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5

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Price and Wage Behavior in the U.S. Aggregate Economy and in Manufacturing Industries

INTRODUCTION

The American economy is in the midst of both a price and a cost inflation of unprecedented magnitude. The causes of these developments are diverse and of unknown power. Substantial increases in the growth of money supply, federal budget deficits, large wage and price settlements, food and fuel price increases, and the prevailing state of expectations about price and wages, among other forces, have been suggested as reasons for the recent inflation. To ascertain the specific roles played by these factors and by certain policy variables, an examination of the behavior of wages and prices at the aggregate and disaggregate industry level is undertaken. The questions we are particularly interested in are:

1. What is the direct response of prices to changes in aggregate demand and to increases in cost factors?
2. Do individual industry prices respond to changes in aggre-

gate demand or are they influenced by industry-specific demand?

3. In contrast to the role of wages, what is the role of the rental price of capital services and of materials prices in determining prices?
4. What is the effectiveness, if any, of government controls in restraining increases in wages and prices?
5. What is the impact of the long-term factors in the commodity and labor markets in contrast to short-run disequilibrium forces?

The policy implications of these questions are very important in designing effective counterinflationary policies. To answer some of these questions, we have constructed a model of price and wage behavior that combines the long-run factors responsible for shifts in equilibrium supply and demand schedules and the short-run disequilibrium forces in the commodity and labor markets. This model is used to estimate price and wage behavior of five aggregates—total economy, private nonfarm, total manufacturing, total durables, and total nondurables—and twelve two-digit manufacturing industries. The data are seasonally adjusted quarterly time series. The estimation period chosen is 1954I–1971II; and for the five aggregates, the period 1971III–1973II is used to test the predictive power of the model beyond the sample period and to assess the effects of the recent controls on wages and prices.

The model is specified in section I. In section II, the econometric specification of the model and the nature of the data are described. In section III, the estimates of the model for the five aggregates are analyzed and their contrasting features are noted. The results for the disaggregate industries are presented and discussed in section IV. The dynamic simulation results for price and wage rates of the aggregate sectors for both the sample and forecast periods are reported in section V, and the effects of recent controls on wage and price behavior are also examined in this section. The summary and conclusions are contained in section VI.

I. SPECIFICATION OF THE MODEL

Assume a Cobb-Douglas production function (1) and a log-linear demand function (2)

(1) $$Q^s = AL^{\alpha_1}M^{\alpha_2}K^{\alpha_3}e^{-\lambda t}$$

(2) $$Q^d = BP^{-\beta_1}Y^{\beta_2}S^{\beta_3}$$

where Q^s and Q^d are the quantity produced and demanded; L, M, and K are labor, raw materials, and capital inputs; α_1, α_2, α_3 are the output elasticities of the inputs; and λ is the rate of technical change. P is the output price, Y is total expenditure, S is the price of other goods; β_1, β_2, β_3 are the price, expenditure, and cross elasticities of demand, Q^d. Assuming that the firm maximizes profit, the long-run equilibrium price P^* is determined by (3):

$$(3) \qquad P^* = \theta_0 W^{\theta_1} V^{\theta_2} C^{\theta_3} Y^{\theta_4} S^{\theta_5} e^{\theta_6 t}$$

$$\theta_1, \theta_2, \theta_3, \theta_4 > 0; \theta_5 \lesseqgtr 0; \theta_6 < 0$$

where W, V, C are the wage rate, price of raw materials, and rental price of capital services; $\theta_1, \ldots, \theta_6$ are constants.[1] According to (3), increases in factor costs and demand will contribute positively to a price increase; gains in productivity due to technical change will lower prices; and an increase in the price of other commodities may lead to an increase or decrease in the output price, depending on whether they are complementary or substitute products.

The long-run supply of and demand for labor determine the optimum money wage rate and the level of employment. A vast literature on employment demand and labor supply functions is available.[2] It would be useful to specify and estimate structural equations for demand for and supply of labor and solve the reduced form equations explicitly. However, here we shall consider the following reduced form equation

$$(4) \qquad W^* = \varphi_0 P_C^{*\varphi_1} \left(\frac{Q}{L}\right)^{*\varphi_2}$$

where P_C^* is the expected price of goods purchased by the workers; $(Q/L)^*$ is long-run average productivity; and φ_1 and φ_2 are elasticities of money wages with respect to expected price and productivity.[3]

Relations 3 and 4 are subject in the short run to disequilibrium forces prevailing in the goods and labor markets. For example, changes in demand for goods may increase or decrease prices, depending on whether excess capacity is present; in the labor market, changes in the unemployment rate or in workers' expectations may influence the short-run course of wage rates. It is also likely that the disequilibrium in one market spills over and generates adjustment in the other market. Government policies such as guideposts and controls, though aimed at correcting some of the existing disequilibriums, may generate some disturbances of their own.

The primary function of these market disequilibrium factors is to modify the moving equilibrium conditions in the commodity and labor markets. Even accounting for these factors, the goods and factor markets may not clear because of search costs, institutional barriers, and so on, which will delay the adjustment of wages and prices to their equilibrium.[4] Combining the market disequilibriums with a simple geometric adjustment process, we obtain the following short-run price and wage equation:

(5) $$P_t/P_{t-1} = (P_t^*/P_{t-1})^{\lambda_1}(U_i)^{\gamma_i} \qquad (i = 1, \ldots, n)$$

(6) $$W_t/W_{t-1} = (W_t^*/W_{t-1})^{\lambda_2}(U_j)^{\gamma_j} \qquad (j = 1, \ldots, m)$$

where P^* and W^* are the equilibrium price and wage rate defined by (3) and (4), λ_1 and λ_2 are the adjustment coefficients, and U_i and U_j are the short-term forces operating in each of the markets. Note that U_i and U_j do not influence P^* and W^* directly. Instead, they modify the rate of adjustment of prices and wages. Guidepost policies and controls can also be considered as part of U_i or U_j.[5]

II. ECONOMETRIC SPECIFICATIONS AND NATURE OF THE DATA

Specification of the Estimating Equations

Before stating the final estimating equations, several specification problems must be considered:

1. The relevant cost variables influencing prices are the *expected* levels of wages, materials price, and user cost; the appropriate demand variable is also the *expected future* level of expenditures. After examining several alternatives, it became clear to us that current factor prices were fairly good representatives of their future values, while a distributed lag of past expenditures seemed to be a good proxy for expected future spending.
2. The most promising short-run variable in the goods market turned out to be either capacity utilization or deviation of productivity from its trend. There were several short-term forces in the labor market, including the level of the unemployment rate or its rate of change, productivity changes, and changes in the consumer price index as a proxy for short-term expectations.
3. The price of substitute goods (S) as a determinant of commodity price was used initially but excluded in further testing of the model since it did not yield satisfactory results.

4. We have not employed any techniques, such as conversion of variables to moving averages, that inevitably improve the goodness of fit of the equations at the cost of introducing or increasing serial correlation. In fact, the Cochrane-Orcutt technique was used whenever evidence of serial correlation was found.
5. To explore the possibility of simultaneous equation bias in the estimating equations, the current wage rate was replaced by its lagged value in the price equation; and current price, by lagged price in the wage equation. Except for some minor changes the results remained the same.[6] The simultaneity issue, however, needs further consideration, especially since movements of other factor costs such as materials prices and the rental price of capital are likely to be endogenous in a complete price-cost model.

The estimating equations based on the above assumptions are the following; both are log-linear:

$$p_t = a_0 + a_1 w_t + a_2 v_t + a_3 c_t + a_4 T + a_5 u_{ct} + a_6 y_t^e + a_7 p_{t-1} + \epsilon_1 \tag{7}$$

$$w_t = b_0 + b_1 p_t + b_2 T + b_3(\rho - \bar{\rho}) + b_4 u_t + b_5(p_{t-1} - p_{t-2}) + b_6 D_1 + b_7 w_{t-1} + \epsilon_2 \tag{8}$$

where $a_1, a_2, a_3, a_6, a_7 > 0$; $a_4, a_5 < 0$; and $b_1, b_2, b_3 > 0$; $b_4, b_6 < 0$; $b_5, b_7 > 0$. All the lower-case variables are in logs. w, v, and c are the factor cost variables defined earlier, y_t^e is a proxy for the expected level of spending, u_c is the capacity utilization variable, u_t is a proxy for prevailing unemployment conditions; D_1 is the guidepost dummy; and T is the time trend depicting long-run productivity growth; $(\rho - \bar{\rho})$ is the deviation of productivity from its trend value, $\bar{\rho}$; and ϵ_1 and ϵ_2 are the stochastic error terms.

Several features of these equations must be noted:

1. Though prices and costs are two facets of the same inflationary process, a distinction should be made between price and wage inflations. Fundamental causes of each one need to be identified. Therefore, we consider prices to increase initially in response to changes in expected spending, y_t^e, which, in turn, can be related to changes in the stock of money supply or fiscal measures.[7]

2. A full statement of the cost factors that affect price behavior is provided. Unlike most other work on price equations, our model includes materials prices and the rental price of capital in addition to the labor cost and demand variables.

3. Moreover, factor costs and productivity terms are introduced separately, with the result that the data determine whether or not

the contribution of wages is the same as that of productivity. Short- and long-run productivity variables are explicitly included in both price and wage equations.

4. Equations 7 and 8 are formulated in level forms, in contrast to formulations in studies that are concentrated on the rate of change of wages and or prices. Most of the Phillips-type studies are disequilibrium models of the commodity and labor markets aimed at explaining changes in wages and prices around their assumed stationary equilibrium paths. They imply that in the absence of any excess demand, changes in wages or prices will be zero (see Agrawal et al. 1972, for further discussion of this point). However, wages and prices may change due to a moving equilibrium of the supply and demand schedules in those markets. By including both the short- and long-run factors, equations 7 and 8 provide a framework for analyzing the influence of short-term variables in the presence of long-run factors. Also, there is an inherent relationship between the level and first-difference form. The decision to use one or the other is a hypothesis that can be tested (see Bischoff 1969 and Rowley and Wilton 1973 for further discussion). We can predict rates of change of wages and prices from equations 7 and 8 and compare them with the predictions of standard wage and price models.[8]

5. In the labor market, unemployment conditions serve as a disequilibrating force. The level and often the rate of change of the unemployment rate may serve as proxies for these conditions. Note that the relationship between the unemployment rate (or its rate of change) specified in equation 8 is quite different from that postulated in Phillips-type studies. A dynamic Phillips relation is implied in equation 8, where the percent wage rate is related to the *percent* change in the unemployment rate (see Kuh 1967 for further discussion of this subject).

6. The state of expectations is of critical importance in determining price and wage behavior. Formulating the process that generates expectations and identifying the precise magnitudes of the parameters that govern this process are important areas of research.[9] Lack of suitable data on expectations has been a particular difficulty in assessing how prices and wage rates are modified in different expectational environments.

After considering several expectations hypotheses we assumed that expectations affect prices directly through the expected spending decisions depicted by y_t^e and indirectly through their effects on wages. In the wage equation two alternative hypotheses were considered for the effect of short-run price expectations: an extrapolative hypothesis and the Eckstein-Brinner threshold hypothesis (see Eckstein and Brinner 1972 for detailed information on these concepts). The extrapolative hypothesis is of the simple log-linear form:

(9) $$\hat{p}_c^e = \alpha_0' + \alpha_1 p_{ct} + \alpha_2(p_{ct-1} - p_{ct-2})$$

i.e., expected consumer prices depend on actual prices prevailing in the current period and price changes over the two previous quarters. The threshold hypothesis is formulated as

(10) $$D_3 = \frac{p_{ct-1} - p_{ct-9}}{p_{ct-5}}$$

$$D_3 = 0 \text{ if } [(p_{ct-1} - p_{ct-9})/p_{ct-5}] \leq 0.05$$

$$= \frac{p_{ct-1} - p_{ct-9}}{p_{ct-5}} - 0.05 \quad \text{otherwise.}$$

In the long run, $p_{ct-1} - p_{ct-2}$ and D_3 will be zero; therefore, they are of interest only in the short run.[10]

7. Guidepost dummy D_1 is introduced in the wage equation to capture the effects of the Kennedy and Johnson administrations' attempts to restrain wage and price increases in 1962–1964. It is assumed that D_1 affects prices indirectly through the wage variable (when D_1 was included in the price equation, its coefficient was either statistically insignificant or had an incorrect sign).

The Nature of the Data

The data used in this study are all seasonally adjusted quarterly time series obtained mostly from published sources. In some cases, new industry-specific data have been constructed from different sources. A brief description of the data is given below.

1. The price series used for the aggregate economy and for the total private nonfarm sectors are the GNP deflator and the implicit price deflator for gross product for nonfarm business sectors. They are seasonally adjusted, with 1967 = 1.00, and are taken from U.S. Department of Commerce, *National Income and Product Accounts of the United States*, 1929–1965, and from various issues of the *Survey of Current Business* (SCB). The output price series for the manufacturing industries are from U.S. Department of Labor, *Wholesale Prices and Price Indexes* and are converted to the base

1967 = 1.00. For dissagregate industries, price series were obtained by weighting BLS price series by 1967 sales data.

2. The employment, hours, and wage data are all from BLS, *Employment and Earnings* (1972) and various issues of the *Survey of Current Business*. Two types of wage variable were used: seasonally adjusted average hourly earnings of production workers (W), and straight-time hourly earnings of production workers (W_1); the latter excludes overtime wages. The overtime factor was derived from overtime hours data (published in *Employment and Earnings*) on the assumption that overtime wages equal 1.5 times straight-time wages.[11] For the aggregate and nonfarm private economy a wage series (W_2) excluding the effects of both overtime and industry mix was also constructed, using the method described by Gordon (1972b).

3. The materials prices used for the two aggregate sectors were the wholesale price index for crude materials for further processing, published by the BLS in various issues of the *Wholesale Prices and Price Indexes*, and the implicit price deflator for the product of the private business farm sector, published in the national income and product accounts and in various issues of *Survey of Current Business*. For total manufacturing, total durables, and total nondurables, the materials price is the wholesale price index for intermediate materials, from *Wholesale Prices and Price Indexes*. For the two-digit industries, the materials prices were those constructed by Eckstein and Wyss, which they made available to us.[12]

4. The rental price of capital (c) is constructed according to the formula stated in Hall and Jorgenson (1967):

$$c = [(1 - k)(1 - \omega z)/(1 - \omega)]\, p_k\, (r + \delta)$$

z, the present value of depreciation, depends upon r, τ, and the depreciation method used. For the private nonfarm economy, z is a weighted average of present values based on straight-line depreciation and accelerated depreciation methods. For the manufacturing industries, accelerated depreciation was used starting in 1954I. δ is the constant depreciation rate for each industry, taken from Hall and Jorgenson (1967) for the aggregate economy and from Jorgenson and Stephenson (1967) for manufacturing industries. τ is the lifetime of capital for tax purposes based on U.S. Treasury Department (1962). k is the rate of tax credit, equal to 0.05 for the private nonfarm economy, and to 0.037 for the manufacturing industries. The measure of r, the rate of interest, is 1.5 times the AAA corporate bond yield for the aggregate economy and the AAA corporate bond yield as given for the manufacturing industries. This was obtained from various issues of the *Federal Reserve Bulletin*. The price of capital goods is the implicit deflator for gross domestic fixed investment, from U.S. Department of Commerce, *U.S. National Income and Product Accounts, 1929–65*, and subsequent July issues of the *Survey of Current Business*. For the aggregate economy, the same source was used to obtain the implicit price deflators for structures and equipment, and the resulting rental price series for structures and equipment were combined into a weighted average. Differences in the rental prices for various manufacturing industries are due only to varying assumptions of depreciation rates.

5. The utilization rate for the aggregate economy is the Wharton index of capacity utilization for manufacturing, mining, and utilities, from the *Wharton Quarterly*. The utilization indexes for the manufacturing industries are all Wharton's specific-industry utilization rates, which were made available to us. All the utilization rates are seasonally adjusted and are on the base 1967 = 1.00. The methodology of constructing this series is described in Klein and Preston (1967).

6. The productivity variables are constructed as follows: the index of current productivity (X/MH) is defined as the index of output per man-hour and was derived as the ratio of the Federal Reserve index of industry production (X) (from the *Federal Reserve Bulletin*) to an index of man-hours (MH). The latter was constructed for the aggregate sectors and the manufacturing industries as the product of the number of persons employed and the average number of hours worked by production workers. The employment and hours data were obtained from *Employment and Earnings* (1972).

The trend productivity variable was derived by regressing output per man-hour on a linear trend; $\rho = \ln (X/MH)$ and $\bar{\rho} = \ln (\overline{X/MH})$, where X/MH and $\overline{X/MH}$ are the actual and fitted values of productivity per man-hour.

7. Four different unemployment rates were obtained from *Employment and Earnings* (1972). All the data—the unemployment rate for all civilian workers (u_t), for total manufacturing (u_m), for total durables (u_d), and for total nondurables (u_n)—are seasonally adjusted unemployment rates of wage and salaried workers. For the two-digit industries, industry-specific unemployment rates are not available; therefore, we used u_d in the wage equations for the durable industries and u_n in the wage equations for nondurables.

8. Total spending (Y_{t-1}) is lagged GNP in current dollars, from *National Income and Product Accounts* and various issues of the *Survey of Current Business*. y_t^e is the distributed lag of the logarithm of Y_{t-1}.

9. P_c is the seasonally adjusted deflator for personal consumption expenditures (1967 = 1.00), from *National Income and Product Accounts* and various issues of the *Survey of Current Business.*

10. Dummy variable D_1, for the wage-price guidelines of 1962–1967, is constructed following Gordon (1967a). It rises by stepwise increments of 0.25 from zero in 1962I to 1.0 in 1962IV. It remains at 1.0 until 1966IV, and then declines in steps of 0.25 to zero in 1967IV.

11. The variable for inflation severity, D_3 is constructed following the Eckstein-Brinner formulation noted earlier. As indicated, it is equal to the positive excess over 5 percent of the eight-quarter rate of change of the consumer goods deflator. It is equal to zero as long as the eight-quarter rate of inflation is less than 5 percent for two consecutive years.

III. ESTIMATION RESULTS FOR THE TOTAL ECONOMY AND AGGREGATE MANUFACTURING INDUSTRIES

The price and wage equations (7 and 8) were estimated using seasonally adjusted time-series data for the total economy, the total private nonfarm sector, the total manufacturing sectors, total durables, total nondurables, and the twelve manufacturing industries listed by SIC number and name in Table 5, note a. The sample period chosen was 1954I–1971II. The cutoff date was 1971II in order to assess the effects of new economic controls initiated in August 1971. For the period 1971III–1973II, forecasts of price and wage changes were obtained for the five aggregate sectors and industries, using their estimated coefficients. Postsample forecasts could not be made for the disaggregate industries because of data limitations; limitations of data and time also prevented us from extending our forecasts for the aggregates to 1974.

Prices and Wages of the Aggregate Sectors and Industries

Price Equations

The estimates of the aggregate price equations are reported in tables 1 and 2. The difference between the two tables is that the lagged dependent variable (p_{t-1}) is excluded in Table 2. Inclusion

TABLE 1 Price Equations for Aggregate Sectors[a] (sample period: 1954 I–1971 II figures in parentheses are t statistics)

Independent Variables	Aggregate Economy (1)	Private Nonfarm (2)	Total Mfr. (3)	Total Durables (4)	Total Non-durables (5)
c_0	−0.3488	−0.3340	0.0248	0.5073	−0.3691
	(4.485)	(3.605)	(0.1321)	(1.369)	(2.061)
w_t	0.1373	0.1247	0.1418	0.2512	
	(2.386)	(2.411)	(3.780)	(3.666)	
T	−0.0013	−0.0015	−0.0014	−0.0020	
	(4.760)	(4.806)	(5.316)	(2.446)	
$ulcn$					0.1070
					(3.111)
c_t	0.0111	0.0166	−0.0118	0.0138	−0.0369
	(1.734)	(2.148)	(1.336)	(0.9977)	(2.753)
v_t	0.0118	−0.0631	0.2841	0.5612	0.1239
	(1.090)	(0.7903)	(6.296)	(6.256)	(3.873)
u_{ct}	−0.0085	−0.0084	0.0118	−0.0320	−0.2098
	(0.7742)	(0.7067)	(1.588)	(2.595)	(1.053)
p_{t-1}	0.8110	0.8192	0.6361	0.2350	0.7935
	(10.85)	(2.294)	(9.699)	(2.794)	(13.10)
y_t^e	0.0544	0.0585	0.0419	0.0770	0.0327
	(2.745)	(2.555)	(3.199)	(1.970)	(2.785)
ρ_1				0.8424	
R^2	0.9997	0.9995	0.9992	0.9993	0.9932
DW	1.511	1.844	1.550	2.172	1.445
SSR	0.0002	0.0004	0.0003	0.0004	0.0011
SER	0.0021	0.0024	0.0021	0.0025	0.0042

[a]The variables are defined in section II; all are in logs except T. ρ_1 is the autocorrelation coefficient; R^2 is the coefficient of multiple determination; DW, the Durbin-Watson statistic; SSR, the sum of squared residuals; and SER, the standard error of regression.

The standard unit of labor cost, $ulcn = \log [W_t(\overline{X}/MH)_t]$, where W is the wage rate and $\overline{X}/MH$ is the trend productivity variable.

The distributed lags of y_t in each equation have the following features:

Total economy	2nd degree polynomial, 6 quarters long, with far end constrained to zero
Private nonfarm	2nd degree polynomial, 6 quarters long, with far end constrained to zero
Total manufacturing	2nd degree polynomial, 10 quarters long, with far end constrained to zero
Total durables	Previous level of aggregate spending
Total nondurables	2nd degree polynomial, 15 quarters long, with far end constrained to zero

of p_{t-1} does not much affect the coefficients of other variables, except that it tends to shorten the length of the distributed lag on the aggregate spending variable (y_t^e). Also, material price (v_t) is collinear with p_{t-1} and, therefore, its coefficient tends to be somewhat unstable. We have used the estimates in Table 1 for simulating price behavior. However, the results were hardly different when the price equations in Table 2 were used.

The results in Table 1 indicate that, with few exceptions, all the variables are satistically significant. This means that the hazards of multicollinearity, which are not unusual in such equations, have been largely avoided. The signs of the coefficients are in accord with theoretical specifications. Factor costs contribute positively to price increase, long- and short-run productivity lowers prices, while expected demand (y_t^e) increases them. The goodness-of-fit statistics of the equations are fairly satisfactory, and R^2, the coefficient of multiple correlation in terms of *changes* of the dependent variable, is 0.50 and over. Existing first-order serial correlation of the residuals is removed by using the Cochrane-Orcutt iterative technique. The autocorrelation coefficient (ρ_1) is near unity in most cases in Table 2, and the Durbin-Watson statistics indicate absence of any serial correlation.

Several observations about the coefficients are in order:

1. The money wage rate is a very significant determinant of the price level. The short-run wage elasticity of prices is about 0.12 in every case except durables, for which it is about 0.25. In nondurables, the coefficients of w and the productivity trend were constrained to equality. The short-term elasticity of price with respect to standardized unit labor cost *ulcn* is about 0.11.
2. The long-run productivity growth variable (T) has a negative and statistically significant coefficient in all cases. The magnitude of this coefficient is much smaller than that of the wage variable in all cases except nondurables. Even if the effect of short-run productivity changes captured by the utilization rate (uc_t) is taken into account, the total contribution of productivity growth in lowering prices is more than offset by wage increases.
3. The rental price of capital contributes positively to price increases in all cases except total nondurables, where its coefficient is negative. The short-term impact of this variable seems to be about 0.01, a rather small effect.[13]
4. Materials costs are very important in the manufacturing industries. Reasons for the statistical insignificance of v_t in

TABLE 2 Price Equations for Aggregate Sectors and Industries[a] (sample period: 1954I–1971II; figures in parentheses are t statistics)

Independent Variables	Aggregate Economy (1)	Private Nonfarm (2)	Total Mfr. (3)	Total Durables (4)	Total Nondurables (5)
c_0	−3.127	−3.181	1.289	0.9108	−2.736
	(3.907)	(3.656)	(3.576)	(2.405)	(2.568)
w_t	0.2916	0.2328	0.2002	0.3274	
	(4.102)	(2.803)	(3.273)	(4.834)	
T	−0.0056	−0.0067	−0.0021	−0.0032	
	(2.505)	(2.855)	(2.885)	(2.746)	
$ulcn$					−0.0032
					(0.0022)
v_t	0.0407	0.0281	0.5927	0.6388	0.5641
	(1.742)	(1.024)	(8.780)	(6.975)	(3.669)
c_t	0.0229	0.0394	0.0204	0.0246	0.0076
	(2.166)	(3.186)	(1.660)	(1.665)	(0.3360)
u_{ct}	−0.0363	−0.0412	−0.0401	−0.0468	−0.0983
	(2.609)	(2.556)	(4.957)	(4.129)	(2.392)
y_t^e	0.5298	0.5719	0.1221	0.1425	0.0936
	(3.543)	(3.541)	(2.406)	(2.234)	(3.805)
ρ_1	0.9513	0.9399	0.8017	0.8806	0.8991
R^2	0.9960	0.9992	0.9971	0.9992	0.9934
R_X^2	0.6080	0.4980	0.7966	0.8025	0.4414
DW	1.338	1.354	1.568	1.836	1.515
SSR	0.0004	0.0005	0.0027	0.0004	0.0011
SER	0.0026	0.0030	0.0021	0.0026	0.0042

[a]The variables are defined in section II; all are in logs except T. The goodness-of-fit variables are identified in Table 1; R_X^2 is the coefficient of multiple correlation in terms of change in the dependent variable.

The distributed lag variable y_t^e is specified as follows:

Total economy	2nd degree polynomial, 15 quarters long, with far end constrained to zero
Private nonfarm	2nd degree polynomial, 15 quarters long, with far end constrained to zero
Total manufacturing	2nd degree polynomial, 15 quarters long, with both ends constrained to zero
Total durables	2nd degree polynomial, 10 quarters long, with far end constrained to zero
Total nondurables	2nd degree polynomial, 15 quarters long, with far end constrained to zero

the aggregate economy could be the inadequacy of our measures of cost of materials and possibly the collinearity between v_t and p_{t-1} and y_t^e. In the manufacturing industries, prices are quite sensitive to changes in v_t, especially for durables. The elasticity of prices with respect to v_t exceeds its elasticity with respect to w in those industries.

5. The utilization rate captures the effects of short-term changes in productivity. Similar results were obtained when a variable measuring the productivity deviation from its trend was substituted for uc_t in the price equations. The consistently negative signs of the utilization rate variable in equations shown in tables 1 and 2 are in sharp contrast to the positive effect of the utilization rate on price changes reported in the literature. (See Nordhaus 1972 for a summary of the empirical evidence on the effect of the utilization rate.) It can be interpreted to mean that when demand increases, higher utilization of existing capacity results in lower costs; that is, an increase in utilization depicts movement along the unit cost curve, and that leads to lower prices when there is excess capacity.
6. The expected demand variable (y_t^e) captures long-run changes in demand. It has a positive and statistically significant coefficient in each regression. The sum of the distributed lag coefficients is reported for each equation in tables 1 and 2; the distributed lag on GNP is a second-degree polynomial of varying lengths with the far end often constrained to zero. However, the distributed lag coefficients, though not reported here, were positive and statistically significant, and they usually traced a geometric lag structure.

Thus, in determining price behavior, both costs and demand factors play important roles; their quantitative influence and the timing of their effects is quite different. The evidence that aggregate spending affects manufacturing prices significantly stands in contrast to results reported in the literature. Also, this effect is in addition to the short-run industry-specific demand increase depicted by the utilization rate.

The Aggregate Wage Equations

The dependent variables in Table 3 are average hourly earnings. Series such as compensation per man-hour or average hourly earnings adjusted for overtime and interindustry shifts might be better measures of labor costs. These series were constructed, and the

TABLE 3 Wage Equations for Aggregate Sectors[a] (sample period: 1954 I–1971 II; figures in parentheses are t statistics)

Independent Variables	Aggregate Economy (1)	Total Mfg. (2)	Total Durables (3)	Total Non-durables (4)
c_0	−1.661	−0.1962	−0.4301	−0.384
	(3.393)	(0.7446)	(2.140)	(1.272)
u^{-1}				0.006
				(2.175)
$u_t - u_{t-1}$	−0.0094	−0.0305	−0.0157	
	(1.333)	(3.979)	(3.717)	
$\rho - \bar{\rho}$	0.0603	0.0864	0.1143	0.0747
	(2.745)	(2.573)	(3.358)	(1.679)
T	0.0022	0.0005	0.0011	0.0005
	(3.556)	(1.306)	(2.251)	(1.174)
p_c	0.4232	0.0869	0.1358	0.0976
	(3.492)	(1.412)	(2.724)	(1.459)
D_1	−0.0039	−0.0038	−0.0046	−0.0041
	(2.218)	(2.133)	(2.376)	(2.507)
$p_{ct-1} - p_{ct-2}$	0.5617	0.5111	0.4032	0.8111
	(3.049)	(2.761)	(1.705)	(1.389)
w_{t-1}	0.6190	0.8932	0.8153	0.8991
	(5.977)	(12.83)	(11.77)	(13.25)
ρ_1				0.1893
R^2	0.9998	0.9996	0.9995	0.9998
DW	1.964	2.533	2.418	2.104
SSR	0.0008	0.0009	0.0013	0.0004
SER	0.0026	0.0038	0.0046	0.0026

[a]The unemployment rates are industry-specific. For total aggregate economy, total civilian unemployment rate (u_t) is used. For the manufacturing industries u_m, u_d, and u_n are used in the equations for total, durables, and nondurable manufacturing industries, respectively.

P in all cases is the implicit price deflator for personal consumption expenditures, and $p_{ct-1} - p_{ct-2}$ is the difference in the logs of this deflator.

The variables are defined in section II; all are in logs except T and D_1.

The wage equation for the private nonfarm sector is the same as that reported in column 1.

The results were quite similar when the regressions were run excluding w_{t-1} and taking account of first-order serial correlations; the regression for total nondurables, however, was the exception.

wage equations were re-estimated. The results were not much different from those reported in Table 3. However, we consider that average hourly earnings including overtime is a more comprehensive wage cost; it includes the short-term rise in wage rates due to business expansion. This cost, which is due to higher utilization of the labor force, is in contrast to the capacity utilization rate, which reflects the spreading of overhead costs.[14]

The estimated coefficients in Table 3 are all statistically significant and have the theoretically correct signs, and the fit of the model in every case is fairly good. It is clear that long-term variables such as trend productivity and the price level and the short-term market disequilibrium variables—changes in the unemployment rate and price expectations—and guidepost policies exert significant influence on money wages.

The impact of unemployment conditions on wage behavior differs among the various sectors: the reciprocal of the unemployment rate was statistically insignificant in every case other than total nondurables, but the rate of change of the unemployment rate was significant in other cases, particularly in total manufacturing and durables. As we noted, the relation of the wage rate and unemployment variables, $u^{-1} = \ln(1/U)$ or $u_t - u_{t-1} = \ln(U_t/U_{t-1})$, in the regressions of Table 3 implies a dynamic relation where the percentage change in the wage rate is associated with percent change in the unemployment rate. If we write wage equation 8 in a simplified form, $\ln W_t = a + b \ln(U_t/U_{t-1})$, and differentiate with respect to time, we get

$$(11)\qquad \frac{\dot{W}}{W} = b\left(\frac{\dot{U}_t}{U_t} - \frac{\dot{U}_{t-1}}{U_{t-1}}\right)$$

where $\dot{W}$ and $\dot{U}$ are the time derivations of the level wage rate and unemployment and b is the coefficient of $u_t - u_{t-1}$ in Table 3. (11) is in contrast to the Phillips-type analysis which relates *change* in the money wage rate to the unemployment rate $\dot{W}/W = b_0'(1/U)$. Our finding is in the spirit of Kuh's productivity theory of wage levels; (see Kuh 1967 for further discussion of this subject).

Continuing, we see that the productivity trend contributes significantly to growth of the wage rate, particularly for the aggregate economy and durables. Short-term productivity measured as a deviation of actual (ρ) to trend productivity ($\bar{\rho}$), i.e., $\rho - \bar{\rho}$, is fairly significant in all cases, especially in the manufacturing industries. The behavior of this variable, which is often a proxy for profits, indicates that cyclical increases in demand for output exert strong effects on wage movements.

The government guidepost effects seem to have been significant in modifying the growth of the wage rate in all the aggregate sectors and in the manufacturing industries. The magnitudes of the coefficients of D_1 are similar among the various equations, with a slightly larger impact in the durables.

The short-term effects of price on the wage level consist of two terms, the level effect and the rate-of-change effect. The coefficients of p_{ct} and $p_{ct-1} - p_{ct-2}$ are both positive, statistically significant, and less than unity. The coefficient of the acceleration term is substantially smaller than unity,[15] and the short-term elasticity of wage with respect to the price level is also less than unity. Note that a dynamic relationship between changes in the money wage rate and changes in consumer prices is embedded in the model.[16]

The coefficient of w_{t-1} can be interpreted as either an adjustment coefficient or a first-order serial correlation coefficient. A test to identify the role played by w_{t-1} in the model suggested, though not conclusively, that it serves as an adjustment mechanism (see Griliches 1967 for the description of this test). The regression coefficients of w_{t-1} indicate that wage adjustment is much stickier in the manufacturing industries than in the aggregate economy. This may be due to aggregation of individual-industry adjustment processes of varying patterns whose convolution creates a much shorter adjustment for the aggregate wage rate.

Long-Run Estimates

The implied long-run elasticities of prices and wages with respect to their long-run determinants can be deduced from the regression results reported in tables 1 and 3. The short-term market disequilibrium variables, such as the utilization rates in the price equations and the unemployment rate and price expectations variable in the wage equations, will take their stationary values in the long run. That is, in the long run, prices will be determined by factor costs and long-run productivity; wages will be determined by the long-run expected price level and long-run productivity growth.

The long-run elasticities of price with respect to costs and expected demand and the long-run elasticity of wages with respect to changes in consumer prices and productivity growth are shown in Table 4. Some interesting patterns emerge. In the aggregate sectors, the wage rate elasticity of prices is about 0.70. The elasticities of prices with respect to rental price of capital are certainly low, and in nondurables the sign of the rental price is negative. In the manufacturing industries, it is materials costs that play the dominant role.

TABLE 4 Long-Run Elasticities of Prices and Wage Rates with Respect to Long-Term Determinants[a]

	Price Equation						Wage Equation	
	w_t	t	$ulcn$	c	v	y^e	p_c	t
Total economy	0.68	−0.007		0.058	0.063	0.284	1.10	0.0057
Total private nonfarm	0.667	−0.008		0.089	0.3318	0.313	1.10	0.0057
Total manufacturing	0.378	−0.003		−0.033	0.781	0.112	0.814	0.0044
Total durables	0.355	−0.003		0.018	0.732	0.101	0.735	0.0059
Total nondurables			0.504	−0.1789	0.600	0.1583	0.967	0.0049

[a] These statistics were calculated by dividing the approximate coefficients shown in tables 1 and 3 by $1 - \lambda'$, where λ' is the estimated coefficient of the lagged dependent variable.

These patterns closely correspond to factor shares reported by Nordhaus (1972).[17]

The long-run contribution of productivity in lowering prices is more than offset by the increase in factor costs, while the contribution of productivity growth to wages is about 0.005 to 0.006. Expected demand has a powerful effect on the price level in every case, but the elasticity of price with respect to changes in spending is well below unity. This suggests that an increase in demand leads to an increase partly in prices and partly in output in the long run. The long-run response of the wage rate to the consumer price index varies among the aggregates. For the aggregate economy and nondurables, the elasticity is unity, but it is less than that in total manufacturing and durables. It seems that a severe money illusion is present in the durable industries, even in the long run.

IV. DISAGGREGATE MANUFACTURING INDUSTRIES

The price and wage equations (7 and 8) were fitted for the same period to the data for the twelve two-digit manufacturing industries described earlier. Price and wage behavior in these industries is quite divergent, and the estimates suggest that the response of industry prices and wages to changes in aggregate and industry-specific variables differs among industries.

The results for individual industries are summarized in tables 5 and 6. Some of the variables were omitted because of multicollinearity. As can be seen from the tables, the fit of the regressions is fairly good. With some exceptions, the explanatory variables have the correct signs and are statistically significant. The industry results can be summarized briefly.

Industry Price Behavior

The long-term productivity trend has a negative and statistically significant effect in all cases except textiles, petroleum, and primary nonferrous metals. It plays a somewhat larger role in the durables than in nondurables, with the largest impact in the primary ferrous, nonferrous, motor vehicles, petroleum, and paper and allied products industries.

TABLE 5 Price Equations for Disaggregated Manufacturing Industries[a] (sample period: 1954I–1971II; figures in parentheses are t statistics)

	Nondurable Manufacturing Industries					
Variables	SIC 20	SIC 22	SIC 26	SIC 28	SIC 29	SIC 30
c_0	−1.128	2.528	−3.415	−4.630	−1.601	−6.213
	(4.288)	(6.399)	(4.203)	(26.35)	(3.222)	(3.909)
T	−0.0022	0.0020	−0.0117	−0.0018	0.0043	−0.0205
	(2.523)	(3.313)	(4.203)	(4.543)	(2.114)	(4.868)
w_t	0.1379	0.5667	0.2780	0.0512	−0.5120	0.5035
	(1.939)	(7.836)	(1.491)	(2.250)	(2.418)	(2.143)
v_t	0.3078	−0.0755			0.2801	
	(9.816)	(1.725)			(2.154)	
c_t	−0.0350	−0.0368	0.0563		0.1077	0.0013
	(1.965)	(4.006)	(1.890)		(2.41)	(0.0208)
p_{t-1}	0.4583	0.6864		0.9119	0.8203	
	(8.450)	(12.59)		(20.76)	(10.45)	
y_t^e	0.1718	−0.4837	0.6442	0.0886	−0.0784	1.158
	(4.039)	(6.510)	(4.347)	(3.805)	(0.9325)	(3.650)
u_{ct}	−0.0144			−0.0156	0.6009	
	(0.8331)			(1.689)	(5.046)	
ρ			0.9126			0.8875
R^2	0.9952	0.9168	0.9888	0.7679	0.8644	0.9962
R_X^2			0.4046			0.4485
DW	1.481	1.035	1.532	1.615	2.045	1.731
SSR	0.0022	0.0018	0.0024	0.0004	0.0239	0.0016
SER	0.0060	0.0053	0.0062	0.0027	0.0189	0.0057

SIC = Standard Industrial Classification.

[a]All the variables except T are in logs. The distributed lag variable y_t^e is specified as follows:

	SIC No. and Description	
20	Food and kindred products	2nd degree polynomial, 6 quarters long, both ends constrained to zero
22	Textile mill products	2nd degree polynomial, 10 quarters long, far end constrained to zero
26	Paper and allied products	2nd degree polynomial, 6 quarters long, far end constrained to zero
28	Chemical and allied products	2nd degree polynomial, 10 quarters long, far end constrained to zero
29	Petroleum and allied products	Previous level of total spending
30	Rubber and allied products	2nd degree polynomial, 10 quarters long, far end constrained to zero

Variables	Durable Manufacturing Industries					
	SIC 32	SIC 331	SIC 333	SIC 35	SIC 36	SIC 371
c_0	−0.1892	−5.650	1.105	−0.0791	−0.1185	−1.238
	(0.9450)	(4.330)	(1.234)	(0.3986)	(0.4822)	(2.435)
T	−0.0017	−0.0178	0.0093	0.0011	−0.0014	−0.0056
	(2.583)	(4.445)	(2.752)	(1.399)	(2.047)	(3.053)
w_t	0.2303	0.4707	−1.100	−0.0749	0.0762	0.2313
	(3.143)	(5.511)	(3.898)	0.7784	(0.9113)	(3.539)
v_t	0.2530	0.1395	0.3803	0.2197	0.1169	0.3618
	(2.676)	(2.598)	(5.365)	(3.957)	(2.972)	(2.879)
c_t	−0.0131	0.0336	0.1751	0.0105	0.0473	−0.0101
	(1.013)	(1.051)	(3.392)	(0.5576)	(2.138)	(0.2533)
p_{t-1}	0.7375		0.7542	0.7472	0.7997	
	(10.27)		(14.80)	(13.42)	(15.19)	
y_t^e	0.0036	1.032	−0.0488	0.0065	0.0086	0.2344
	(0.0950)	(4.331)	(0.3816)	(0.1680)	(0.2546)	(2.599)
u_{ct}	0.0068	−0.0335	0.0759	0.0140		−0.0378
	(0.5661)	(3.795)	(3.546)	(1.123)		(3.394)
ρ		0.9390		0.4233		0.9202
R^2	0.9980	0.9973	0.9834	0.9995	0.9848	0.9917
R_X^2		0.6075		0.7375		0.3619
DW	1.902	1.160	1.272	1.905	1.323	1.904
SSR	0.0009	0.0199	0.0200	0.0005	0.0018	0.0023
SER	0.0039	0.0057	0.0179	0.0031	0.0055	0.0061

	SIC No. and Description	
32	Stone, clay, and glass	Previous level of total spending
331	Primary ferrous	2nd degree polynomial, 10 quarters long, far end constrained to zero
333	Primary nonferrous	Previous level of total spending
35	Nonelectrical machinery	2nd degree polynomial, 10 quarters long, far end constrained to zero
36	Electrical machinery	2nd degree polynomial, 10 quarters long, far end constrained to zero
371	Motor vehicles and equipment	Previous level of total spending

TABLE 6 **Wage Equations for the Disaggregated Manufacturing Industries**[a]
(sample period: 1954I–1971II; figures in parentheses are t statistics)

	Nondurable Manufacturing Industries					
Variables	SIC 20	SIC 22	SIC 26	SIC 28	SIC 29	SIC 30
C_0	−0.4988	−2.032	−0.0682	−0.0980	0.5628	−0.1321
	(0.9480)	(2.803)	(0.5615)	(0.4343)	(2.703)	(0.6423)
T	0.0019	0.0002	0.0018	−0.0003	0.0026	0.0019
	(3.408)	(0.6069)	(3.657)	(1.033)	(4.292)	(4.375)
u^{-1}		0.0223		0.0077		
		(2.392)		(3.069)		
$u_t - u_{t-1}$			−0.0079		−0.0239	−0.0216
			(1.982)		(2.266)	(2.353)
$\rho - \bar{\rho}$	0.1096	0.1495	0.0400	0.0187	−0.0541	0.0762
	(0.9892)	(2.467)	(1.770)	(1.473)	(1.374)	(1.833)
D_1	−0.0074	−0.0055	−0.0052	−0.0020	−0.0027	−0.0052
	(2.564)	(1.595)	(4.493)	(1.340)	(0.7910)	(1.557)
D_3	0.6691		0.5287	0.3410	1.296	0.7128
	(1.489)		(2.551)	(2.434)	(3.501)	(2.578)
p_{ct-1}	0.0808	0.3180	0.0855	0.0059	0.1271	0.0518
	(1.747)	(2.120)	(3.080)	(0.1300)	(3.699)	(1.487)
w_{t-1}	0.8376	0.8030	0.7926	1.028	0.6835	0.7410
	(16.13)	(10.10)	(13.62)	(31.23)	(9.390)	(12.34)
ρ_1		−0.1278		−0.2697		
R^2	0.9989	0.9986	0.9997	0.9998	0.9981	0.9982
R^2_X		0.3633		0.5596		
DW	2.738	2.021	2.169	2.079	2.033	2.485
SSR	0.0032	0.0033	0.0010	0.0005	0.0042	0.0031
SER	0.0071	0.0073	0.0039	0.0029	0.0082	0.0071

The wage rate is a very important explanatory variable in every case except petroleum, primary nonferrous, and nonelectrical machinery, where the sign of the wage is negative. This is mainly due to the multicollinearity between the wage rate and the lagged dependent variable, p_{t-1}. When p_{t-1} is dropped, the coefficient of w_t becomes positive and statistically significant. The short-run elasticity of price with respect to the wage rate varies among the different industries, ranging from a high of 0.57 for textile mills products

Variables	Durable Manufacturing Industries SIC 32	SIC 331	SIC 333	SIC 35	SIC 36	SIC 371
C_0	−0.2242	−0.0407	0.2853	0.2810	−0.1416	−3.631
	(1.192)	(0.3555)	(2.387)	(2.084)	(1.195)	(4.170)
T	0.0019	0.0018	0.0010	0.0015	0.0020	0.0019
	(3.089)	(4.690)	(2.948)	(2.616)	(5.227)	(2.418)
u^{-1}	0.0056			0.0076		0.0083
	(2.426)			(0.3596)		(1.631)
$u_t - u_{t-1}$		−0.0193	−0.0207	−0.0074	−0.0008	−0.0487
		(2.560)	(3.905)	(2.627)	(2.609)	(4.680)
$p - \bar{p}$	0.0766	0.0908	−0.0269	−0.0119	0.0546	0.0513
	(2.166)	(6.075)	(1.293)	(0.5337)	(2.136)	(1.435)
D_1	−0.0058	−0.0068	−0.0040	−0.0018	−0.0038	0.0055
	(3.355)	(2.256)	(1.303)	(1.094)	(2.609)	(1.085)
D_3	1.077	0.2136	0.5015	0.7994	0.8674	
	(5.211)	(0.7297)	(2.010)	(3.623)	(4.730)	
p_{ct-1}	0.0992	0.2357	0.0074	0.1174	0.0352	0.8975
	(1.553)	(5.336)	(0.6388)	(2.898)	(4.110)	(4.904)
w_{t-1}	0.7397	0.6570	0.8805	0.7469	0.7421	0.3935
	(7.999)	(10.10)	(23.69)	(8.706)	(14.77)	(3.600)
ρ_1	−0.2192				0.0642	−0.2843
R^2	0.9995	0.9983	0.9992	0.9997	0.9997	0.9965
R^2_X	0.5421				0.5780	0.5831
DW	2.021	1.996	2.081	2.128	1.861	2.009
SSR	0.0011	0.0037	0.0018	0.0008	0.0007	0.0102
SER	0.0044	0.0077	0.0055	0.0036	0.0033	0.0139

[a] All variables except T, D_1, and D_3 are in logs. In nondurables industries the unemployment rate for total nondurables is used for u_t, and in durables, the unemployment rate for total durables is used for u_t. The industries are identified by name in Table 5, note a.

to a low of 0.05 for chemicals. Also, this is invariably greater than the elasticity of price with respect to the productivity variables. This implies that an increase in productivity has to be very large to compensate for wage increases; otherwise, there might be a general tendency for industry prices to drift upward.

Materials price is the most important explanatory variable for price behavior in several industries, especially the durables. The short-run elasticity of prices with respect to v_t is about 0.40 in primary nonferrous (SIC 333) and motor vehicles (SIC 371) and 0.12 in electrical machinery (SIC 36).[18]

The utilization rate in the disaggregate industries plays different roles: it has a negative sign in some industries and a positive sign in others. The positive sign indicates a demand effect, while the negative sign, as mentioned before, stands for movement along the average cost curve before capacity output is achieved. It is interesting to note that whenever the utilization rate is positive and significant the expected demand variable (y_t^e) is negative and insignificant, suggesting that u_{ct} captures the effect of expected demand in those industries. Generally, the utilization rate is not a very important variable in the nondurables, except petroleum (SIC 29), where it has a positive coefficient of 0.6. In durable industries, it is usually significant with a negative sign in primary ferrous (SIC 331) and motor vehicles and positive and significant in primary nonferrous.

The rental price of capital services is statistically significant in several industries and enters with a positive sign in most, with the exception of two nondurables (food and kindred products, SIC 20, and textiles, SIC 22) and two durables (stone, clay, and glass, SIC 32, and motor vehicles, SIC 371). However, the coefficients of c_t in the two durable industries are not statistically insignificant. If we were to interpret this variable as a proxy for a fair rate of return, the negative coefficients would suggest that firms would raise prices in order to maintain a given rate. Changes in rental price play a very important role in the durables, particularly in primary nonferrous, where the short-run elasticity of price with respect to c_t is about 0.2. Among the nondurables, petroleum prices seem to respond strongly to changes in the rental price of capital.

Total spending, y_t^e, exerts an important influence on prices in several industries. Except for the industries where the utilization rate enters positively, y_t^e has a statistically significant positive coefficient. The effect of aggregate spending seems to be large and highly significant in the durable industries.[19]

The coefficient of p_{t-1} varies somewhat among industries, from a high of 0.9 in chemicals to a low of 0.46 in food and kindred products. However, in most cases, it is about 0.7 or 0.8, implying an average of four quarters for prices to adjust to their equilibrium values, which are calculated as $(1 - \lambda)/\lambda$, where $1 - \lambda$ is the coefficient of p_{t-1} in the industry regression.

Long-run elasticities of the price level with respect to factor costs, productivity growth, and expected demand can be calculated using the estimates in Table 5. Tentative calculations indicate that a majority of the industries respond strongly to wage rate and materials price changes in the long run. The effect of the rental price of capital is rather small, and the long-run elasticity of prices with respect to expected demand is large but less than unity, and it varies among industries.

Industry Wage Behavior

The response of wages to the explanatory variables differs considerably among the industries. The main features of the results in Table 6 can be summarized briefly.

The labor market disequilibrium variables, u^{-1} and $u_t - u_{t-1}$, and sometimes both, have statistically significant effects on wages in every industry except food and kindred products.[20] The reciprocal of the unemployment rate has a positive sign and is statistically significant in textiles, chemicals, and stone, clay, and glass. The rate of change of the unemployment rate is significant in all other industries. Both unemployment variables are significant in two industries—nonelectrical machinery and motor vehicles. Note the dynamic characteristic of the wage rate and unemployment rate, which we discussed before. This relationship is sustained at the disaggregate level as well (see the section, Aggregate Wage Equations, above).

The long-run productivity trend, T, and the short-run productivity changes contribute significantly to wage increases in most industries, except in chemicals, where the coefficient of T is negative and statistically insignificant. The coefficients of trend productivity generally cluster around 0.0018 except for petroleum, for which the figure is especially high (0.0026). The contribution of the short-run productivity variable $(\rho - \bar{\rho})$, which is often a proxy for profits, varies among industries. In some nondurable industries, such as rubber products and textiles, short-term productivity contributes significantly, while in nonferrous and in nonelectrical machinery it is not significant.

The guidepost dummy (D_1) is statistically significant in every case except petroleum, nonelectrical machinery, and motor vehicles. The negative sign of this variable in all industries except motor vehicles suggests that guidepost policies effectively dampened the growth of the wage rate in the majority of U.S. manufacturing industries. This finding is complementary to the evidence found by Perry (1970) and to our results for the aggregate sectors and industries of the economy reported in Table 3.[21]

The threshold variable (D_3) plays an important role in the wage behavior of the disaggregate manufacturing industries. Except for textiles, primary ferrous, and motor vehicles, D_3 always has a positive and statistically significant coefficient, but the magnitude of the coefficient varies considerably among industries. Nonetheless, it seems that industry wage rates are quite sensitive to changes in prices after a certain critical level.

The short-run elasticity of wages with respect to the price level varies considerably. In a majority of cases, the coefficient of p_{t-1} is positive and statistically significant, and it is always less than unity. The largest coefficient—0.90—is for motor vehicles.

The lagged wage rate is statistically significant, but its coefficients vary in magnitude among industries. Its largest value occurs in chemicals, and its lowest value, in motor vehicles. The implied adjustment process of wages to their equilibrium value seems to be about one year in most industries other than motor vehicles, where the adjustment is much faster.

Tentative long-run elasticities of wages with respect to price and productivity can be derived from the estimates of Table 6. Generally, the price elasticity of wages varies among industries and is smaller than unity except in textiles and motor vehicles. The long-run elasticity of wages with respect to trend productivity also varies considerably among industries. Food, paper, petroleum, and most durables have elasticities that range between 0.007 and 0.010. All these results on long-run elasticities should be considered tentative, since some specification errors could be present in estimating industry wage equations.

V. GOODNESS OF FIT, FORECASTING ABILITY, AND EFFECT OF CONTROLS

Comparison with Autoregressive Models

A useful test of the overall explanatory power of the estimated equations is to compare them with a set of autoregressive models. This comparison is a stringent test for the analytical models (see Jorgenson-Hunter-Nadiri 1970 for a discussion and tests for such comparisons). We shall compare the price and wage equations both at the aggregate and disaggregate levels with a set of secord-order autoregressive models of the form:

(12) $p_t = \alpha_0' + \alpha_1' p_{t-1} + \alpha_3' p_{t-2} + \epsilon_p$

$w_t = \beta_0' + \beta_1' w_{t-1} + \beta_3' w_{t-2} + \epsilon_w$

All variables are in logarithms, and ϵ_p and ϵ_w are the residuals.

The F statistics computed from the sums of squared residuals of the analytical and autoregressive models are shown in Table 7. For the calculations shown in the table, the critical value of F with degrees of freedom (1, 60) is 7.08 at the 1 percent level of significance and 4.00 at the 5 percent level. It is clear that in every case, the analytical model performs much better than its autoregressive counterpart. This is quite impressive, since autoregressive models have an edge over analytical models whenever the data are highly serially correlated, as is the case with price and wage series.

Forecasts of Prices and Wages for Rates for Aggregate Sectors and Industries

The estimated equations can be used to dynamically simulate price and wage behavior for the sample period 1954I–1972II and the forecast period 1971III–1973II. Also, it is possible to examine the effectiveness of price and wage controls which were imposed during the latter period. Because of the unavailability of data on materials prices at the disaggregate industry level after 1971III, we cannot generate forecasts of individual-industry prices and wages, but we have been able to do so for aggregate sectors and industries. To save space, we shall present certain summary statistics on the simulation results for the sample period, but for the forecast period, the absolute and percent errors will also be reported and analyzed.

The summary statistics of the simulation of prices and wages over the sample period are reported in Table 8. The predictions are very good. The root-mean-square error (*RMSE*) for prices is often about 0.002, while that for wage rates is about 0.012. The mean absolute error (*MAE*) and mean errors (*ME*) are also very small. The largest error as a percent of the actual rates is seldom more than 0.01 for both prices and wage rates; the largest error in absolute terms seldom exceeds two to three cents. We also calculated quarterly and four-quarter percent changes of the actual and predicted values of the variables and obtained their percent forecast errors.[22] In prices, the largest absolute quarterly percent error in the sample period was in the private nonfarm sector (about 0.016); for the wage rate, it was in durables (about 0.015). The summary statistics of the forecast errors for the period 1971III–1973II are also shown in Table 8.

TABLE 7 F Statistics for Comparison of Regression Equations in Tables 1 and 3 with Their Autoregressive Counterparts[a]

Industry	*F* Statistics		Industry	*F* Statistics	
	F_p	F_w		F_p	F_w
Aggregate economy	100.00	60.00	Chemical and allied products	20.00	40.00
Private nonfarm	42.85	60.00	Petroleum and allied products	23.00	33.86
Total mfr.	80.00	45.00	Rubber and allied products	52.4	38.00
Total durables	85.11	70.00	Stone, clay, and glass	60.00	55.00
Total nondurables	20.00	28.57	Primary ferrous	13.25	33.33
Food and kindred products	18.00	11.00	Nonelectrical machinery	50.00	50.00
Textile mills and products	13.33	23.33	Electrical machinery	16.66	50.00
Paper and allied products	10.50	23.41	Motor vehicles	15.59	49.00

[a] In calculating these *F* statistics for various industries, appropriate adjustments were made to take account of variations in the degrees of freedom.

TABLE 8 Analysis of the Residuals of the Aggregate Price and Wage Equations over the Sample and Forecast Periods[a]
(residuals as quarterly differences between actual and simulated level of prices and wages)

	Aggregate Economy		Private Nonfarm		Total Manufacturing		Total Durables		Total Nondurables	
	p_t	w_t	p_t	w_t	p_t	w_t	p_t	w_t	p_t	w_t
					Sample Period: 1954I–1971II					
RMSE	.0010	.012	.002	.012	.0034	.012	.0063	.012	.004	.0029
MAE	.0082	.010	.0016	.010	.0028	.010	.0055	.010	.003	.0023
ME	−.0018	$.4 \times 10^{4}$	$.18 \times 10^{-5}$	$.4 \times 10^{-4}$	$.2 \times 10^{-4}$	$-.4 \times 10^{-3}$	$-.9 \times 10^{-4}$	$-.13 \times 10^{-3}$	$.6 \times 10^{-5}$	$.22 \times 10^{-2}$
					Forecast Period: 1971III–1973II					
RMSE	.0043	.035	.0075	.035	.019	.023	.0016	.032	.030	.0065
MAE	.0036	.028	.0062	.028	.012	.017	.0010	.029	.018	.0051
ME	.0018	.023	−.0061	.023	−.011	−.015	$-.2 \times 10^{-3}$	.014	.017	.0007

RMSE = root-mean-square error.
MAE = absolute mean error.
ME = mean error.
[a] All price indexes are on base 1967 = 1.00, and the wage rates are in dollars.

TABLE 9 Absolute and Relative Forecast Errors of Prices and Wages for the Aggregate Economy and total Manufacturing[a]

Year and Quarter	Aggregate Economy				Total Manufacturing			
	Prices		Wages		Prices		Wages	
	A	B	A	B	A	B	A	B
1971III	.0079	−.0016	−.0041	−.0014	.0005	.00003	−.020	−.0053
IV	.0035	−.0037	−.0138	−.0012	−.0015	−.0017	−.029	−.0023
1972I	.0068	.0022	.0612	.0078	−.0007	.0007	.015	.0085
II	.0034	−.0023	.0290	−.0068	.0026	.0029	.052	.0009
III	.0009	−.0020	.0192	−.0021	.0080	.0046	−.014	−.0051
IV	−.0019	−.0023	.0247	.0011	.0100	.0016	.0011	.0041
1973I	−.0042	−.0018	.0651	.0079	.025	.0123	−.086	−.0044
II	−.0011	.0025	.0077	−.0114	.0462	.0168	−.051	−.0088

[a] In each case, column A contains the absolute magnitude of the errors recorded. For prices, column A shows $P_t - P_{t-1}$ and for wages, $W_t - W_{t-1}$. Column B contains the percent rates of change of quarterly forecast errors of prices and wages. For prices, the relation-

They are generally small and trace the same pattern as those observed for the sample period. As is to be expected, they are generally larger in magnitude than the corresponding statistics in the sample period.

In Table 9, the absolute and percent forecast errors for the aggregate sectors and industries are presented.[23] In columns A, the absolute magnitudes of the errors are recorded; and in columns B, the percent changes of quarterly forecast errors of price and wages. Several observations are in order: In general, the size of errors is fairly small; the forecast errors are larger in the individual industries than in the aggregate economy; the percent forecast errors for prices and wage rates seem to increase in the manufacturing industries after 1972III; and there seems to be a jump in the errors in 1972I and 1973II, dates which correspond to the lifting of controls.

It is difficult to evaluate the relative predictive performance of our model against alternative models for individual industries because industry forecasts of wages and prices are not readily available. However, we can compare our price forecasts for the aggregate economy with the recently published projections of the Federal Reserve Bank of St. Louis; the figures shown in the following tabulation are absolute errors in forecasts of percent changes in the GNP price deflator at annual rates:[24]

Year and Quarter	Total Durables				Total Nondurables			
	Prices		Wages		Prices		Wages	
	A	B	A	B	A	B	A	B
1971III	.0120	.0049	−.030	−.0074	−.0028	−.0030	.0135	−.0003
IV	.0079	−.0035	−.032	−.0005	−.0016	.0015	.0077	.0080
1972I	.0062	−.0016	.014	.0122	−.0003	.0007	.0180	.0089
II	.0071	.0007	.0279	.0033	−.0006	−.0003	.0175	−.0021
III	.0087	.0013	.0189	−.0023	.0048	.0047	.0147	−.0023
IV	−.0076	−.0129	.0461	.0066	.0211	.0442	.0152	.0036
1973I	−.016	−.0076	.0482	.0003	.0470	.0115	.0147	.0073
II	−.019	−.0023	.0182	−.0074	.0683	.0159	.0088	−.0121

ship shown is $[(P_t - P_{t-1})/P_{t-1}] - [(\hat{P}_t - \hat{P}_{t-1})/\hat{P}_{t-1}]$. The relationship for wages is the same, with W substituted for P and $\hat{W}$ for $\hat{P}$ in each case.

Period	Forecast Errors	
	St. Louis Model	Equation 3
1971I	2.4%	−0.64%
II	2.8	−1.48
1972I	1.7	0.88
II	1.9	−0.92
III	1.8	−0.80
IV	1.6	−0.92
1973I	1.2	−0.72
II	0.6	1.00
Average absolute error	1.75	0.736

It is clear that except in 1973II, the prediction errors of our model are much smaller than those generated by the St. Louis model. In fact, the average error of our model over this period seems to be less than half that predicted by the St. Louis one.

The Effectiveness of Controls

Price and wage controls were imposed in August 1971, and they were continued in some modified form until August 13, 1973. Prices and wages were frozen in Phase I (August 15 to November 12, 1971), in Phase II (November 12, 1971, to January 11, 1973) a set of mandatory but flexible controls was imposed; in Phase III (January 11 to June 13, 1973), a policy of voluntary restraints was pursued, that was followed by Phase III and a half (June 13 to August 13, 1973), in which the second freeze on wages and prices was decreed. Finally, in Phase IV, a policy of mandatory but flexible controls was followed.

The question is whether the incomes policies pursued were effective. Our model can be used to throw some light on this question. We can introduce dummy variables in our regression equations to capture the effects of price controls, or we can look at the dynamic forecasts generated by the model for the control period and compare them with the actual values of prices and wages; the difference between those predicted and actual values constitutes a measure of the effectiveness of the income policies. That is, if the model overpredicts prices and wages in this period, the magnitudes of the overpredictions will be considered as a measure of the effectiveness of the wage-price controls.

We did not re-estimate the original equations by introducing dummy variables for controls; rather, we followed the second alternative of comparing the actual and predicted values of the series for 1972III–1973II in order to obtain some feeling for the degree of effectiveness of the controls.

In Table 9 the differences between actual and predicted percent changes in prices and wage rates for the aggregate economy and the three aggregate manufacturing industries are reported in columns B. The negative sign means that percent rates of price and wage change projected by the model exceed their actual values, and the magnitudes indicate the extent of overprediction. For the aggregate economy, the percent change in the GNP deflator is overpredicted for each quarter during the period 1971III–1973II, except for 1972I and 1973II, which are associated with termination or modification of the control policies. In those two quarters, the jump in actual prices was quite substantial, and the model underpredicts the amounts. Similarly, controls in phases I and II were fairly important in restraining wage increases. After each of these two periods, the wage rate seems to shoot up, indicating a catching-up phenomenon. The magnitude of this effect is particularly significant after the termination of Phase I. In Phase III, the percent change in the wage rate is underpredicted in 1973I and overpredicted in 1973II, while the opposite is true of prices. Thus, the actual rise in the wage rate continues its momentum in 1972I and 1973I in spite of controls, while for prices, the influence of Phase II controls continues up to the beginning of Phase III. For the entire period of the controls, aggregate-economy prices and wages are overpredicted by the model to such an extent that in spite of overreaction of the economy to the termination of phases I and II, controls seem to have had a net dampening effect.

In the case of the manufacturing industries, the effectiveness of the controls is not very clear. In Phase I, the model generally overpredicts both prices and wages. Actual prices and wages respond to the lifting of Phase I controls, and there is a consistent pattern of price and wage bulges in 1972I. This catching-up phenomenon is very strong in total manufacturing and total durables. There is a difference in the effect of controls on wages and prices in phases II and III. In total manufacturing and nondurables, prices seem to continue to rise irrespective of the controls: prices are underpredicted throughout the period 1972II–1973II. In durables, the controls seem to exert some influence in 1972IV–1973II. The effect of controls on wages in that industry grouping does not exhibit a systematic pattern, except that at the end of Phase II, wage rates bulge, i.e., actual wage rate increases are substantial, and the model underpredicts them. In Phase III there is evidence that wage rates in the manufacturing industries have been affected by the controls. For the whole period 1971III–1973II, it seems that wage and price controls have been fairly ineffective in controlling price increases in total manufacturing and nondurables but have had partial success in the durables. This success of the controls was more visible on the wage side, though the pattern, timing, and magnitude of their influence have varied considerably.

Thus, it seems that both the Kennedy-Johnson and Nixon control policies had some effect on wage rates and prices. The guideposts influenced wages directly and strongly and prices only indirectly through wages.[25] Although the recent controls did exert a direct effect on the growth of general price level and had some effect on manufacturing prices, there is reason to believe that the controls were more successful in restraining wages. When the controls were lifted or modified, prices and wages reacted sharply in response to efforts to recoup the losses incurred during the controls. The magnitude and timing of the influence of guideposts and of recent control policies in restraining price and wages increases differed substantially among various sectors of the economy.

VI. SUMMARY AND CONCLUSIONS

We have constructed a model that integrates the long-run determinants of equilibrium price and wage rates with short-run disequilibrium factors operating in the commodity and labor markets. We have tried to take account of all the relevant factor costs, productivity changes, and demand considerations that enter into the determination of the price level. In formulating the wage equation, long-run factors such as the growth of productivity and prices were integrated with short-term phenomena such as controls and changes in unemployment conditions, price expectations, and productivity. The wage and price equations were fitted using data for the total economy and for fifteen manufacturing industries for 1954I–1972II. Price and wage forecasts were generated for the aggregate sectors and for manufacturing industries for 1971III–1973II, covering the period when economic controls were in effect.

Several important conclusions are derived from the analysis:

1. Factor costs such as wage rates, rental price of capital services, and materials prices are important determinants of prices in both aggregate and disaggregate industries. Their individual contributions vary among sectors and industries, but the usual practice of omitting materials prices and, particularly, the rental price of capital in price equations was found to be unwarranted.

2. Capacity utilization has a significant negative effect on prices in the aggregate economy and in a large number of individual industries. This finding is in contrast to the positive relationship found by other investigators. Our results suggest that higher utilization of existing capacity, everything else remaining the same, will reduce costs and lead to lower prices. Thus, up to a point, policies designed to increase resource utilization will not be inflationary.

3. An important finding of our analysis is that aggregate spending influences prices at both the aggregate and industry levels. This is in contrast to the findings of several studies which imply no influence of the economy-wide variables on individual-industry price behavior. The pervasive effect of aggregate spending on the level and structure of prices has important policy implications.

4. A combination of long- and short-term factors determines the course of money wages. Long-run productivity growth and consumer prices play important roles in determining long-run wage rates. There is considerable variation in the response of wage rates to these two variables in different sectors and industries. In a majority of cases, the long-run elasticity of wages with respect to prices was found to be less than unity.

5. There is a dynamic relationship between the wage rate and the unemployment rate at the aggregate and industry levels; the unemployment rate or its rate of change, depicting short-term disequilibria in labor markets, influences wages in almost all industries. The precise relationships between wage changes and unemployment variables and the magnitudes of their effects vary considerably among industries. On the whole, the results suggest that wage increases could be slowed down to some extent if the unemployment rate is rising at an increasing rate.

6. Prices and price expectations play an important role in determining wage behavior. The elasticity of the wage rate with respect to prices is below unity in the short run. In many cases, even in the long run, money illusion seems to prevail in several industries. Short-run price expectations affect wage behavior both at the aggregate and disaggregate levels. The expectation phenomenon is best captured by an extrapolation hypothesis at the aggregate level and by a nonlinearity relation in the form of a threshold effect at the disaggregate levels.

7. The results indicate that guideposts have significant effects on aggregate and disaggregate industries. Their effects on wage rates have been quite pervasive and of varying magnitudes.

8. Productivity changes play an important role in wage determination in the sectors and industries considered. The trend productivity has a significant effect on wages of the aggregate and individual manufacturing industries, while deviation from productivity contributes importantly to all the aggregate wage regressions and some of the durables and nondurables.

9. For dynamic simulations of the model within the sample period, at both the economy and industry levels, the errors were smaller and wages and prices tracked far better than for a set of autoregressive models. The forecasts generated by the model are close to actual prices and wages for the aggregate sectors and manufacturing industries during the period 1971III–1973II. Moreover, the percent rates of change of prices and wages generated by the model satisfactorily track the actual values during the period when controls were in effect.

10. The effects of controls on price and wage rates of the aggregate sectors and manufacturing industries seem to have been mainly on the wage side; aggregate price increases were slowed down by the controls in phases I through III; in the manufacturing industries the controls were effective mainly in Phase I but ineffective in phases II and III. However, this assessment is only tentative.

11. The overall policy implication of our findings is that simple counterinflationary policies will be inadequate in stabilizing prices and wages. A combination of policies should be considered that will combat not only short-run inflationary conditions but also the effects of the underlying forces of secular inflation in the economy. A complex set of strategies is needed, which would involve management of total spending, promotion of long-run productivity growth, dampening excessive expectations, better utilization of the existing capacity, and effective wage and price controls.

NOTES

1. See Nordhaus (1972) for the details of the deviation of similar price rules under different technological constraints.
2. See Fair (1969) for a survey of the literature on labor-demand functions and Mincer (1970) for a general survey of the research on labor supply behavior.
3. We can specify log-linear demand and supply functions (4a) and (4b):

   (4a) $L^d = a_0 P^{*a_1} X^{*a_2} W^{-a_3}$

   (4b) $L^s = b_0 P_C^{*-b_1} W^{b_2}$

   P^* is the expected output price, X^* is the expected output, P_C^* is the expected price of consumer goods: Solving for equilibrium wage, we get

   $W^* = \gamma_0 P^{\gamma_1} X^{\gamma_2} P_C^{\gamma_3}$

   where $\gamma_0 = (a_0/b_0)[1/(a_3 + b_2)]$; $\gamma_1 = a_1/(a_3 + b_2)$; $\gamma_2 = a_2/(a_3 + b_2)$; $\gamma_3 = b_1/(a_3 + b_2)$.

   In principle, therefore, both output price and price of goods purchased by the workers should determine equilibrium wage rate. The problem is that P_C and P are highly collinear and one of them must be excluded from the regressions. Of course, it is possible that either the specific industry output price or the consumer price index may best represent the price effect. At the individual industry level, it is labor's negotiation strategy that determines whether the specific commodity or the general price level should be used as a determinant of wage rate settlements.
4. There is the question of whether the adjustment factors and the short-term factors are interdependent. We have assumed that some part of the adjustment to the equilibrium condition can be identified explicitly by the short-term factors and that the rest may be associated with the adjustment coefficient specified in the model.
5. However, certain fiscal measures such as investment tax credits, reductions in income tax rates on corporations, and taxes on depreciation allowances are part of the cost structure. They are transmitted to prices through the market forces; in the model, their effects are incorporated through the rental price of capital. Guideposts and controls, on the other hand, are superimposed on the market adjustment process.
6. The experiments were performed using aggregate price and wage equations. Therefore, the conclusion may hold only tentatively for other sector and industry results.

7. We did not have enough time to attempt to specify the determinants of y_t^e. However, using Christ (1973) and Anderson and Carlson (1972), it is possible to estimate a reasonable function explaining total spending y_t^e in terms of monetary and fiscal variables.
8. The problems of multicollinearity that will be present in estimating level equations can be treated by using the Ridge regression estimation technique (see Hoerl and Kennard 1970 for a discussion of this method). Some preliminary efforts showed that in the regressions for the aggregate economy, the coefficients were fairly stable. Also, most of the coefficients as shown in tables 1 to 3 are statistically significant, which suggests that multicollinearity is not very severe in the aggregate sectors and industries.

   The rate-of-change formulation has severe shortcomings. First, by construction, the influence of short-run factors is emphasized, sometimes at the expense of long-run factors; the latter may be the most important determinants of wage and price movements. Second, various arbitrary moving average arrangements are often used to obtain better fits and sensible results, but such attempts introduce serial correlation in the estimating equations, and that leads to biased parametric estimates. (See Black and Kelejian 1972, Oi n.d., and Rowley and Wilton 1973 for further discussion.)
9. See Turnovsky (1972), Mincer (1969), and Juster and Wachtel (1972) for further discussion of the issues concerning formulation and effects of expectation on various economic decisions.
10. The expectational variables p^e and D_3 were used as alternatives in the wage equations for the aggregate and industry regressions. The results generally favored using p^e in the aggregate equations and D_3 in the industry ones.
11. For the disaggregate industries overtime hours are not available for 1953–1957. The regression technique was used to extrapolate backward the straight-time earnings series.
12. The methodology used to construct this data set, which is based on the input-output tables for the United States, is fully described in Eckstein and Wyss (1972).
13. The existence of collinearity between this variable and p_{t-1} may explain some of the instability of its coefficient.
14. Using adjusted wage series would have made it difficult to distinguish the effects of labor utilization and capacity utilization; also, it would be difficult to distinguish the effects of trend increase in wages (because of removal of overtime component) and a trend increase in productivity.
15. The coefficient of $p_{ct-1} - p_{ct-2}$ for the nondurables is rather high but statistically not significant.
16. Differentiating a truncated version of the wage equation

$$\ln W_t = a_1 + a_2 \ln P_{ct} + a_3 \ln \left(\frac{P_{ct-1}}{P_{ct-2}}\right)$$

with respect to time and rearranging terms, we get the expression

$$\frac{\dot{w}}{w} = a_2 \left(\frac{\dot{P}_{ct-1}}{P_{ct-1}}\right) + a_3 \left(\frac{\dot{P}_{ct-1}}{P_{ct-1}} - \frac{\dot{P}_{ct-2}}{P_{ct-2}}\right)$$

This implies a short-term price elasticity of less than 1.0 when a_2 and a_3 are less than 1.0; therefore, our results are consistent with those reported by Solow (1968), Gordon (1972), Perry (1970), and others.

17. Nordhaus (1972) reports factor shares as follows:

Sector	Factor Shares (percent)		
	Labor	Capital	Materials
Manufacturing			
Nondurables	.24	.08	.68
Durables	.40	.13	.47
Total	.45	.13	.42
Private nonfarm	.61	.19	.20
GNP	.73	.22	.05

The GNP figures are from the national income accounts; those for manufacturing for 1958 are from the input-output table in *Survey of Current Business*, 1965.

18. In some of nondurables, such as chemicals (SIC 28) and paper products (SIC 26) materials do not enter significantly and are excluded. However, this may be caused by the high collinearity of m_t and p_{t-1} in those industries.
19. Several experiments with industry output variables suggested that aggregate expenditure is a better measure of demand in industry price equations. In most cases, the short-run elasticity of prices with respect to y_t^e ranges from about 0.08 to 0.60. In primary nonferrous, the coefficient of y_t^e depicts the long-run elasticity, since the lagged dependent variable p_{t-1} has been excluded from the regression.
20. Time-series data on unemployment rates for individual industries are not available. Therefore, the unemployment rate for total durables is used in each durable industry and that of total nondurables for each nondurable industry.
21. In the literature the evidence on guideposts has been challenged; see, for example, Gordon (1972b) and Wachter (1970).
22. These were calculated as

$$x_1 = \frac{z_t - z_{t-1}}{z_{t-1}} - \frac{\hat{z}_t - \hat{z}_{t-1}}{\hat{z}_{t-1}}$$

and

$$x_2 = \frac{z_t - z_{t-4}}{z_{t-4}} - \frac{\hat{z}_t - \hat{z}_{t-4}}{\hat{z}_{t-4}}$$

where z_t is the actual and $\hat{z}_t$ is forecast value of levels of prices and wage rates.

23. The results for the private nonfarm sector are not reported because the wage equation is identical to that for the total economy, and the price forecasts are quite similar to the ones presented in the first two columns of Table 9.
24. See Federal Reserve Bank of St. Louis *Review*, September 1974, p. 20, Table 1. These figures are calculated by taking the difference between actual and ex ante projections of the St. Louis Model. The signs of the forecasts errors generated by equation 3 are ignored for comparison purposes.
25. These results are in accord with the recent evidence reported by de Menil (1974).

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COMMENTS

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The Nadiri-Gupta paper is an ambitious attempt to separate and identify the forces driving wages and prices in the United States. The novelty of their approach lies in their including capital costs, and in their attempt to integrate both the long- and short-run disequilibrium factors operating in factor and commodity markets into a single model or set of reduced form estimating equations. While this approach is a standard one in labor markets, this is the first time, to my knowledge, that the same disequilibrium approach has been followed in goods markets. The authors have firms and workers adjusting actual wages and prices toward their long-run equilibrium levels by a simple geometric adjustment process, where the amount of the adjustment is assumed to be influenced by the indicators of short-run disequilibrium, unemployment, and idle capacity.

Solving the profit and utility maximum conditions and combining them with ad hoc short-run adjustment functions, the authors arrive at short-run reduced form estimating equations for prices and wages which show P to be a function of the variables influencing equilibrium price (demand, wages, raw materials, and capital cost) and the short-run adjustment factors (capacity utilization and lagged price level). Similarly, wages are a function of the factors influencing the demand and supply curves of labor (productivity and the cost-of-living index) and the disequilibrium factors (unemployment rates and lagged wages).

The resulting equations are fitted to quarterly observations for 1954I–1971II, using single-equation ordinary least squares or, where autocorrelation is a problem, generalized least squares. The equations are estimated for several aggregates: the aggregate economy, private nonfarm, manufacturing; and several disaggregated subsectors of manufacturing. Separate equations for wages and prices are estimated for each of these sectors. The fitted equations are then used to project prices and wages over the price control period to determine the effect of the control program.

In general, the fits of the model are very good, although this is hardly surprising, since we are fitting time series with a strong time trend. Most of the variables, with the significant exception of capacity utilization, enter the regressions with the expected sign. Wages are the most significant determinant of prices, although the short-run elasticity of prices with respect to wages is only 0.12 in the aggregate. The rental price of capital, a variable generally left out of investigations of inflation, enters positively in most equations, although quantitatively its effect is small.

Demand also enters positively, although there appears to be an unavoidable bias in the aggregate regression since it in effect regresses prices on themselves multiplied by quantity. Note that the coefficients on the demand variable are much smaller in the disaggregated regressions. Also, these coefficients do not capture the entire influence of demand on prices, for demand also has an influence through capacity utilization, a variable that enters negatively and significantly in all the aggregate regressions, in marked contrast with previous studies. Hence the net relationship between prices and aggregate demand remains somewhat unclear.

In the wage equation, the effect of unemployment is as expected, although the additional explanation afforded by the unemployment variable is rather small. In the authors' words: "On the whole, the results suggest that wage increases could be slowed down to some extent if the unemployment rate is rising at an increasing rate."

The model generates long-run elasticities if the regression coefficients are divided through by the adjustment coefficient, which is the coefficient on the lagged endogenous variable. In the long run, the elasticity of prices with respect to demand appears to be quite low (0.28 for the total economy), especially considering the possible bias in the short-run coefficient alluded to above. Productivity enters as a positive influence on wages and a negative influence on prices. According to the model, the first effect outweighs the second, which implies that wages fully capture rising productivity over time. In the long run, the reaction of wages to changes in expected prices is close to if not greater than unity, as can be seen in the right-hand columns of Table 4. Curiously enough, the long-run price coefficient on wages is smaller in manufacturing than in the aggregate economy, which is the opposite of what one might expect, given the extent of union power in the two labor markets.

The model was also run for twelve subsectors of manufacturing. In general, the results are parallel to those at the aggregate levels. Wages and capital costs contribute positively to prices in most cases. The utilization rate is somewhat peculiar. It is positive in four cases, negative in four, and not entered in four. The short-run adjustment coefficients seem to show a tendency to faster adjustment in the more competitive industries.

The model is tested by comparing its goodness of fit during the sample period to a second-order autocorrelation scheme, a test which it passes with flying colors. Having jumped that hurdle, it is then put to work to determine whether price and wage controls had any dampening effect. This is done by running a dynamic simulation of the model over the period 1971III–1972II. If the model overpredicts price or wage levels or both over this period, the authors will conclude that the control program had some effect. However, this procedure will not work if some of the effect of the program finds its way into the supposedly exogenous variables in the model. One such variable is the Consumer Price Index (CPI), an important determinant of wage levels in the short run. If the control program reduces the CPI, then it will have had an effect on wages that will not be captured in the test used by the authors. It could also be the case that the existence of the controls encouraged the authorities to set aggregate demand higher than it would otherwise have been. Since aggregate demand is a positive determinant of prices, the test used will overstate the *net* effect of the control program on prices. Given these conditions, the results indicate that controls had some dampening effect on prices, although its size appears to be small, and a larger, though still small, effect on wage rates. For manufacturing, the controls do not appear to have been effective, particularly as regards prices. It would be useful to the reader if the authors were to provide some cumulative index of predicted and actual prices and wages here, so that a somewhat better judgment could be made about the quantitive importance of the controls program. It certainly does not appear to be large.

Turning now to some comments on the paper, on the theoretical level the most significant departure of this paper from previous work is its attempt to provide a model capable of distinguishing between long- and short-run influences on prices and wages. While that represents a worthwhile advance over the ad hoc models used in previous research, I believe that certain problems still remain in the way that excess capacity and unemployment, the indicators of market disequilibrium, appear in the model. In the first place, it turns out that in the goods market equation, capacity utilization generally enters the regressions with a negative sign. That is, the lower is capacity utilization, the higher prices are likely to be. The authors justify these findings by reference to U-shaped average cost curves. While that explanation may well be right, and while it may be consistent with a markup pricing model, it does not fit very well with equations 5 and 6. If the market systems represented by those equations are dynamically stable, the rates of change of prices and wages should be positively, not negatively, related to the indicators of excess demand.

I have another problem with equations 5 and 6. Because actual and equilibrium prices are explicitly allowed to differ, disequilibrium quantities implicitly influence prices, even if they are not put into the regressions directly. To avoid this, there must be a side relationship between U_i and the difference between P_t and P_t^*. Now, U_i has been put into the regressions as a determinant of the speed of adjustment of prices and wages to their long-run equilibrium levels, an adjustment process which is also partially captured by the other indicator of disequilibrium in the model, namely, P_t^*/P_{t-1}. As far as I can make out, there is nothing in the system guaranteeing that the two indicators are consistent, or to put it another way, there is nothing to guarantee that the system will stop at equilibrium. For example, suppose that prices last period were at their long-run equilibrium level, P^*. Unless $U_{i,t} = 1$ (i.e., excess demand is equal to zero), prices according to the model will continue to change, moving away from their equilibrium level. In order for the model to be consistent, there must be a side condition relating $U_{i,t}$ to the difference between P_t^* and P_t. That being the case, $U_{i,t}$ does not give us any independent information and could be eliminated by a respecification of the model.

Another of the main thrusts of this paper is its disaggregation within the manufacturing sector. Given the work and expense involved, one wonders whether the disaggregation is worth the trouble. That depends on what the disaggregation is intended to accomplish. If one is interested in testing for different models of price setting in manufacturing, the results for individual industries are useful in their own right. If, however, one is primarily trying to improve his predictions of aggregate inflation rates, he will only be interested in disaggregation if the prediction errors he gets by summing up the industry indexes are smaller than those obtainable through some aggregate scheme. Since the paper does not have a complete disaggregation, one cannot judge how worthwhile disaggregation is in this case. However, before researchers plunge off into such work, they ought to stop and ask themselves—and make clear to their readers—just what the purpose of the disaggregation is.

My second category of comments has to do with econometric problems in the paper. One can think of at least three different kinds of simultaneous equation biases in these regressions. The most obvious is that between wages and prices. At the aggregate level there is surely a reverse relationship operating between prices and wages that is affecting coefficient estimates, and I cannot see any reason for not re-estimating the wage and price models simultaneously. Another possible source of bias, as I have already mentioned, is between the demand variable and prices. The demand variable is nominal GNP. Hence, in the aggregate regressions one is very close to regressing prices on themselves. Still another source of bias lies in the possible endogenicity of capacity. Following Hay,[1] if one conceives of firms with market power setting both their production levels and prices as functions of the level of expected aggregate demand, then the capacity variable will not be independent of the error term in the price regression equation and its coefficient will be biased. Finally, given the undoubted serial correlation in all of these time series, I am uncomfortable about using the lagged endogenous variables on the right side of the regression equations.

Assuming that these econometric and structural problems do not invalidate the results, the paper has a basic and very important policy implication that I think bears emphasizing. Though the authors have not given us a way of doing so, it appears that if we were to calculate the effect of a stabilization program on price and wage levels, we would reach the conclusion that demand management is a poor way to try to reduce inflation. The reason is that even though demand enters the regression equations positively, it does so with a rather small sign and is likely to be overshadowed at least in the short run by the behavior of the capacity utilization variable, which would tend to drive prices up as demand was pushed down by the government. There is nothing much to hope for from the labor side, where we see that the unemployment rate has a very weak influence on wages. It is unfortunate that the authors have not worked out a dynamic simulation using their results to show explicitly the effect of demand reduction on prices and wages. I believe that such a simulation would show that restraining aggregate demand would only reduce inflation with a long lag if it reduced it at all.

Furthermore, the simulation would dash the sanguine hopes of some that wage reactions in the labor market would make the stabilization policy effective even if prices react perversely to reductions in capacity utilization. Even though the authors do not quite agree, I think that this paper provides additional evidence on the uncertain relationship between demand and prices in our economy. If that evidence finally leads policymakers to question the assumptions on which they continue to advocate recessions to fight inflation, the paper will have made an important contribution.

NOTES

1. George A. Hay, "Production, Price and Inventory Theory," *American Economic Review*, September 1970, pp. 531–545.