suggests that we are already approaching full resource use, so that new supply pressures could cause accelerating inflation. Indeed, on two earlier occasions, capacity utilization went from 85 percent to the cyclical peak of 87-88 percent very rapidly, within the space of two to three quarters. But the recent unemployment rate suggests that fiscal and monetary stimulus could be applied for a protracted period with little danger of accelerating inflation.

Which of these conflicting signals is correct? Most recent studies have tried to show that the signals may, in fact, not conflict as much as seems apparent, because structural changes in the economy have made it difficult to compare the measures over time. According to some labor-market studies, the shifting age-and sex-composition of the labor force have tended to increase the economy's "normal" rate of unemployment, so that the current level is actually close to "full employment."[1] According to some capacity studies, the OPEC-caused upsurge in oil prices has tended to lower the nation's potential capacity to produce.[2]

In this article, we argue that it is not necessary to resort to these structural arguments to explain the current divergence of the unemployment and capacity-utilization rates. Rather, the two markets need not reach full-resource use at the same point in business expansions, because capital and labor supplies exhibit different cyclical patterns. New additions to the capital stock are concentrated in the mature-recovery portions of cyclical expansions, while new additions to the labor force are concentrated in a brief period following cyclical troughs. Short-term movements in the capital stock, unlike movements in the labor force, are largely dominated by shifts in expected output. Firms make substantial adjustments to their desired capital-output ratios in short periods of time, through movements in investment which are substantially faster than the adjustments they make to changes in the labor force-output ratio.

The standard Keynesian aggregate-demand model includes only one factor market—usually the labor market—but in this article we add a second factor market—the capital market. Our rationale is that capital normally adjusts more rapidly than labor to changes in economic conditions. The single-factor model has adequately described most early-recovery periods, when both labor and capital were in ample supply. Again, the single-factor model has adequately described such mature recovery periods as 1956-57 and 1967-69, which were capital-constrained with high levels of capacity utilization, and also labor-constrained with quite low levels of unemployment. In other periods, however, that model has proved to be an inadequate description of the cyclical process.

The two-factor model provides a better explanation of three brief, but important, periods of transition to full employment—in 1955, 1965

*Senior Economist, San Francisco Federal Reserve Bank

and 1973. More importantly, that model may be relevant to the period immediately ahead, which might be marked by capital constraints but also by adequate supplies of labor.[3] Capital utilization is already quite high, so that strong real growth over the next half-year could place the economy under significant capital constraints. But the unemployment rate at that point could still be close to 6 percent, which means that the economy could sustain a capital-constrained expansion for at least a year before the labor market showed severe signs of tightness.

In such a period, high levels of capacity utilization would tend to stimulate rapid investment, prolonging the business expansion. This investment then would generate strong demands for credit, applying substantial pressure on interest rates. But it would be wrong to interpret rising rates in this case as indicating an excessive tightness of monetary policy—which might be deemed inappropriate in view of the likelihood of continued high unemployment. Indeed, if the monetary authorities resisted the upward trend in interest rates, they could ratify the demand pressures from the capital-investment expansion and thus set off a new spurt of inflation. Consequently, policymakers should monitor closely the signals from both the capital and labor markets over the coming year.

Section I of this article describes the factor-market regularities which tend to exist both in a transition period where there is an excess supply of only the labor input to production, and in a mature-expansion period where there are no excess factor supplies. The following section discusses the implications of these factor-market movements for the cyclical changes in fixed investment, labor-force growth and interest rates. Section 3 discusses the derivation and operation of the two-factor model, and the concluding section describes the implications of this analysis for current policy.

There are two special problems in treating the published unemployment and capacity-utilization rates as roughly equivalent measures of the degree of pressure on the capital and labor markets. These should be noted at the outset, because their treatment in this article affects the analysis at several points.

1. Measures of excess capacity are available for manufacturing only. The non-manufacturing "service" industries have no comparable measure, largely because of the ambiguity of the concept as applied to these industries. We here assume that the cyclical timing, though not the amount of fluctuation, in the size of the capital stock in service industries is much the same as in manufacturing.

2. Because excess capacity is measured for manufacturing only, the obvious labor-market comparison is with the unemployment rate in manufacturing. In fact, those rates do have very similar cyclical patterns, with both tending to reach cyclical lows before the overall unemployment rate reaches its cyclical low. However, they do so for very different reasons. The early trough in capacity utilization occurs because rising demand causes producers to expand their capital stock to meet this demand.

Other things equal, a larger capital stock means lower capacity utilization. The early turning point in manufacturing unemployment occurs because the growing availability of good-paying jobs in manufacturing brings about an increase in the supply of manufacturing labor. Thus manufacturing unemployment is a poor guide to the general pressure on the labor market, so that we may assume that the overall unemployment rate is the appropriate measure of the state of the labor market.

Because manufacturing capacity utilization appears to be an adequate measure of overall capital usage, and because the overall unemployment rate appears to be the best measure of labor supply conditions, we can make the direct factor-market comparison provided in Section I without danger of involving an "apples and oranges" type of inappropriate comparison.

I. Cyclical Behavior of Factor Utilization Rates

First, let us note some intrinsic weaknesses in the factor-utilization data used in this section. These numbers contain ambiguities. Both capacity-utilization data and unemployment data are based on surveys, one of manufacturers and the other of households. The questions asked in the household survey are straightforward. The interviewer asks whether a person had worked, or had looked for work, during the survey month. Even so, the survey fails to pick up such phenomena as "discouraged workers"—people counted by the survey as having dropped out of the labor force entirely, but who in fact have simply given up all hope of finding a job.

The analogous survey problem for capacity utilization concerns marginal plant and equipment. In the manufacturing survey, business firms are asked to assess the degree of their capacity usage, compared to full use under "normal operating conditions." Each must decide whether pieces of hopelessly obsolete equipment—perhaps kept around to meet peak-load problems—qualify as part of his "normal" capacity. The answer will vary from firm to firm, so the concept of capacity utilization is intrinsically somewhat fuzzier than that of the unemployment rate.

As noted above, we here assume that service industries' economic behavior differs from manufacturers' by at most a scale factor. The assumption may not be entirely true, because many services are substantially less cyclical than manufacturing. The analysis in Section III thus will be supported by other evidence—for example, the cyclical behavior of such series as investment and interest rates. The first step in this approach, however, must be an examination of the cyclical character of movements in the factor-utilization rates themselves.

Three postwar business expansions have reached full maturity—in 1954-57, 1960-69 and 1970-73 (Table 1)[4]—and the current period may yet reach the same stage. Transition periods are defined as those when capacity utilization first approaches its peak level but when unemployment still remains above its cyclical lowpoint. (Rather arbitrarily, the start of the transition period is dated from the point when the capacity-utilization rate first exceeds 84½ percent.) Mature-expansion periods are defined as those when capacity utilization remains high, and unemployment as well has reached its cyclical low. This distinction between transition and mature-recovery periods is most evident in the long 1954-57 and 1961-69 expansions (Chart 1). Still, it is evident even in the relatively short 1970-73 expansion, when the period of low cyclical unemployment continued over five full quarters.[5]

In all of the post-Korea expansions, the rise in capacity utilization was slightly faster than the fall in unemployment (allowing for the difference in scale of the two series). In all except the abortive 1958-59 recovery, capacity utilization reached its peak before unemployment reached its trough. In each early-recovery period, unused capacity and unemployment declined almost as rapidly as they rose during the preceding recession period, that process continuing to about the seventh quarter of recovery.[6]

The 1970-73 expansion represented a partial exception to this pattern, however. Real GNP[7] and capacity utilization rose during the early part of that expansion at about the same rate as in earlier cycles, but the unemployment rate did not drop appreciably below the 6.0-percent recession-trough figure until late 1972, six quarters after that trough. The jobless rate then averaged 4.8 percent during the mature-recovery period—a full percentage point above the average for the two previous mature recoveries. This difference in movement is attributable, first, to the post-Vietnam reversal of the artificial lowering of the civilian labor force associated with that conflict, and second, to the influx of unskilled

Table 1
Factor Usage and the Rate of Inflation in Three Expansions

	Capacity Utilization			Unemployment Rate			Inflation Rate		
	1954-57	1961-69	1970-73	1954-57	1961-69	1970-73	1954-57	1961-69	1970-73
Year before transition	80.1	82.8	83.1	5.5	5.6	5.8	1.9	1.4	4.5
Transition period*	86.0	87.2	86.5	4.6	4.9	5.2	2.9	2.0	5.0
Mature expansion**	86.2	87.4	86.9	4.1	3.7	4.8	3.3	4.4	9.1
Year after end mature expansion	75.3	78.2	73.1	6.5	5.0	7.0	1.3	5.1	9.8

* Dating of transition periods: 1955I-1955II; 1963IV-1965IV; 1972IV-1973II.

** Dating of mature expansions: 1955III-1957III; 1966I-1969IV; 1973III-1974III.

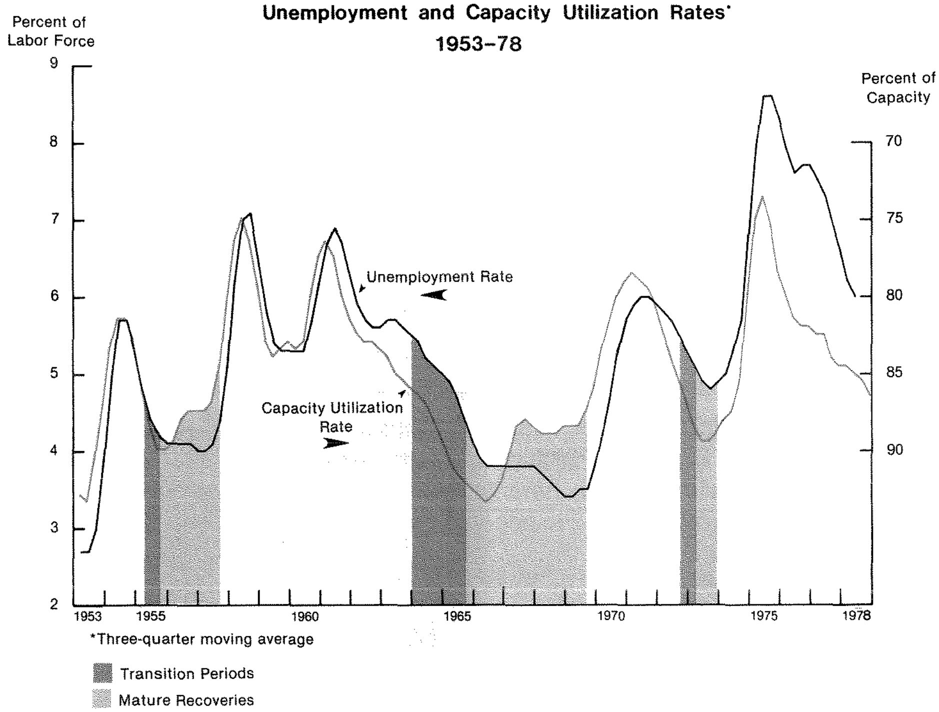
younger workers and women workers into the labor force.

A systematic difference between the two series has typically emerged after the early-recovery period.[8] On average, capacity utilization stopped rising after the seventh quarter of recovery, while unemployment continued to fall slowly throughout the expansion. All of the complete post-Korea expansions—again with the exception of the abortive 1958-59 recovery—went through such a transition period and then entered a mature-expansion period marked by both full employment and full capacity utilization.

A striking regularity has been the narrow range of movement of capacity utilization in both the transition and mature-recovery period of the average cycle. This is doubly striking in view of the fact that the capacity utilization rate exhibits five times as much overall cyclical variation as the unemployment rate.[9] Yet given its smaller relative movement, the unemployment rate clearly has varied more than the capacity-utilization rate from cycle to cycle. A substantial difference can be observed between the 3.7-percent average jobless rate of the 1966-69 mature recovery and the 4.8-percent rate of the 1973-74 mature recovery. This variation underlines the importance of structural elements, such as the demographic factors cited above, in determining the level of full employment. The labor market thus contains an element of long-period adjustment to changing demographics as well as a normal cyclical adjustment—as we are certain to see over the next decade as those earlier factors begin to reverse themselves.

Another strong regularity during these cycles has been the tendency for full-employment periods to determine the timing of accelerated-inflation periods. Both of the major inflationary bursts—in 1966-69 and 1973-74—occurred during periods of mature expansion. In both cases, the labor and capital markets showed considerable tightness, with little variation in either the capacity-utilization rate or the unemployment rate. Price acceleration also appeared to be relatively large during the 1956-57 mature expansion, although it tended to be swamped by the generally declining trend in the inflation rate which marked the 1950's.[10]

Chart 1
Unemployment and Capacity Utilization Rates*
1953–78



*Three-quarter moving average

II. Cyclical Patterns of Factor Growth

As we have seen, the capital and labor markets exhibit some difference (although sometimes a modest difference) in their cyclical rates of adjustment. This distinction may be traced to the pronounced difference in the cyclical growth patterns of the underlying stocks—business fixed capital and the labor force. That difference in turn probably reflects different treatments of fixed and variable production inputs. Capital in principle is a hybrid kind of factor; large quantities of available capital will be left unused in recessions, but will then be brought back into use during mature recoveries—depending on the level of aggregate demand and hence on the quantities available of variable production factors. However, this characteristic may not be shared to the same extent by the labor input.

Fixed factors are those production inputs whose available quantities are relatively independent of current rates of production. The desired stock of a fixed asset responds primarily to changes in the expected flow of services the asset will yield over a long span of time. Asset holdings should adjust slowly to changes in relative prices as all expected future flows of services become adjusted to the current market rate of return. Because of the slowness of adjustment, fixed-factor markets will often appear to be in a state of excess supply, yet with no significant decline in rates of return. To explain this, we may assume that the expected future rate of return is high enough to make current owners of unused assets willing to continue to hold them. Firms will not scrap unemployed capital as long as they expect those assets to be profitable in the future; instead, they will simply report those assets as idle capacity.

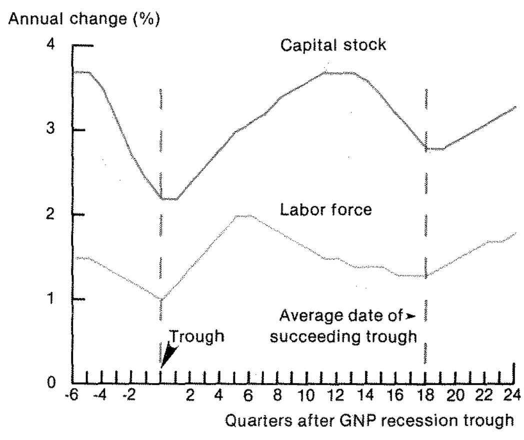
In principle—although not necessarily in practice—the same argument applies to the labor market.[11] We may assume that expected wage rates are high enough to persuade current owners of unused skills—the unemployed—to be willing to continue in the labor force. In the labor market as in the capital market, these resources are available factors for further expansion of the economy. But from the overall view of society rather than the limited view of individual firms, labor is the major long-run fixed factor in the economy. Rapid scrappage can reduce a stock of obsolete capital fairly quickly, but the same cannot be said for a group of skilled workers who are displaced by new technology.

According to the evidence of the two strongest expansions (1954-57 and 1961-69), capacity utilization and labor utilization tend to move differently in the later stages of expansion, with capacity utilization turning down long before the unemployment rate reaches its low point (Chart 1). Because the two series tend to move together in the preceding recession and early-expansion phases, their divergent behavior in later stages of the cycle suggests substantially different cyclical behavior on the part of the underlying stocks of labor and capital (Chart 2). The two series exhibit similar cyclical amplitudes; the labor force increases over the cycle by about 1 percent of the underlying stock, while the amount of investment increases by about 1½ percent of its stock. However, their patterns of movement vary considerably.

All of the cyclical increase of the labor force typically occurs in the first year of expansion, and is then followed by a prolonged period of stagnation or decline. Thus the most substantial growth occurs in the early-recovery period, when the level of aggregate demand (though not its growth rate) is still low. This pattern reflects the underlying secular nature of labor-force growth—plus a discouraged-worker effect, with some potential workers leaving the labor force as

Chart 2

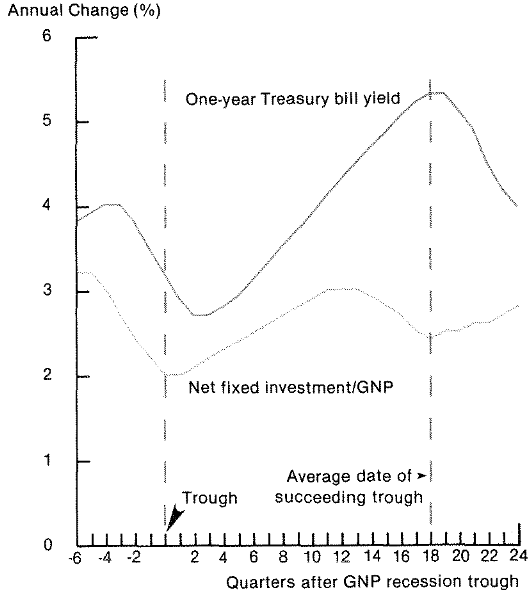
Cyclical Changes in Capital Stock and the Labor Force (Average of five post war cycles)



market conditions worsen, but then returning to the labor force as demand picks up in the early-recovery phase. Investment demand, in contrast, is strongly pro-cyclical, so that its movements cannot be explained in the same way as the movements of the labor force. Again, its movements cannot be easily explained in terms of interest-rate effects (Chart 3), because interest rates, like investment, move in a strongly pro-cyclical fashion. (Interest rates generally peak at the GNP peak, and reach a low point just after the GNP trough.) Interest rates can significantly affect investment, of course, primarily by helping to determine the best long-run ratio of capital to output, but over the cycle, the level of output tends to have more effect than interest rates on new investment spending. Thus investment tends to be concentrated in the transition and mature-recovery periods of the cycle, when by definition the highest levels of output occur.

The transition and mature-recovery periods are similar because both are periods of heavy investment, but they differ in respect to patterns of inflation—with accelerated inflation being evident only in the mature-recovery phase. This distinction may reflect the fact that capital is the only effective factor constraint on continued output growth during the transition period, whereas both capital and labor act as factor constraints during the mature-recovery phase. The different behavior of the economy in these two periods implies that there is a systematic difference in the economic response to the two kinds of factor constraint.

Chart 3
Cyclical Changes in Investment and Interest Rates
(Average of five post war cycles)



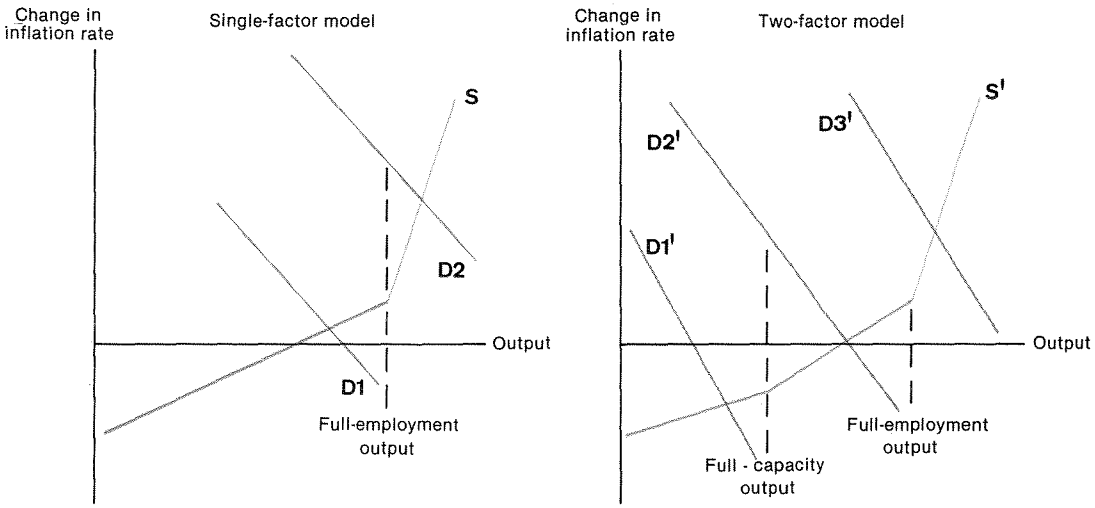
III. Aggregate Demand and Supply

In a single-factor model, with the unemployment rate used as a general measure of the amount of demand pressure, the economy may be faced with an aggregate supply function as shown in the left panel of Chart 4. If output is below its full-employment level, expansive monetary and fiscal policy will tend to increase aggregate demand and reduce unemployment (shifting demand from D1 toward D2), but with relatively small inflationary consequences because of the availability of excess factor resources. If output is above its full-employment level, however, expansive aggregate-demand policy will have a greater impact on prices than on output, because of the lack of available factor resources.

This single-factor model may be incomplete in certain circumstances, because of the different rates of adjustment in the capital and labor markets. Full capacity utilization will occasionally be reached before full employment, leading to a supply function such as that shown in the right panel of Chart 4. If output is below the full-capacity level, neither capital nor labor will act as a constraint. In that case, expansionary aggregate-demand policy will tend to increase income, lower unemployment, and increase capacity utilization. As in the single-factor model, the factor markets would generate little inflationary pressure within this range of income.

When income reaches the full-employment level, however, both available capital and available labor act as constraints on real output, although capital does so only by requiring a switch of resources away from consumption and toward investment. When both labor and capital are fully utilized, expansive monetary and fiscal policy cannot be expected to produce further large additions to output. At that point, the only effective way of increasing real income will be a

Chart 4
Aggregate Supply and Demand

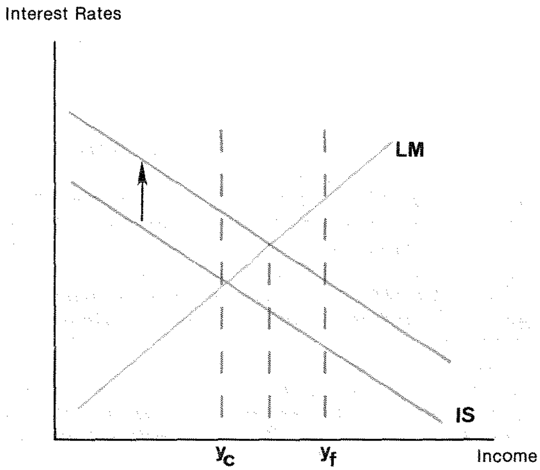


structural policy, designed to shift the supply curve itself to the right.

Just as in the single-factor model, if both labor and capital are less than fully employed (at aggregate-demand line D1′), we may experience little acceleration and perhaps even some deceleration of inflation. Inflation in actuality tends to decelerate at low levels of aggregate demand—that is, in late recession and early recovery. But the slope of the aggregate supply schedule S′ is quite low where it is crossed by the low-aggregate-demand line D1′, which implies that a large shortfall in aggregate demand is required to produce a modest decrease in the inflation rate.[12] In contrast, the slope of the aggregate-supply schedule is steep where it is crossed by the high-aggregate-demand schedule D3′, which implies that the policy impact on the inflation rate mostly occurs during the mature-recovery period of very high aggregate demand. Also, as we argued in Section I, a transition period exists between the early-recovery and mature-recovery periods, which is marked by a low transmission of inflation. We can now see that this is the portion of the aggregate-supply schedule crossed by the middle aggregate-demand schedule D2′.

Between the stages of full capacity and full employment, further growth depends on an increased demand for investment goods at any level of interest rates. As income approaches y_c, the full-capacity level of income, the investment function tends to shift upward as business increases its estimate of the future demand for output (Chart 5). This in turn shifts upward the IS schedule, the total demand for goods and services. We can then determine a complete solution by adding the LM curve, which indicates the similar trade-off determined in the financial markets. As IS shifts upward on reaching full capacity (y_c), income and investment both increase, and so do interest rates.

Chart 5
Income and Interest Rates



IV. Implications for Current Policy

In this paper, we have emphasized the fact that the capital market adjusts more rapidly than the labor market over the cycle, which implies that a transition phase exists between the period of full capacity use and the period of full employment. This phase is relevant to us because the economy now seems to be in the midst of just such a transition, moving toward a mature-recovery period. In the past, capital accumulation has been significant only in the transition and mature-recovery periods, and not in the earlier stage of expansion. Thus, if we failed to enter these cyclical phases, we might experience a permanently reduced rate of growth of the capital stock and hence of productivity. On the other hand, a mature recovery carries inflationary seeds of destruction within itself, so that we must recognize the warning signals and avoid overly full use of the factor markets.

The upward shift in the investment schedule which typifies the transition period is the clearest guide to the policy signals which can be anticipated in the advanced stages of recovery. First, we should look for a rapidly rising ratio of investment to output. Secondly, we should recognize that any given setting of fiscal and monetary policy will produce more inflation than it did earlier in the recovery. The danger at such a point is that policymakers will resist the interest-rate increases which characterize the transition, and thereby overstimulate the economy and bring it rapidly from a wasteful state of unused resources to an inflationary state of overfull employment. To some extent, this is what happened in the closing stages of both the 1954-57 and 1970-73 expansions.[13]

In both 1954-57 and 1970-73, the transition was quite brief, with capacity utilization moving from 84½ percent to cyclical peaks in the 87-88 percent range within two to three quarters. Because of the brevity of those transition periods, the bulk of each cycle's net capital accumulation occurred in the mature-recovery period. In contrast, the 1964-65 transition period was prolonged more than two years by shifting but generally tight monetary policy measures which permitted both higher interest rates and a higher investment-output ratio.

The current recovery appears to be in its own transition phase. The unemployment rate, at slightly below 6 percent, is still quite high by the standards of earlier cycles. Yet interest rates have moved sharply upward, with Treasury bill rates up almost 200 basis points to date this year, and with the bill-futures market expecting even further increases. Meanwhile, the investment-output ratio has begun to rise, from a static level of 9.7 percent in 1977 to 10.2 percent in the second quarter of 1978. That combination of circumstances suggests that it would be wise to avoid overstimulating the economy during this transition phase. In particular, the rising level of (present and prospective) interest rates appears to be an integral component of real growth in a capital-constrained economy. If such increases are not resisted by policy, and if monetary growth is kept to a steady path, the recovery should be able to continue for some time without a further acceleration of inflation.

FOOTNOTES

1. See George Perry (1974) and Michael Wachter. (1977)
2. See Robert Rasche and John Tatom. (1977)
2. The structural problems are important, as has been seen in Rose McElhattan's article in this **Review** (1977). But the evidence should not be overemphasized. The lowest post-Korea unemployment was not reached in the expansions of the 1950s, but as recently as 1969.
4. The investment, labor force, and interest-rate implications of the factor-usage rates are discussed in the next section.
5. The dates where the labor market began to weaken are chosen as the endpoints of mature recoveries. Because of the short lag between GNP growth and labor-market growth, the 1960-69 recovery is one quarter longer and the 1970-73 recovery three quarters longer than is indicated by the official National Bureau data.
6. A more detailed examination of the recession and early-recovery relation between the two factor-market measures was presented in the Spring 1977 issue of the **Review**. The present article focuses on this relation in transition and mature recovery.
7. Real GNP has grown at an annual rate of almost exactly 5 1/2 percent in the first eight quarters of **each** of the five most recent business-cycle recoveries.
8. The narrow difference in the cycle averages accounts for the general assumption that the two measures are interchangeable. Statistical methods based on long spans of time must account first and foremost for large swings in behavior. In the factor markets, these are the

large movements in factor use centered on the recession trough of the business cycle.
9. The average increase in unemployment in the last five recessions was 3.1 percent of the labor force; the average decline in capacity utilization was 14.9 percent of total utilization. The ratio of the two—4.8—measures the relative cyclicity of the two.
10. Monetary policy was generally restrictive throughout the Eisenhower years. Also, the end of Korean War price controls in the Spring of 1953 pushed the inflation above what might have been expected during the 1953-54 period of recession and early recovery.
11. Adjustment does occur in such markets. If low employment persists for long enough, some of the unemployed will lower their estimates of their future earning power and either leave the labor force or lower their wage offer. If low capacity utilization persists, some firms will not replace depreciated plant and equipment. Such changes in expected future returns to capital and labor may also produce long-term stability of factor-usage rates in these markets. A reduced expected return to capital lowers the desired capital stock and makes the hiring of labor more attractive, and thus creates an incentive to shift to more labor-intensive technology over the long term. Thus the notion of a fixed factor is a short-term concept; in the long term, all inputs to production are variable. But a large difference remains in the way short-term fixed and variable factors affect the nation's effective economic capacity.
12. R.J. Gordon (1976), in a recent survey of the Phillips Curve literature, argued that theory provides scant guidance as to the slope of the aggregate-supply schedule. He also noted that empirical economists have become steadily more gloomy concerning the strength of this trade-off.
13. This is not to say that policy of itself ended either expansion. Rather, policy led to a state of extremely high aggregate demand, and thus made the economy vulnerable to any sort of downward shock to either aggregate supply or demand. The 1973 oil-supply shock, for instance, marked the end of recovery, although full employment had not been reached by mid-1973.

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