ROBERT J. GORDON

Northwestern University

Can the Inflation of the 1970s be Explained?

BY MANY STANDARDS inflation has been a "surprise" during the past six years. Errors in forecasting inflation have increased markedly compared with earlier periods. For instance, during the interval 1971:3 to 1975:4 the root mean-square error of the Livingston panel of economists in forecasting the consumer price index six months ahead was 3.5 percentage points at an annual rate, compared with an error of 1.6 percentage points over the previous seventeen years.[1] Not only did the panel forecasters fail to predict the increased variance of the inflation rate in the 1970s, but also they fell far short in predicting the cumulative total price change between 1971 and 1976—24.0 percent compared with the actual change of 34.0 percent.[2] Most of the error occurred during the four quarters of 1974,

1. The Livingston forecasts were obtained from John A. Carlson, "A Study of Price Forecasts," *Annals of Economic and Social Measurement*, vol. 6 (Winter 1977), table 1, pp. 33–34. I calculated the errors by comparing the six-month-ahead forecasts with the change in the consumer price index in the two relevant quarters. For instance, Carlson's calculation of the predicted quarterly rate of change between December 1973 and June 1974 is compared with the average quarterly rate of change of the CPI in the first and second quarters of 1974. The "previous seventeen years" runs from 1954:1 to 1971:2.

2. The actual figure refers to the sum of the quarterly rates of change of the CPI in the interval 1971:3 through 1976:2. The forecast figure is the sum of the six-month predicted changes calculated by Carlson from the Livingston panel data for the ten surveys between June 1971 and December 1975.

with an actual increase of 11.6 percent, almost twice the 6.0 percent increase forecast six months in advance.[3]

In searching for an explanation for this inflation, this paper can be likened to an investigative report following a railroad or airline crash. The news of the disaster—in this case, the failure to forecast inflation accurately—was reported long ago and by now is well known. But what can we say beyond the fact that the disaster occurred? Just as transportation investigations attempt to determine which specific parts of the machine failed, and to recommend improvements, so here the relationship of the inflation rate to other important economic variables is studied to determine as precisely as possible what was different about the experience of the 1970s, and what lessons can be learned from past mistakes. Which theories and structural relationships relevant for predicting inflation remain intact, and which require surgery or euthanasia? What are the implications for policy?

Most econometric models base their inflation forecasts on structural price and wage equations, either a single pair for the aggregate economy, or a larger set of disaggregated equations. In my own past work on inflation, I have specified and estimated aggregate price and wage equations, and have studied the sensitivity of the results to alternative specifications, estimation methods, and sample periods. This paper investigates the performance of my price-wage model in tracking the inflation of the 1970s, and studies the implications of its successes and failures for the future conduct of economic policy.

The paper is divided into three sections, one on the price equation, one on the wage equation, and one on dynamic simulations in which the two equations interact.

1. *Structural price equation.* An equation that explains price change with wage change as a predetermined variable is a component of almost all large-scale econometric models of the U.S. economy. In a previous paper I argued that the total increase in prices relative to wages between mid-1971 and late 1975 was almost exactly what would have been predicted by a structural price equation fitted to the 1954–71 period, and

3. The errors for the forecasts from five large-scale models compiled by McNees were similar. The four-quarter-ahead forecast made in 1973:4 for the change in the GNP deflator to 1974:4 was 6.04 percent; the actual was 11.04 percent. See the revised reprint of Stephen K. McNees, "An Evaluation of Economic Forecasts: Extension and Update," *New England Economic Review* (September/October 1976), pp. 30–44.

that the timing of postsample errors was consistent with the hypothesis that prices had been held down by controls in 1971–72 and then rebounded when controls were terminated in 1974.[4] This paper extends this test through the end of 1976, notes the effects of recent data revisions on the original price equation, and explores alternative explanations of its overprediction of price change in 1975 and 1976.

2. *Structural wage equation.* Can a wage equation specified in 1971 and estimated for pre-1971 data explain the behavior of wage change since 1971? What was the impact of 1973–74 "supply shocks" on wage change, and how should policy respond to future supply shocks?[5] Has high unemployment during 1975 and 1976 held down wage increases by more or less than would have been expected on the basis of pre-1971 relationships? Finally, can the pre-1971 data or the 1971–76 experience distinguish among the various proxies for labor market tightness used by different econometric investigators?[6]

3. *Dynamic simulations.* How potent are high unemployment and a slack economy in slowing the inflation rate? What would have been the consequences for inflation of an alternative expansionary policy in 1974? Is the Carter administration's planned economic recovery consistent with its goal of decelerating inflation? A dynamic simulation in which the price and wage equations interact can provide answers to these questions.

Behavior of the Main Variables, 1969–76

Table 1 displays the behavior over the 1969–76 period of several important measures of changes in prices, wages, money, and nominal demand. The figures are annual rates of change. The first column covers the ten quarters prior to the imposition of the controls program in 1971, the second column covers the two quarters influenced by the 1971 freeze, and the next five columns show for the five years 1972–76 the sum of the quarterly rates of change for the four quarters of each year.

The official price indexes displayed in the first four lines uniformly

4. Robert J. Gordon, "The Impact of Aggregate Demand on Prices," *BPEA,* 3:1975, pp. 613–62.

5. See Robert J. Gordon, "Alternative Responses of Policy to External Supply Shocks," *BPEA, 1:1975,* pp. 183–204.

6. Robert J. Gordon, "Inflation in Recession and Recovery," *BPEA, 1:1971,* pp. 105–58.

Table 1. Annual Rates of Change in Major Economic Measures Before, During, and After Wage and Price Controls, 1968:4–1976:4

Percent[a]

Measure	Before controls 1968:4– 1971:2	Freeze 1971:2– 1971:4	Full controls 1971:4– 1972:4	Relaxed controls 1972:4– 1973:4	After controls			Total change, 1971:2– 1976:4
					1973:4– 1974:4	1974:4– 1975:4	1975:4– 1976:4	
Price index								
Gross national product	5.24	3.43	4.10	7.30	11.04	6.95	4.55	35.66
Consumption	4.36	3.52	3.43	7.31	11.45	5.86	4.64	34.45
Consumer prices	5.22	3.13	3.38	8.18	11.55	7.13	4.92	36.72
Nonfarm business	4.76	2.88	2.93	5.91	12.14	6.48	4.88	33.78
Nonfood business net of energy	5.06	2.75	3.07	5.33	9.97	6.27	5.12	31.14
Wage index[b]								
Compensation per manhour adjusted	6.71	5.55	5.77	7.78	10.68	9.12	7.19	43.31
Hourly earnings adjusted	7.18	5.51	7.16	7.58	9.56	8.03	7.01	42.09
Final demand and money supply								
Nominal final sales	6.65	7.80	10.69	9.40	8.29	10.24	9.16	51.68
M₁ (currency plus demand deposits)	5.14	4.63	8.15	6.11	4.97	4.30	5.55	31.39
M₂ (M₁ plus time deposits)	6.95	7.78	10.75	8.56	7.47	8.07	10.41	49.15

Sources: With the exceptions noted, the data are from U.S. Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929–74: Statistical Tables* (GPO, 1977), and *Survey of Current Business*. The consumer price index and money supply are official data from the U.S. Bureau of Labor Statistics and the Federal Reserve Board, respectively.

The deflator for nonfood business product net of energy and the adjusted measures for compensation per manhour are constructed using the methodology explained in Robert J. Gordon, "The Impact of Aggregate Demand on Prices," *BPEA, 3:1975*, pp. 613–62. Adjusted hourly earnings is constructed as explained in Robert J. Gordon, "Inflation in Recession and Recovery," *BPEA, 1:1971*, pp. 153–54. The sources for the last three measures are extensions of those given in the previous papers cited here and incorporate the 1976 Department of Commerce revisions of the national income accounts.

a. Calculated as sums of quarterly rates of change, converted to annual rates in first two columns.

b. Adjusted for overtime and shifts in the interindustry employment mix; for hourly earnings, also adjusted for fringe benefits.

record little price change in late 1971 and 1972, double-digit inflation in 1974, and a return in 1976 to rates similar to or below those of 1969–71. The fifth line displays the "nonfood, net of energy" deflator that I developed earlier, as recomputed from the revised national income accounts and extended to the end of 1976.[7] This index misses double-digit inflation in 1974 by only a hair.

Two wage indexes are displayed next. The first is compensation per manhour, with an adjustment for overtime and shifts in the interindustry employment mix; this is used as an independent variable in the structural price equation. The second is the official index of adjusted hourly earnings compiled by the Bureau of Labor Statistics, further adjusted here to include fringe benefits; this is the dependent variable in the wage equation. The most notable difference between wage and price behavior over this period has been the lower variability of wage change—less slowdown during late 1971 and 1972, less acceleration in 1974, and less deceleration between 1974 and 1976. As in the case of prices, wage change in 1976 returned to roughly the same rate as in 1969–71—a bit higher for compensation, and a bit lower for average hourly earnings.

The final section of the table displays the growth of final demand and two measures of the money supply. In none of these was growth nearly as variable as price change. The difference between the minimum and maximum annual rates of change in the 1972–76 period was 2.4 percentage points for demand, 3.8 for M_1, 3.3 for M_2, but 6.9 for the GNP deflator and 8.2 for the CPI. Simple reduced-form regressions in which price change is regressed on a distributed lag of past changes in money or final sales confirm that virtually none of the variance of inflation in the 1970s can be attributed to the behavior of money or final sales. When estimated for 1954–71, and extrapolated to 1976, such reduced-form regressions can explain at most one-sixth of the acceleration of inflation from the 5 percent range in 1969–71 to double digits in 1974, and the subsequent deceleration back to 5 percent in 1976.

Structural Price Equations

In an earlier paper I estimated structural price equations that exhibited relatively strong effects of aggregate demand on the price

7. Gordon, "Impact of Aggregate Demand," pp. 622–29, 656–60.

"markup," that is, on the relationship of the aggregate price level to the aggregate wage level. These equations appeared able to explain the cumulative 1971–75 inflation using coefficients estimated through 1971:2. Although the postsample prediction errors were large, their timing was consistent with the interpretation that the controls had temporarily held down the price level. In table 2, the first column lists the coefficients of a version of the "core" equation as published in 1975.[8]

The specification of the various price equations presented in table 2 corresponds to that derived in my 1975 paper. The price level net of excise and sales taxes is marked up over total cost by a margin that depends on the level of excess demand for commodities. Total cost in turn consists of unit labor cost, materials prices, and the user cost of capital. After each variable is transformed into a percentage rate of change, and when technical change is assumed to be labor-augmenting, an equation is derived in which the rate of change of prices depends on each of the variables listed in table 2: (1) the rate of change of an excise-tax term; (2) the rate of change of the relative price of materials; (3) the deviation of the growth rate of actual productivity from its trend; (4) the rate of change of wages minus the trend growth rate of productivity—"trend unit labor cost"; (5) the rate of change of the relative price of capital goods; and (6) a proxy for the excess demand for commodities, either the rate of change of the ratio of unfilled orders to capacity (*UFO/C*), or the rate of change of the gap between actual and potential output.

While in the earlier paper equations including the two alternative proxies were essentially identical, the same cannot be said of the equations reestimated with new data from the 1976 revision of the national income accounts. The data revisions reduce the statistical significance of most variables when either demand proxy is used, but the version using *UFO/C* is affected most adversely (compare columns 2 and 3). The out-put-gap equation is superior on almost every count, with a lower standard error of estimate and higher *t* ratios on every independent variable.

In contrast to the initial core equation, which tracked the cumulative postsample price change very closely, both of the new equations in columns 2 and 3 overpredict inflation during 1971–76 very substantially. The problem is not that inflation has been mysteriously low over the five-year extrapolation interval, but rather that the sum of coefficients on

8. See ibid., pp. 634–35, for the equations, and p. 639 for an illustration of the prediction errors of one equation.

labor cost (line 4) is so far above 1.0 that a significant overprediction builds up. The same cumulative postsample overprediction is exhibited in column 4, where both demand variables are excluded. An interesting feature of the no-demand version is the higher coefficient on materials prices, which in the postsample extrapolation captures more of the 1974 upsurge in prices and allows the equation to achieve a lower postsample root mean-square error. But the higher coefficient on materials prices adds to the overprediction of the equation in column 4, offsetting the lower coefficient on labor cost.

The postsample performance of the best equation—that in column 3 —is markedly improved when the sum of coefficients on labor cost is constrained to equal precisely 1.0. The constrained equation in column 5 fits the sample period about as well as the unconstrained version. While the root mean-square extrapolation error is only slightly improved in the constrained version, the cumulative overprediction disappears.

The actual change in the deflator for nonfood product net of energy and the predicted value from the constrained equation of column 5 are displayed in figure 1. A comparison of the curve marked "actual" (solid line) and that labeled "fitted values (1954:2–1971:2 sample period)" (dotted line) reveals that the equation underpredicts inflation at the end of its sample period in early 1971, but then overpredicts in late 1971 and throughout 1972 by a cumulative 2.44 percentage points. If interpreted as a measure of the effect of the controls program, that figure lies at the low end of the range estimated in my previous papers.

Next, the cumulative underprediction error in the two years ending in 1975:1 is 6.13 percentage points, more than double the 1971–72 overprediction. That finding is not consistent with my previous interpretation that all of the 1973–75 underprediction can be attributed to the effect of the unwinding of controls. A more plausible interpretation is that the equation goes astray by exaggerating the lag between wage and price changes in an abnormal period in which firms recognized that controls had ended and reacted to postcontrol wage increases by passing them forward to customers much faster than they normally would have done.

A final puzzle is why the inflation rate in 1976 was consistently below the prediction of the equations—in figure 1 the cumulative overprediction is 0.92 percent. One way to isolate any recent change is to examine the predictions of a similar structural price equation reestimated through the end of 1976.

Table 2. Structural Price Equations and Extrapolation Errors, Alternative Variants[a]

Independent variable (quarterly rate of change) and regression statistic	Sample period and type of equation						
	1954:2–1971:2					1954:2–1976:4	
	Original equation		UFO/C replaced with gap (3)	Demand variables excluded (4)	Constrained coefficient on trend unit labor cost[b] (5)	Unconstrained with gap (6)	Constrained coefficient on trend unit labor cost[b] (7)
	As published in 1975 (1)	With revised data (2)					
Independent variable							
1. Indirect tax rate	0.402 (2.09)	0.048 (0.22)	0.271 (1.31)	0.148 (0.68)	0.427 (2.18)	0.239 (1.21)	0.212 (1.11)
2. Materials prices	0.025 (1.46)	0.014 (0.69)	0.019 (1.13)	0.043 (2.52)	0.026 (1.74)	0.035 (2.91)	0.031 (2.98)
3. Deviation of productivity from trend	−0.024 (−0.77)	−0.049 (−1.12)	−0.118 (−2.11)	−0.047 (−1.03)	−0.093 (−1.70)	−0.145 (−2.91)	−0.152 (−3.18)
4. Trend unit labor cost	1.090c (19.2)	1.076c (19.9)	1.074c (20.96)	1.021c (20.0)	1.000c	0.963c (20.59)	1.000c
Mean lag	[4.8]	[5.3]	[4.8]	[4.3]	[4.8]	[3.2]	[3.2]
5. Relative price of capital goods	0.401c (3.37)	0.290c (2.07)	0.385c (2.75)	0.235c (1.66)	0.499c (4.34)	0.134c (1.05)	0.088c (0.84)

	1	2	3	4	5	6	7
6. Ratio of unfilled orders to capacity	0.065ᶜ (2.74)	0.052ᶜ (2.08)	... ...	... ...	... ...	... ...	... ...
7. Output gap	...	...	−0.324ᶜ (−3.27)	...	−0.256ᶜ (−3.05)	−0.195ᶜ (−2.15)	−0.218ᶜ (−2.72)
8. Dummy = 1.0, 1971:3–1972:4	...	...	...	...	...	−0.330 (−2.73)	−0.350 (−3.10)
9. Dummy = 1.0, 1974:2–1975:1	...	...	...	...	...	0.510 (2.28)	0.460 (2.21)
Regression statistic							
10. Standard error	0.207	0.244	0.235	0.254	0.234	0.261	0.259
11. Postsample root mean-square error (1971–76)	...	0.599	0.676	0.507	0.667	...	...
12. Cumulative error	...	−4.61	−3.65	−4.68	0.77	...	...

Sources: Column 1, Gordon, "Impact of Aggregate Demand on Prices," table 3, equation 3.5: for the other columns, the equations were reestimated using revised and extended data from the sources in ibid., appendix B. The methods used to construct the variables are identical to those used in ibid.

All distributed lags in this paper are estimated by the polynominal distributed-lag technique, with the lag coefficients constrained to lie along a third-degree polynomial, and with the far end constrained to be zero. The lag length is allowed to extend over twelve quarters on line 4 and eight quarters elsewhere.

a. The dependent variable is the deflator for nonfood business product net of energy. The numbers in parentheses are *t* ratios.

b. The constraint is applied in columns 5 and 7 by taking the distributed-lag coefficients estimated in columns 3 and 6, respectively, dividing each coefficient by the sum of the coefficients, and subtracting the result from the dependent variable.

c. The figure is the sum of a set of distributed-lag coefficients, and the number in parentheses below is the *t* ratio indicating the statistical significance of the sum of the coefficients.

Figure 1. Actual and Predicted Change in Deflator for Nonfood Business Product Net of Energy Using the Specifications of the Structural Price Equations, 1969–76

Annual rate of change in percent
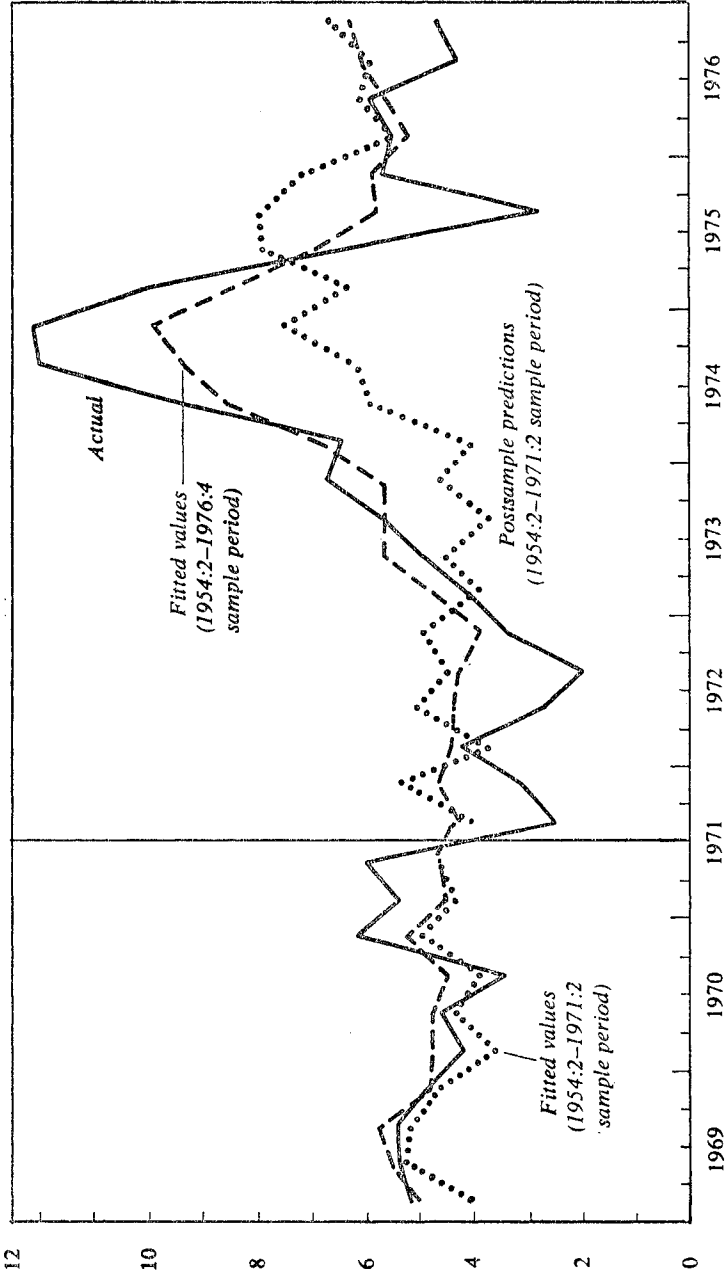
Sources: Actual, see table 2 sources; predicted and fitted, table 2, columns 5 and 7.

Column 6 in table 2 reports the coefficients of the extended equation. The effect of price controls is captured by two dummy variables, one covering the six-quarter interval beginning in 1971:3, and the second covering the four-quarter interval beginning in 1974:2. The coefficients of the dummy variables are highly significant and cumulate to a value of −1.98 percent of the controls period and +2.04 for the postcontrols rebound (there is no constraint imposed to force these cumulative totals to equal each other).

Column 7 amends column 6 by constraining the sum of the coefficients on trend unit labor cost to equal 1.0. To highlight the differing time paths of the two sets of predictions, based on columns 5 and 7, respectively, fitted values for the extended equation are displayed in figure 1 with the impact of the dummy variables excluded. The major differences occur in the 1973–75 period, when the extended equation does a much better job of capturing the timing of the acceleration and subsequent deceleration of inflation. This performance is achieved by three shifts in coefficients when the equation is extended. First, the coefficients on labor cost shift sufficiently to reduce the mean lag by 1.6 quarters.[9] This allows more of the postcontrols, 1974 bulge in wage change to influence price change in 1974, rather than in 1975. Second, the coefficient on materials prices is higher, which raises predicted inflation in 1973–74 while reducing it in 1975. Third, the coefficient on current productivity change is higher, allowing the negative values of productivity change in late 1973 and throughout 1974 to boost predicted price change.

What is the proper interpretation of the shifts in coefficients when the sample period is extended? Any coefficient in a time-series regression is sensitive to conditions inside the sample period. Thus it is not surprising that an equation estimated for the relatively placid 1954–71 period misses some aspects of the timing of pricing decisions by firms during 1971–76,

9. The mean lag of 4.8 quarters in the 1954–71 equation seems unreasonably long. When that sample period is split in half, the mean lag falls to 2.9 quarters for 1954–62 but rises to 8.1 quarters for 1963–71. A close examination of the data leads me to suspect that erratic movements of the series on compensation per manhour (*CMH*) in the latter period forced the computer to "stretch out" the lags. The alternative wage index, average hourly earnings (*AHE*), moved more smoothly and actually is more successful as the wage variable for the equation in column 5. It cuts the standard error from 0.234 to 0.213, and the mean lag from 4.8 to 4.0 quarters. I now believe that, despite its narrower scope, *AHE* is the preferable wage variable for price (as well as wage) equations, returning to a judgment reflected in my 1971 paper.

a period that included price and wage controls, a tremendous surge in materials prices, and an unprecedented slump in productivity.

Structural Wage Equations

Structural wage and price equations suitable for estimating the surprising aspects of the 1971–76 inflation are contained in a paper that I wrote in early 1971.[10] While the specification of the structural *price* equations reported in table 2 and figure 1 was altered somewhat in 1975 and thus incorporates knowledge of events to that point, no such reevaluation of the 1971 *wage* equations has yet been carried out.[11] Thus this section on wage behavior in the last five years can identify genuine "surprises" relative to 1971 expectations.

The first column of table 3 presents the relevant statistics of the "final" 1971 wage equation.[12] The dependent variable is the *two-quarter* rate of change in a private hourly earnings index, the *AHE* variable mentioned above, which is adjusted by the Bureau of Labor Statistics to exclude the effects of changes in overtime and of interindustry employment shifts, and which incorporates as well an adjustment to include the effects of changes in fringe benefits (including employer contributions for social security).

Coefficients for two of the independent variables in the equations are not listed in table 3, the constant term and the constrained effect of changes in the social security tax rate. The first three listed independent variables are proxies for labor market tightness—unemployment dispersion among demographic subgroups, the "disguised unemployment rate" (the difference between the actual labor force and its trend), and the "unemployment rate of hours" (the difference between private hours per week and its trend). The official unemployment rate does not appear in the equation; the three labor market variables are all correlated with it and incorporate its influence. Although only current values of the three variables are included in the wage equation, each of the three reacts to changes in output with a differing lag pattern, allowing output changes and thus

10. "Inflation in Recession and Recovery."

11. Detailed comparisons of the performance of the 1971 wage equations with alternative versions proposed by other authors are contained in Robert J. Gordon, "Wage-Price Controls and the Shifting Phillips Curve," *BPEA, 2:1972,* pp. 385–421.

12. This information is copied from "Inflation in Recession and Recovery," table 1, equation 11.

changes in labor market conditions to influence wages with a distributed lag.

Two price variables are listed (lines 6 and 7). The first is a distributed lag of past changes in the personal consumption deflator, with lag weights obtained from a separate regression of the nominal interest rate on past inflation. The second is the difference between changes in the "product price" (nonfarm deflator) and the consumption deflator. The final variable (line 9) is the rate of change in the employee-tax variable, the sum of the effective tax rate on personal income and the employee's effective social security tax rate.[13]

Data revisions between 1971 and 1976 alter the coefficients and their statistical significance, as is evident in comparing column 1, which is based on the original data, and column 2, which is based on the most recently revised data. Ironically, the "natural rate hypothesis," in the form of a coefficient of unity on price inflation, is vindicated by the revisions in the official data. The unemployment-dispersion variable becomes insignificant while the coefficient on inflation increases in lines 6 and 7; as I showed in 1972, the dispersion variable and high coefficients on inflation are substitute explanations of wage change in the 1954–70 sample period.[14]

When the sample period is extended by two quarters, in column 3, coefficients shift further but the results are reasonably satisfactory. Although the unemployment-dispersion variable has faded away, the coefficient of the disguised-unemployment variable remains significant and that of unemployment of hours is considerably increased and enhanced in statistical significance as compared with column 1. The coefficients on the price variables strongly indicate that wage change fully incorporates changes in price inflation and that it is influenced by changes in product prices, not consumer prices.

13. The 1971 specification, with the social security tax appearing both as a constraint on the left-hand side of the equation and as part of the employee-tax variable on the right-hand side, allows measurement error to bias downward the coefficient on the employee-tax variable. In columns 2 through 7 this bias is eliminated by defining the employee-tax variable as the two-quarter change in $1/(1 - \tau_p)$, where τ_p is the effective personal income tax rate. This and the replacement of the nonfarm deflator by the deflator for nonfood business product net of energy are the only changes in specification in moving from column 1 to column 2. Each equation includes a constant term and a social security tax constraint, not shown in table 3.

14. See my "Wage-Price Controls," figure 1, p. 402.

Table 3. Structural Wage Equations and Extrapolation Errors, Alternative Variants[a]

Independent variable and regression statistic	Sample period and type of equation							
	1954:1-1970:4 Original equation		1954:1-1971:2				1954:1-1976:4	
					Output gap			
	As published in 1971 (1)	With revised data (2)	Original specification (3)	Constrained sum of coefficients on price (4)	Unconstrained prices (5)	Constrained prices (6)	Original specification (7)	Output-gap version (8)
Independent variable								
1. Unemployment dispersion	0.018 (2.3)	0.019 (0.86)	−0.009 (−0.39)	−0.016 (−0.86)	...	...	0.005 (0.25)	...
2. Disguised unemployment rate	−0.278 (−4.3)	−0.111 (−1.57)	−0.170 (−2.63)	−0.153 (−2.52)	...	...	−0.187 (−2.85)	...
3. Unemployment rate of hours	−0.086 (−1.0)	−0.133 (−2.34)	−0.162 (−2.79)	−0.043 (−0.78)	...	...	−0.144 (−2.78)	...
4. Output gap	...	...	...	...	−0.011 (−1.04)	−0.008 (−1.31)	...	−0.023 (−2.89)
5. Change in output gap	...	...	...	...	−0.069 (−2.71)	−0.063 (−2.70)	...	−0.055 (−2.14)
6. Change in consumption deflator	0.600[b] (4.0)	1.006[b] (8.67)	1.085[b] (11.55)	0.974[c] (6.69)	...	...	...	...
7. Change in product price minus consumption deflator	0.596[c] (2.8)	1.343[c] (5.41)	...	−0.220[c] (−1.55)	−0.067[c] (−0.38)	−0.035[c] (−0.27)	−0.110[c] (−0.87)	−0.103[a] (−0.80)

8. Change in product price	...	0.169 (3.3)	...	1.000[d]	1.136[e] (15.81)	1.000[d]	0.939[e] (16.95)	1.008[e] (22.06)
9. Change in employee tax rate	...	0.080 (1.24)	0.061 (0.96)	0.064 (1.08)	0.061 (1.03)	0.032 (0.54)	0.035 (0.72)	0.035 (0.74)
10. Dummy = 1.0, 1971:3–1972:4	...	...	...	...	...	...	0.331 (2.37)	0.312 (2.25)
11. Dummy = 1.0, 1974:2–1975:1	...	...	...	...	...	...	0.018 (0.06)	−0.012 (−0.04)
Regression statistic								
12. Standard error	0.261	0.278	0.275	0.271	0.263	0.267	0.299	0.303
13. Root mean-square error (1971–76)[e]	...	...	0.754 / 1.059	0.664 / 0.913	0.644 / 0.962	0.539 / 0.807	...	...
14. Cumulative error (actual minus predicted)[e]	...	...	−2.91 / −13.05	−1.30 / −7.03	−4.23 / −11.17	0.11 / −6.70	...	...

Sources: Column 1, Gordon, "Inflation in Recession and Recovery," table 1, equation 11; for the other columns the equations were reestimated using revised and extended data from the sources in ibid., pp. 155–58. See table 1 above for sources for revised national income accounts data. The gap variable is the same as table 2 above, line 7. The data used for the product-price variable are those for the deflator for private nonfood business product net of energy—that is, the dependent variable in table 2.

a. The dependent variable is the two-quarter rate of change in the private hourly earnings index. The numbers in parentheses are t ratios.

b. Lag coefficients estimated from an equation relating the nominal interest rate to past price change reported in "Inflation in Recession and Recovery," appendix A (cited in sources). This set of lag coefficients remains unchanged in columns 1 through 3.

c. The sum of a series of distributed-lag coefficients estimated by the polynomial-distributed-lag method, with details of estimation the same as in table 2. The lag length is eight quarters in line 7 and twelve quarters in line 8.

d. The sum of a series of twelve lag coefficients is constrained to equal 1.0.

e. The upper figure in each column is derived from an equation using the deflator for private nonfood business product net of energy. The coefficients reported in lines 1-11 for equations in columns 2–8 are all from equations using that deflator. The lower figure is derived from an equation using the deflator for private nonfarm business as the product price.

As in the case of the structural price equations, the postsample extrapolation errors of the wage equation are vastly larger than the in-sample standard error (lines 12 and 13 of column 3). Two separate extrapolations are performed; the lower figures in lines 13 and 14 result from using the nonfarm business deflator as the "product price" while the upper figures result from using the deflator of nonfood business product net of energy.[15] The cumulative overprediction given in line 14 is much higher when the nonfarm deflator is used. This is the first indication of a conclusion that emerges very strongly in this section: *none* of the 1973–74 inflation in food and energy prices "got into" wages, and all pre-1971 wage equations that allow any influence of food and energy prices drastically overpredict the cumulative 1971–76 wage increase.

Just as the postsample extrapolations of the structural price equation were superior when the sum of labor-cost coefficients was constrained to be 1.0, the extrapolations of the wage equation improve when the sum of the price coefficients is constrained to be 1.0. The constraint is introduced by changing the arrangement of the price variables. Since the result in column 3 indicates that only the product price "matters"— since the 1.085 coefficient on the consumption deflator in line 6 is virtually cancelled by the 0.974 coefficient on "minus" the consumption deflator in line 7—the product price is entered directly in line 8 with the sum of coefficients constrained to equal 1.0. Now the size of the coefficient on line 7 measures (with reverse sign) the separate influence of the consumption deflator; a coefficient of 0.0 would indicate that only product prices matter, and a coefficient of −1.0 that only consumption prices matter.

The constrained equation in column 4 fits the sample period slightly better than the unconstrained version does, and achieves a marked improvement in the postsample root mean-square error. The cumulative postsample overprediction is cut to slightly more than 1 percentage point when the deflator for nonfood business product net of energy is used as the product price. Nevertheless, the postsample performance is by no means perfect, as is clear in figure 2 from a comparison of the solid, "actual," line with the dotted line representing the postsample predictions of column 4. The equation underpredicts in 1972 and 1973. Although the similar underprediction in the four quarters prior to controls in 1970–71

15. The coefficients in columns 2 through 8 are based on the deflator for nonfood business product net of energy.

complicates the verdict, the performance suggests that the controls program did not reduce wage change at all; beyond that, wage change during the controls program did not even reflect the deceleration of prices. The other major error in the extrapolation is a substantial overprediction of wage change during 1975 and 1976. A possible interpretation of the pattern of these errors is presented below.

The strong evidence that product prices and not consumer prices matter suggests that the major determinant of wage behavior is the demand for labor by firms, not the needs of workers or union aggressiveness. That, in turn, raises the question of whether wage changes depend basically on demand conditions in the product market rather than exclusively in the labor market.

Considerable experimentation with lag structures suggests that the effect of the commodity market on wages can be represented by a pair of proxies for excess demand: (1) the gap between actual and potential output, and (2) the first difference in the gap (the same variable used in the price equation).[16] When the pair of output-gap variables replaces the three labor market variables of the original specification, the standard errors of estimate improve slightly (compare columns 3 and 5). The same holds true for a comparison of the respective versions with constrained price coefficients in columns 4 and 6. The postsample performance of the constrained output-gap version in column 6 is markedly better than that reported in column 4 by the criteria of both the root mean-square error and the cumulative error. When the product price is represented by the deflator for nonfood business product net of energy, the output equation in column 6 can track cumulative wage change between 1971 and 1976 to within 0.1 percent.

The output-gap equation in column 6 is remarkable in attributing virtually all of the impact of the demand for commodities on wages to the *change* in the output gap. The coefficient on the level of the output gap is

16. The output gap is equal to potential output minus actual output, with the difference divided by potential output. The level of potential output is a trend that equals actual output when unemployment equals the natural rate of unemployment. Details of the methodology for estimating the natural unemployment rate are contained in Robert J. Gordon, "Structural Unemployment and the Productivity of Women," in Karl Brunner and Allan H. Meltzer, eds., *Stabilization of the Domestic and International Economy,* Carnegie-Rochester Conference Series on Public Policy, vol. 5 (Amsterdam: North-Holland, 1977), pp. 181–229.

so small, and so weak statistically, that it plays only a trivial role, implying that an economy with output gaps of 6 percent and −6 percent would have almost exactly the same rates of wage inflation, given the rate of price inflation. This implication of the output-gap version in column 6 conflicts with the vast body of previous research, including the original specification in columns 1 and 4, in which the dominant labor market variable is disguised unemployment, which tends to be correlated more with the *level* of total unemployment than with its rate of change.

Finally, in constructing table 3, I extended the sample period of the wage equations to the end of 1976. Results for the unconstrained versions are shown in columns 7 and 8. Dummy variables for the controls are included in the equation for the same time intervals as in table 2, and imply not only that controls in 1971–72 did not hold down wages, but that wages increased *more* than would have been expected in light of the moderating impact of the controls on price inflation. The improvement in fit in the extended version with the original specification is evident in the contrast between the dotted and dashed lines in figure 2. At the cost of only a slight deterioration in the tracking of wage change in 1969–71, the extended equation is able to cut drastically the overprediction of wage change in 1975.

Other than the inclusion of dummy variables, the main difference in the extended equation in column 8 is a marked increase in the absolute value of the coefficient on the level of the output gap. The recession appears to have been more effective during 1975–76 in holding down wage change than would have been predicted from the sample period ending in 1971:2. The output-gap equations estimated for the 1954–71 period tend to exhibit a relatively flat short-run Phillips curve, because of the influence of the rapid wage change during the recession of 1970–71. Equations estimated to the full 1954–76 period display a higher coefficient on the level of the output gap, reflecting the reduced rates of wage change in 1975–76. The same contrast is evident in a comparison of the coefficient on the unemployment of hours in columns 4 and 7, the two equations that are plotted in figure 2. Is it the 1970–71 period that should be considered the outlier, or 1975–76? Some previous research suggests an unusual spread in 1970–71 between union and nonunion wage change which may be associated with the timing of union negotiations over the 1967–71 period. Based on this evidence, I tend to favor the interpretation that the 1970–71

Figure 2. Actual and Predicted Change in Adjusted Hourly Earnings Index Using the Specifications of the Structural Wage Equations, 1969–76

Annual rate of change in percent
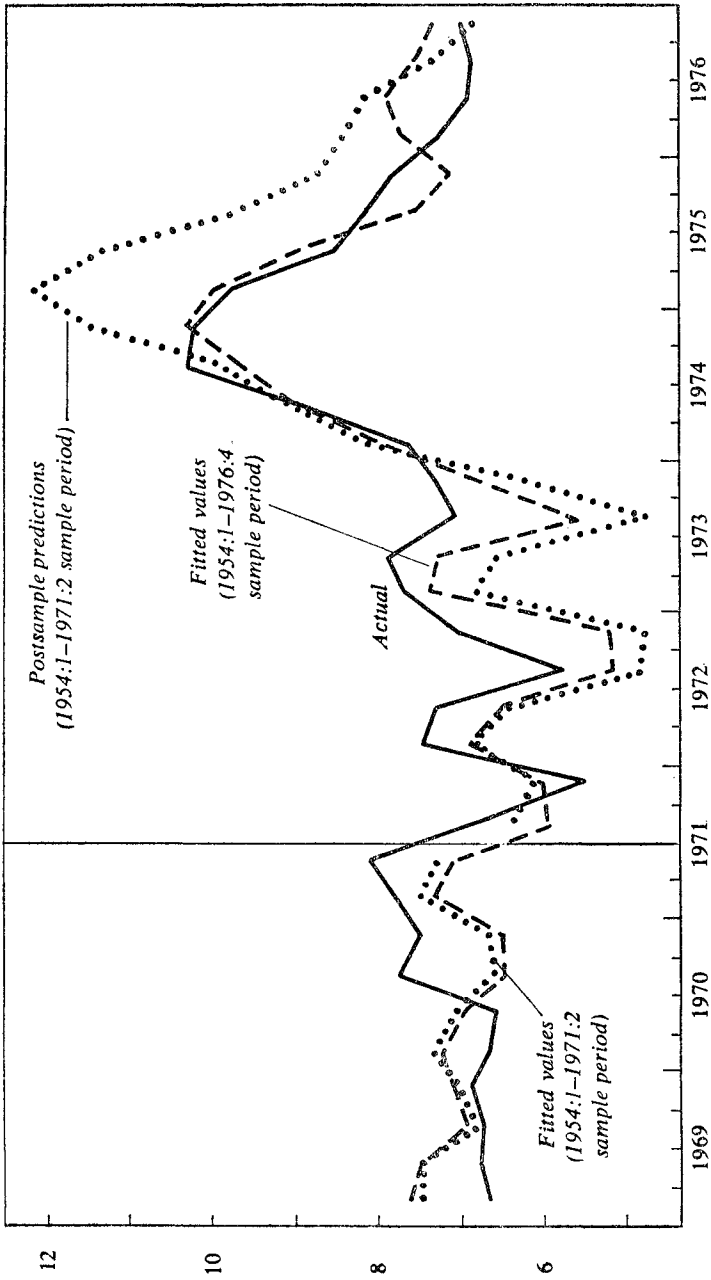
Sources: Actual, see table 3 sources; predicted and fitted, table 3, columns 4 and 7.

period was unusual, and hence to prefer the coefficients in the extended equations in columns 7 and 8.

Some authors have developed models of wage-setting behavior in which wage change depends not on price change, as in table 3, but only on the past behavior of wages. While it is plausible to argue that both firms and workers base wage changes on wage changes recently granted to comparable employees in other firms or industries, both theory and the data decisively support a role for price change.[17] When a distributed lag on past changes in wage rates is substituted for price change in the 1954–71 period, using the specification of column 5 in table 3, the sum of squared residuals *triples*. For the longer 1954–76 period, the sum of squared residuals rises by 59 percent. Further, the pattern of residuals indicates that the "wage-wage" version cannot explain any of the acceleration of wage change between 1973 and 1974.
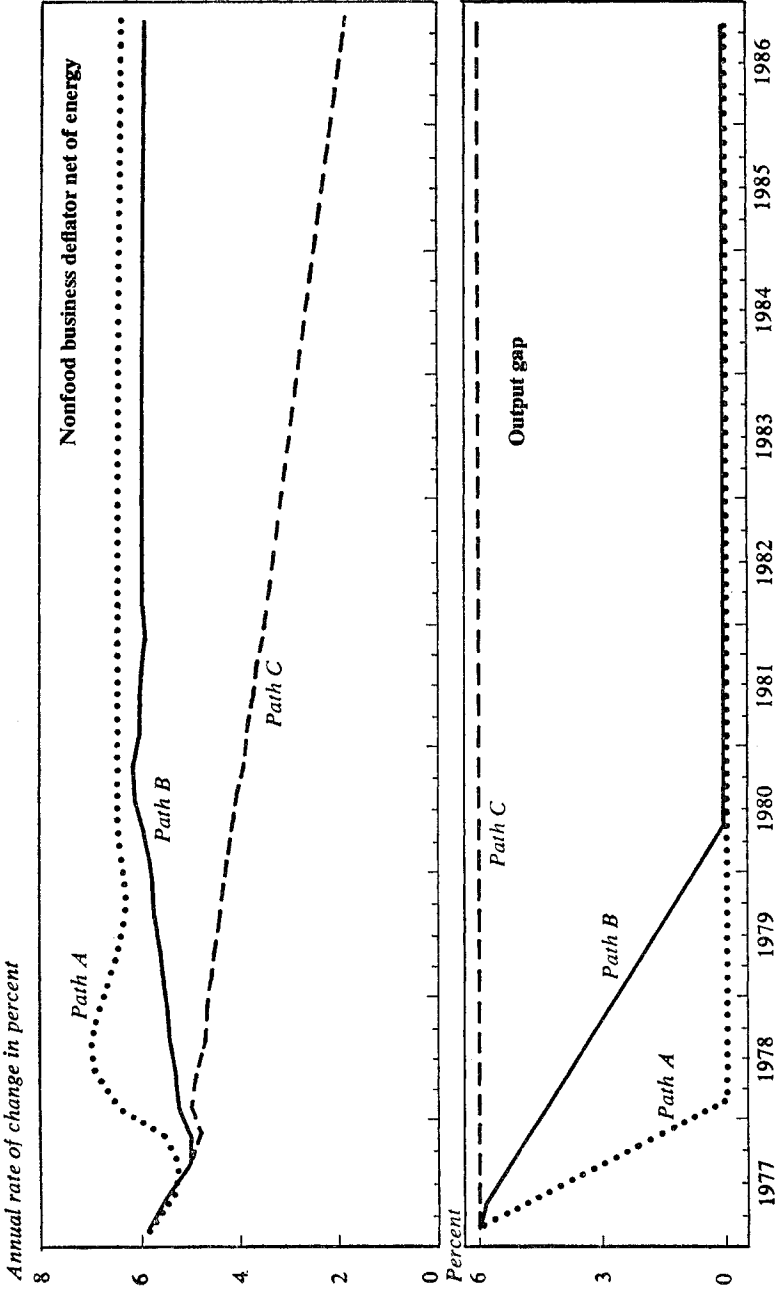
Policy Simulations

A dynamic simulation of the wage and price equations, which allows for the effects of wages on prices and prices on wages, provides an assessment of the inflationary implications of alternative paths of economic recovery and of the required duration of a "stable prices at any cost" policy that *prevents* recovery and maintains today's output gap.

Policy simulations with a two-equation wage-price model have both disadvantages and advantages as compared to simulations using the large-scale forecasting models. The main disadvantage is that the specification must be restricted to rely (largely if not entirely) on a single exogenous variable—for example, the output gap—which "drives" the simulation. Offsetting advantages are that the simulation results may be more easily studied, interpreted, and understood, and that the equations that underlie the simulations are similarly "open for inspection."

The policy simulations derive alternative paths of inflation in the nonfood sector net of energy implied by alternative exogenous paths of the output gap. Since relative energy prices are likely to rise over the next few years, the corresponding paths for the GNP deflator would all lie above that presented in figure 3.

17. See particularly Robert E. Hall, "The Process of Inflation in the Labor Market," *BPEA, 2:1974,* pp. 343–93, and my criticisms of that paper, pp. 394–99.

Figure 3. Inflation Implied by Various Paths of Output, 1977:1–1986:4

Annual rate of change in percent

Nonfood business deflator net of energy

Path A

Path B

Path C

Output gap

Path C

Path B

Path A

Percent

Because the previous analysis leads to the conclusion that the extended-period price equation contains a more plausible lag pattern on trend unit labor cost, and that the steeper Phillips curve in the extended-period wage equation is likely to be more accurate, the simulations presented here are based on the price equation in table 2, column 7, and the wage equation in table 3, column 8. The wage equation that uses the output gap rather than the unemployment variables of the original specification is employed to avoid the problem of creating equations that link those unemployment variables to the output gap.

Tax rates were all assumed to remain unchanged at their values in 1976:4, and the change in the relative prices of capital and consumption goods was set equal to zero in all simulations. Simple equations were developed to relate changes in materials prices and the change in the productivity deviation to the change in the output gap. Further adjustments were made to ensure that the inflation rate would neither accelerate nor decelerate when the output gap was zero. To obtain this result in dynamic simulations, it is not enough to constrain the sum of coefficients on wages in the price equation, and on prices in the wage equation, to be equal to 1.0. Three other important restrictions must be imposed: First, the trend rate of productivity growth in the price equation must be set equal to the constant term in the wage equation. This switch, from 1.96 to 2.13 percent annually, is small enough to be acceptable and within the range of the standard error in the equation originally used to estimate the productivity trend. Second, the growth rate of the wage variable in the price equation must equal that of the wage variable in the wage equation. Third, there must be no change in relative materials prices.

Figure 3 corresponds to these assumptions and displays three combinations of inflation and unemployment. Path A is an implausibly rapid recovery that reduces the output gap from its 6.2 percent rate at the end of 1976 to zero by 1978:1. At first inflation is predicted to slow down moderately, benefitting from the lagged influence of low rates of change in wages and prices in 1976, but then an acceleration begins. The "rate of change" effects of a rapidly falling output gap push inflation close to 7 percent in late 1978, followed by an adjustment to the long-run "steady state" rate of 6.4 percent.

A slower recovery, path B, reaches a zero gap in 1980 (the quarter before the next presidential election), rather than in early 1978. Slower growth has both transitory and permanent benefits. Inflation is lower by

as much as 1.3 percentage points at an annual rate in late 1978, and the long-run "steady state" rate of inflation is 0.4 point slower.[18]

Since path B corresponds most closely to the recovery path apparently desired by the Carter administration, this "optimistic" simulation conflicts with the administration's avowed aim of reducing unemployment while simultaneously achieving a deceleration of inflation to 4 percent. Even on the optimistic assumption of zero change in relative energy and food prices, the administration's policy goals are inconsistent.

The third alternative in figure 3, path C, shows the rate of deceleration of inflation that would obtain if the output gap were held permanently at 6.2 percent. The inflation rate would fall rapidly during 1977, reflecting the delayed impact of the lower-than-predicted actual rates of wage and price change during 1976. Subsequently, a further modest slowdown of inflation would occur, beginning with a 0.24 percentage point drop in the inflation rate in 1978, widening to a deceleration of 0.36 percentage point per year in 1986. This turtle-like deceleration of inflation reflects the extremely weak effect of a high output gap on wage behavior, and the absence of any effect of a maintained gap on price behavior.

In my own judgment, the assumptions underlying the simulations reflected in the figure lean toward the optimistic side. First, as noted above, they ignore the prospect of rising relative prices of energy over the years ahead. Second, they assume no upward trend in relative materials prices, in contrast with the actually observed trend of 2.0 percent a year for 1963–76 (adjusted to a constant output gap). Third, they assume that compensation per manhour and average hourly earnings will grow at equal rates, when in fact the former has outpaced the latter by 0.3 percentage point a year on average since mid-1971. If that trend were assumed to continue, it would put added upward pressure on the price equation for any path of average hourly earnings predicted by the wage equation. Alternative, more pessimistic, assumptions could easily add 1 to 2 points to the inflation rate by 1980 and as much as 3 to 4 points by 1986.

18. As an example of a more optimistic conclusion, a "control solution" recently published by Data Resources, Inc., predicted that the economy could reach 5.5 percent unemployment in 1980, a path roughly equivalent to my path B, with only a 5.4 percent change in the GNP deflator in 1980. See Otto Eckstein and others, *Economic Issues and Parameters of the Next 4 Years* (Data Resources, Inc., 1977), table 6, p. 30, solution "CONTROL1229."

Conclusion

All approaches fail to explain the increased variance of inflation during 1971–76 as compared to the pre-1971 period. But overall, the *cumulative* amount of inflation since 1971 can be explained—even overexplained —by established econometric procedures. Both the structural price and the structural wage equations can track the cumulative change in the prices of nonfood business product net of energy and in wages to within a percentage point, once they incorporate the sensible constraint that sums of coefficients of prices on wages and wages on prices equal unity.

The analysis of this paper leads to the following interesting conclusions.

First, the short-run Phillips curve relating wage change to unemployment or the output gap may well be steeper than implied by equations estimated for sample periods ending in 1971. While this result helps to explain why wage changes were so moderate in 1976, it implies that a rapid economic recovery may bring about a greater acceleration in inflation than some commentators appear to anticipate.

Second, the speed of recovery matters, in both the price and the wage equations. It is the rate of change of the output gap that influences the rate of change of prices relative to wages, and there is also a partial impact from the speed of the change in output in the output-gap version of the wage equations.

Third, the ability of product prices and the output gap alone to explain wage behavior suggests that the demand for labor by firms is the main determinant of wages, and that autonomous actions or reactions by workers have little impact.

Fourth, as in previous papers, I conclude that price controls worked temporarily, with a decline in the price level followed by a rebound, but that wage controls had if anything a perverse effect. Why the effectiveness of the controls program should have been limited to prices is a puzzle that others may be better able to answer. The implications for wage guidelines or jawboning are not reassuring.

Fifth, none of the increases in food or oil prices in 1973–74 appears to have been incorporated into wages. In the context of my previous study of supply shocks, this implies that policymakers could have stimulated nominal income growth to accommodate some of the effect of food and oil prices without setting off an endless inflationary spiral. But the strong

demand effects exhibited in the equations of this paper suggest that such a policy of accommodation would have substantially lessened the deceleration of inflation between 1974 and 1976.[19]

Sixth, perhaps most important, the outlook for inflation is rather grim. Despite the continuing output gap, the statistical evidence presented above indicates that any further deceleration in inflation is highly unlikely. On the contrary, it points to the probability of some acceleration as the economy continues its recovery. While the extent of that acceleration will depend on the speed of the recovery, inflation rates of 6 or 7 percent seem likely for the next several years, compared with the 5 percent rate during 1976. Any serious effort to eliminate inflation through demand restraint would be exceedingly costly; a strategy of maintaining the late 1976 output gap might bring the inflation rate down to 2 percent by the mid-eighties, but only through a loss of output that would substantially exceed $1 trillion.

Finally, as a corollary to this unpleasant verdict, the recovery itself is likely to require a maintained growth of monetary aggregates above rates that now seem acceptable to the Federal Reserve, in order to finance an annual growth of nominal gross national product of 12 or 13 percent during the rest of the decade. How the makers of monetary policy will react to this dilemma remains to be seen.

Discussion

SEVERAL participants commented on the substantial differences between the coefficients in the price and wage equations fitted through 1971 and those for the period as a whole. They questioned the stability of the underlying structure in light of these changes. George Perry noted, in particular, the much greater role played by the level of the output gap in the full-period estimate of the wage equation. Franco Modigliani cautioned against drawing the inference that consumer prices do not matter on the

19. A hypothetical accommodative policy that maintained the output gap at zero in 1974–76 would have caused substantial extra inflation, reaching a peak in mid-1975 of 3.8 percentage points over that which actually occurred, and then tapering off to an excess of 2.0 percentage points in late 1976. This conclusion is based on a dynamic simulation of the same equations as are used in figure 3.

basis of revised data and updated equations when the earlier evidence suggested otherwise.

Arthur Okun remarked that path C in figure 3 implied extremely asymmetrical effects of excess demand and excess supply. According to the simulation, it takes a 6 percent GNP gap for a whole decade to eliminate an inflation rate that resulted from much smaller excesses over potential in the past. Yet there is no nonlinearity in the equations used for that simulation. Gordon responded that the apparent asymmetry resulted from the contribution to inflation in the past of variables other than excess demand—particularly tax rates and materials prices—which are artificially held constant in the simulations of figure 3. Perry commented that over the years growing awareness of inflation may have caused the price effects on wages to rise, in line with Michael Wachter's analysis of a shifting Phillips curve. Okun suggested that any advocate of extreme demand restraint would have a far more optimistic view than path C, relying on a "hawkish" policy stance to reverse inflationary expectations. He reminded the group that William Fellner had developed that line of argument in detail.

Pentti Kouri was somewhat surprised to see that such a small role was assigned to consumer prices in U.S. wage behavior during the recent period, unlike other industrial countries. In the United Kingdom and Italy, in particular, deteriorations in the terms of trade had induced wage demands aimed at sustaining previous real wage levels. Perry recalled, however, that in his research on European wage behavior he had found that value-added and wage-wage effects dominated those of consumer prices. Modigliani disagreed with Perry over the importance of consumer prices, especially in the case of Italian wage behavior. Wachter suggested that food and fuel inflation might have ultimately gotten into wages in the United States if not for the severity of the recent recession. He found it quite plausible that price feedbacks on wages interact with demand conditions.

Edmund Phelps believed that the nonfood nonfarm deflator may have performed better than the consumer price index because the former is a proxy for lagged wage changes. He would prefer to see a lagged wage term used instead of prices; he felt that, on theoretical grounds, the appropriate variable is the expected rate of wage change, which should have a coefficient of unity given labor demand and supply. Gordon reported, however, that in tests he conducted lagged prices performed better than

lagged wages. Christopher Sims expressed some amusement that the best wage equation had no labor market variables in it. This result conformed with his belief that wage and price equations cannot be distinguished as applying to different categories of behavior. It was preferable to consider them as interesting statistical reduced-form summaries of the dynamic relationships among the variables.

Wachter found it implausible that disguised unemployment, which is composed largely of marginal workers, could exert the major influence on wage changes attributed to it by Gordon's wage equation. He also observed that the small demand effects in the early price equations meant that together the wage and price equations formed an almost purely autoregressive system, in which prices and wages fed upon each other without being influenced significantly by demand.

Gordon supported Sims' interpretation that the wage and price equations represented reduced-form summaries of dynamic relationships. Many different variables shared the major cyclical movements of the sample period, preventing statistical discrimination among finely differentiated hypotheses. As Gordon saw Wachter's criticism of the disguised unemployment variable, it attempted to place a structural interpretation on a variable that simply represented a generalized demand effect and that performed no better or worse than the output gap, an alternative proxy. Gordon concluded that, even when the wage and price equations were viewed as reduced forms, several conclusions emerged strongly, particularly the important role of inertia in the wage-price process, and of the *rate of change* of output. On the other hand, no confidence could be placed on the impact of the *level* of output without an informed judgment on unusual aspects of the 1970 and 1973–75 recessions.