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Econometrics of Inflation, 1965–1974: A Review of the Decade

The decade ending December 31, 1974, has been a turbulent one in the history of postwar inflation. It is ending on a strong upbeat that has caused econometricians to take some new hard looks at their models because they, together with most other economists, failed to foresee the magnitude of the present spurt.

We often tend to magnify contemporary problems, claiming that present issues are more complicated than ever, making analysis especially difficult. Today's problems are certainly not simple, but it is questionable whether they are any worse than usual, particularly when the outstanding ones are viewed in relation to the others. In analyzing inflation since World War II, we have had to deal with postwar decontrol, the Marshall Plan, the Korean War, the closing of the Suez Canal, major European currency revaluations, U.S. stockpiling, and a number of other major complications.

In the present paper, we are faced with the job of disentangling the effects of Vietnam, New Economic Policy (NEP) controls, dollar devaluation, reclosing of Suez, tripling or quadrupling of crude oil

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NOTE: Vincent Su provided much material and insight for the analysis of price and wage relationships during the NEP period.

prices, massive crop failures in the USSR, and many other complicating circumstances. It is unquestionably a difficult period, and gives us reason to think again about fundamental model structure, but it is probably not worse by a different order of magnitude than the two preceding postwar decades.

Ultimately, the inflation record gets registered in price statistics; but in order to understand the econometrics of price formation, it is helpful to look simultaneously at other market-determined variables, namely, wage and interest rates. The prices of factors play strategic roles in determining the prices of goods.

In Table 1, annual values are given for three major price indexes, an overall hourly earnings rate, and the Treasury bill rate. In Table 2, some sensitive and strategic components of the various price indexes are separately listed. Although a great deal of econometric analysis is concerned with short-run analysis by quarters or even months, the broad outlines here are given by years for compactness in presentation. The full flavor of the decade's events is given by an annual presentation.

Prices, by any of the three indexes in Table 1, showed the influence of Vietnam War burdens, growing by more after 1965 than in the early 1960s; but they picked up considerably in 1973, and more so in 1974. Wholesale prices appear to have been a leader in 1973 and have kept right on increasing in 1974. Wage rates, according to the hourly earnings series in Table 1, showed a steady, modestly growing increment until 1974 and are shooting up forcefully now in

TABLE 1 A Decade of Market Rates: Prices, Wages, Interest

	GNP Deflator (1958 = 100)	Consumer Price Index (1967 = 100)	Wholesale Price Index (1967 = 100)	Nonagricultural Earnings (dol. per hr.)	Treasury Bill Rate (percent)
1965	110.9	94.5	96.6	2.45	3.95
1966	113.9	97.2	99.8	2.56	4.88
1967	117.6	100.0	100.0	2.68	4.32
1968	122.3	104.2	102.5	2.85	5.34
1969	128.2	109.8	106.5	3.04	6.68
1970	135.2	116.3	110.4	3.22	6.46
1971	141.6	121.3	113.9	3.43	4.35
1972	146.1	125.3	119.1	3.65	4.07
1973	154.3	133.1	134.7	3.92	7.04
1974	170.2	147.7	160.1	4.22	7.89

SOURCE: *Survey of Current Business*, various issues.

TABLE 2 Components of Major Price Indexes

	GNP Deflator: Import Deflator	Consumer Price Index		Wholesale Price Index	
		Food	Services Excl. Rent	Farm Products	Crude Materials
		(1967 = 100)			
1965	103.4	94.4	91.5	98.7	99.3
1966	105.6	99.1	95.3	105.9	105.7
1967	106.5	100.0	100.0	100.0	100.0
1968	107.7	103.6	105.7	102.5	101.6
1969	110.8	108.9	113.8	109.1	108.4
1970	119.2	114.9	123.7	111.0	112.3
1971	125.0	118.4	130.8	112.9	115.0
1972	133.6	123.5	135.9	125.0	127.6
1973	155.6	141.4	141.8	176.3	174.0
1974[a]	219.7	161.7	152.0	187.7	176.0

SOURCE: *Survey of Current Business,* various issues.
[a] Estimate.

order to recoup some lost ground, as a result of a most unusual American situation in which real wages fell during 1974.

Interest rates behave differently from most of the other market variables; they occasionally come down. The pattern in Table 1 is definitely up, but some declines occurred in 1967 and 1971–1972. Basic commodity prices exhibit this kind of behavior, too. They often fall in the short run. Interest rates were not different from prices, however, in that they rose to record high levels in the most inflationary period, 1973–1974.

When we look at component indexes, in Table 2, it is apparent that import prices show strong effects of dollar devaluation and rising commodity prices. Food and crude materials rise much faster than general averages of consumer or wholesale prices, as do many services. The latter index has significant wage and interest components that account for its rapid rise in recent years.

Price behavior in econometric models must respond to movements in raw material prices, factor prices, exchange rates, major world events, and domestic controls if we are to be able to interpret recent events and to be better prepared for future price projections than we have been in the past. In this period, apart from a brief flurry in 1965, there have not been major changes in indirect taxes, but the future may bring value-added taxes (VAT) or analogous policy changes. It is clearly important to be prepared for them.

ECONOMETRIC SPECIFICATIONS

It may appear superfluous to present a paper on the econometrics of inflation at this time, since a book called *The Econometrics of Price Determination*, based on a Federal Reserve–Social Science Research Council conference held in October 1970, was published just a few years ago.[1] It is odd that we appear to be in need of serious rethinking of the subject so soon after the conclusion of a significant and important conference on it, complete with a published record. The fact of the matter is that the considerations of the 1970 conference offered too little guidance on devaluation, food, fuel, and other basic materials costs in the international transmission of inflation.

The dominant specifications for price determination in U.S. econometric models were ably summarized at that conference in overview papers by James Tobin and Saul Hymans. In a very general way, most of the major macroeconometric models determine price as a markup over unit labor cost, with some allowance for demand pressure. In turn, they determine wage change as a function of unemployment rates and price change.

Distinctions between normal and actual unit labor costs, expected and observed price change, demand pressure through special variables like capacity utilization, order backlogs, inventory position, normal and actual labor force occur in the special structural forms of the different models. These are nontrivial refinements of the basic structure, which may be written as

$$p_t = \alpha_0 + \alpha_1 \left(\frac{wL}{X}\right)_t + \alpha_2 \frac{1}{1 - C_p} + e_{pt}$$

$$\frac{\Delta w_t}{w_t} = \beta_0 + \beta_2 \frac{1}{U_t} + \beta_3 \frac{\Delta p_t}{p_t} + e_{wt}$$

where p = price, w = wage rate, L = employment, X = output, C_p = capacity utilization, U = unemployment, and e_p, e_w = disturbance.

This model implies a partial Phillips-curve relation between $\Delta w/w$ and U for a given value of $\Delta p/p$. If we fix the level or the rate of growth of productivity (X/L) and the rate of capacity utilization (C_p), we can, by substitution, derive a trade-off relationship between the inflation rate $(\Delta p/p)$ and U.[2] It is better to take the analysis further and obtain complete system solutions for $\Delta p/p$ and U as functions of all the exogenous variables and initial conditions. At any given time, these two solution values can be jointly varied through common exogenous input changes, producing the trade-off relationship. These are presented for three models by Hymans and individual authors in *The Econometrics of Price Determination.*[3]

It is easy to see how the degree of overall economic performance as measured by the rate of unemployment or capacity utilization will affect inflation according to these equations, and it is also easy to see how wage costs will influence prices. It is less obvious how exchange rates, indirect taxes, food costs, fuel costs, other materials costs, and capital costs will influence the inflation rate. These are all important in the immediate context. In complete system simulations, many of these factors and government policies, including NEP, may affect price solutions by various indirect routes. These are all important but probably not enough to explain the extreme inflation of 1973–1974.

Most macroeconometric models are designed to explain one basic price, say, the manufacturing, nonagricultural, or GNP price level, and then to relate each separate price level to the main price. This is close to the procedure followed in financial analysis. One basic interest rate, the Treasury bill or commercial paper rate, is explained in a market behaviorial equation, and other rates are made functions of the basic rate in term structure equations.

The basic price equation is customarily a markup on wage and other costs, with an allowance for demand pressure, like the equation above. Prices of major final demand components such as consumer goods or services (and their subdivisions), producer goods, exports, imports, and public purchases are related either to the central price level directly or to the same explanatory variables that appear in the equation for the central price. Allowance is also made for special factors, such as individual tax rates and subsidies or restrictions in particular markets. There are, however, some basic identities that must be fulfilled, namely

$$X = \sum_{i=1}^{n} G_i$$

$$pX = \sum_{i=1}^{n} q_i G_i$$

$$X = \sum_{i=1}^{m} X_i$$

$$pX = \sum_{i=1}^{m} p_i X_i$$

where X = real GNP, p = implicit deflator of GNP, G_i = ith component of GNP on the expenditure side, q_i = implicit deflator of G_i, X_i = value added in the ith sector, and p_i = implicit deflator of X_i. If there is a direct equation for p, one element of q_i and one element of p_i will be residually computed from the identities. Alternatively, all elements of p_i can be directly modeled, and p will be determined by identities. Import prices will generally be assumed to be exogenous.

Nordhaus[4] has conveniently outlined specifications for price equations corresponding to different production functions: fixed proportions, Cobb-Douglas, and constant elasticity of substitution (CES). There are two significant characteristics of his formulas that should be mentioned separately. He introduces materials inputs explicitly into his production functions; therefore, his output variable should be interpreted as gross real output and not value added, as implied in the preceding formulation. This is important for showing how changes in materials input prices affect output price.

The second feature of Nordhaus's formulation is that his price equations are derived as semireduced forms, obtained by substituting product demand and marginal productivity conditions into the production functions and rearranging terms to express output price as a function of three input prices: wage rate, capital rental, and materials price. Productivity is introduced as a neutral time function that is solved for explicit representation in the price equation.

The usual procedure, outlined in the previous section, is to use unit labor cost (wL/X) as a combined variable showing both wage and productivity (output per man-hour) effects all at once. In the Cobb-Douglas case, there is nothing wrong in using this variable in a price equation, together with other marginal conditions, production functions, and demand functions as separate simultaneous equations. These should give the same system results as Nordhaus's semireduced price equations, provided that all stochastic properties are carefully watched on substitution and reduction. Similar propositions would hold for other production functions. The point is that legitimate transformations and combinations within simultaneous equation systems can be made without having any essential effects on the outcome, although the apparent structure may look different and convey different degrees of information about the underlying system.

There is much simplicity and elegance in Nordhaus's specifications, however, and they are convenient for showing how each input price makes a marginal contribution to final output price, at the same time allowing for overall productivity effects. His general form is $p = f(w, q, v, Y, t)$, where p = output price, w = wage rates, q = capital rental, v = materials price, Y = consumer income, and t = time trend (productivity effect).

This formulation is highly desirable for partial or satellite model studies in which the production process has a small number of materials inputs. Agriculture with feed, seed, fertilizer would be a case in point. Energy industries with intermediate fuel input would be another. However, for outputs in a general system, it will probably be advisable to make use of an input-output approach, as sketched immediately below.

The basic I/O equation, $(I - A)X = F$, relates the gross output vector X to the final demand vector F through the technology matrix A. The matrix I is the identity matrix. We shall define two other matrices, $X = BY$ and $F = CG$, where Y is a vector of values added by the producing sector and G is a vector of GNP components. The matrix B is diagonal and can be obtained from the original I/O matrix as

$$B = \begin{pmatrix} \frac{1}{1-\sum_i a_{i1}} & 0 & \cdots & 0 \\ 0 & \frac{1}{1-\sum_i a_{i2}} & \cdots & 0 \\ \cdot & \cdot & \cdots & \cdot \\ 0 & 0 & \cdots & \frac{1}{1-\sum_i a_{in}} \end{pmatrix}$$

In the present context it is a diagonal matrix of markup factors, showing how value added must be factored up to equal gross output. If we multiply an element of X by an element of B^{-1}, we show how much must be subtracted from gross output in order to obtain value added. The matrix C is constructed from the composition of final demand deliveries by sector. Let us consider m types of final demand, ranging from consumption through investment and public purchases to exports.

$$\begin{aligned} F_1 &= F_{11} + F_{12} + \cdots + F_{1m} \\ F_2 &= F_{21} + F_{22} + \cdots + F_{2m} \\ &\vdots \\ F_n &= F_{n1} + F_{n2} + \cdots + F_{nm} \end{aligned}$$

Elements of the GNP vector G are column sums

$$\sum_{k=1}^{n} F_{kj} \qquad j = 1, 2 \ldots, m$$

If we divide each F_{ij} by its corresponding column sum, we have the matrix

$$C = \| F_{ij}/\sum_{k=1}^{n} F_{kj} \|$$

From the matrix equation $(I - A)\, BY = CG$, we can derive $Y = B^{-1}(I - A)^{-1}CG$, which expresses how elements of G are transformed into elements of Y. This is called a row transformation because row elements of $B^{-1}(I - A)^{-1}C$ express Y as a weighted sum of elements of G. The sum of Y elements define GNP and so, also, the sum of G elements. We should modify this for appropriate treatment of imports as separate elements of Y, either combined with competitive goods produced domestically or in a separate component if they are noncompetitive. The elements of G, therefore, sum to GNP plus imports, or total supply of goods and services available.

A current-price accounting identity is $p'Y = q'G$. This says that the total of available supply measured as current value added plus imports equals the total current value of GNP plus imports. The row vector p' is a vector of value-added prices, and q' is a vector of implicit GNP deflators.

By substitution we have the identity

$$p'B^{-1}(I - A)^{-1}CG = q'G$$

This identity must hold for all values of G; therefore, we can write

$$\sum_{i=1}^{n} p_i d_{ij} = q_j \qquad j = 1, 2, \ldots, m$$

These are column transformations of p into q. They express each q_j as a column-weighted sum of the elements of p. The weights come from the columns of

$$D = B^{-1}(I - A)^{-1}C$$

The deflators of GNP components, or final demand prices, are, therefore, weighted averages of all sector prices, many of which are intermediate goods and some of which are imported goods. They are elements of p corresponding either to a (noncompetitive) import row or to goods whose characteristics are like those of imported world goods. In general, we would expect movements in domestic prices to follow world prices for nearly identical goods. Equations to explain sector prices in such a model should include international factors that affect domestic prices. Price equations by sector of origin of production should be markup relations on sector costs, as indicated above, but they should be modified by variables representing supply-demand balance. In the cases of sectors that have large competitive import components, it is important to include world price conditions for the commodity line in question. In all cases, indirect tax rates, tariffs, and other special exogenous variables should be included in the sector price relationships.

The price conversion or column problem has been outlined for value-added prices. These are more available in a neat social accounting sense as deflators of gross product originating by sector, i.e., as deflators of X when its elements are measured in current prices. Although data may be less available on a large scale across all sectors, it is more straightforward to explain price of gross output by sector. Let us denote this price vector by p^*. Then we have by definition[5]

$$p_j^* X_j = p_j Y_j + \sum_{i=1}^{n} p_i^* x_{ij}$$

This can be transformed to

$$p_j^* = p_j \frac{Y_j}{X_j} + \sum_{i=1}^{n} p_i^* \frac{x_{ij}}{X_j}$$

$$p_j^* = p_j \left(1 - \sum_{i=1}^{n} a_{ij} \right) + \sum_{i=1}^{n} p_i^* a_{ij}$$

In matrix notation this becomes $p^* = B^{-1}p + Ap^*$. The relation between p^* and p can be written as $p^* = (I - A')^{-1} B^{-1} p$.

We thus have a system of equations to transform prices of value added, p, into prices of gross output, or vice versa. As long as the elements of A are constant, it does not matter whether the analysis is carried out in terms of prices of gross output or of value added. The crux of the matter, however, is to model changes in A (and hence B) and also in C. This is needed in order to construct complete models that combine both I/O and macroeconomic analysis. This is the kind of model building and price explanation started in the Brookings model and implemented on a large scale by Ross Preston.[6]

If there are complete equation sets for wage and other costs by sector, in a combined I/O–macromodel system, price equations for each sector with conversion into price deflators of final demand would seem to provide a full explanation of the pricing process. In addition to cost factors in price determination by sector, there should be equations for inventories or other measures of demand pressure, such as order backlogs or capacity utilization, to complete the explanation.

There is, however, another approach to input-output analysis that appears to be feasible and promising for price determination, namely, through the use of rectangular input-output systems.[7]

Let

X_i = output of the ith commodity, $i = 1, 2, \ldots, m$

Z_j = output of the jth sector, $j = 1, 2, \ldots, n$

F = vector of final demand

The basic input-output relations are

$$X = AZ + F$$

$$Z = RX$$

Typical elements of A and R are

$a_{ij} = \frac{X_{ij}}{Z_j}$ = input of the ith commodity per unit of output of the jth sector

$r_{ij} = \frac{Z_{ij}}{X_j}$ = share of sector i in the output of commodity j.

We can compute total output of each commodity from

$$\begin{aligned} X &= ARX + F \\ &= (I - AR)^{-1} F \end{aligned}$$

This should give "target" or "desired" amounts of X. Call them X^*. Dynamic price formation equations can then be formulated as

$$\Delta p_{it} = \lambda_i \, (X^*_{i,t} - X_{i,t-1})$$

Other adjustment equations would also be possible.

The elements of A and R might, in the first instance, be assumed to be constant. This would be in the spirit of conventional I/O analysis. A more elaborate theory could be constructed to generate time movements of a_{ij} and r_{ij} as direct analogues of the systems that have been developed to generate movements in conventional I/O matrices, assuming a specific underlying production function, such as Cobb-Douglas, CES, or some other.[8]

ECONOMETRIC EXPERIENCE

In the inflationary decade, how did econometric analysis of prices fare? There are several different ways of looking at this question. The first will be to examine the residuals from estimated price equations to see whether "unexplained" variation is random or whether it shows a systematic tendency to be positive and increasing during the period of acceleration of inflation. This tendency can be examined for the whole decade or for any subperiod of particular interest from the viewpoint of inflation. It will be a matter of separating systematic variation that can be "explained" by variables in the price formation equations, as outlined above, from residual variation.

A second approach will be to examine complete system simulation residuals to see how well price movements are interpreted in an inflationary era within the sample period of equation estimation, in extrapolation (ex post), and in genuine forecast simulations.

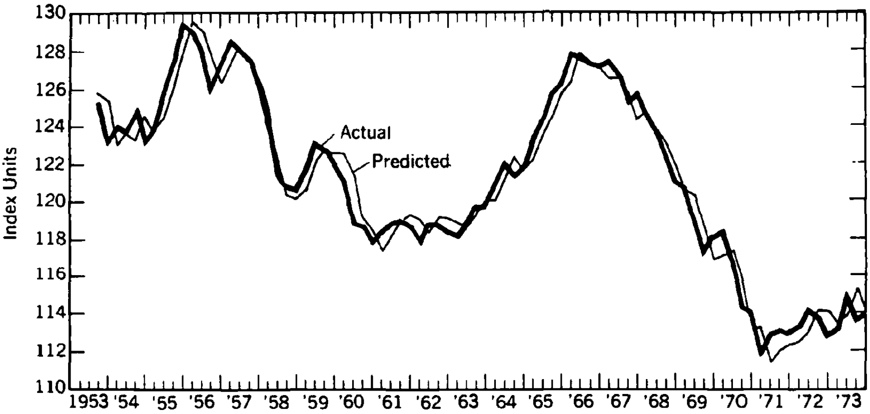
Finally, system response to external disturbances can be investigated, particularly price responses to disturbances that would be naturally associated with inflation. These responses will be investigated by means of hypothetical simulations.

The vehicle for econometric study in this paper will be the Wharton model. During the period under consideration, this model has gone through three major changes of updating, elaboration, respecification, and comprehensive re-estimation. This means that one single set of price equations, definitions of price variables, or model simulations cannot be used for the whole period of analysis. Also, within a given model, some changes were made in specification of the price equation alone when inflationary problems became so severe that deficiencies were brought to light. Record keeping for actual forecast performance is relatively recent, especially in terms of detail; consequently, more information is available for the past few years than for the whole decade.

There are two principal price variables in the Wharton model. One is the price of manufacturing output, originally the wholesale price index of nonfarm, nonfood products, and later taken to be the implicit deflator of value added in manufacturing.[9] The other is the implicit GNP deflator. As explained in an earlier section, the price of manufacturing output is obtained directly from a behavioral equation for price formation, while the GNP deflator is obtained from a definitional relation as a ratio of nominal to real GNP. The separate deflators of the components of GNP depend principally on the price of manufacturing output or on things related to it. In that sense, both price variables give similar information as indicators of inflation. When residual analysis is considered, the price index of manufacturing output will be the variable to take into account. For system simulation, however, it will be preferable to use the GNP deflator because it has remained as a conceptually stable statistical series through the successive variants of the model, while the manufacturers' price has changed from time to time and provides a variable rather than a fixed standard of reference.

In the latest version of the Wharton model, Mark IV, there are many sector prices, and manufacturing is disaggregated into durable and nondurable components. The equations for these two prices follow the usual markup over normal unit labor costs, pressure of capacity utilization, and lags. The residuals determined in fitting these equations to a given series of price data show no tendency toward acceleration in 1965–1966 or in the most recent period. They do not even show clearly the effects of the freeze and successive phases. Residuals for these periods are not fundamentally different from those of earlier periods. The largest residuals, in absolute value, occur in 1960II and 1953IV (see Table 3 and Figure 1). The root-mean-square residual is 0.97 over the whole eighty-quarter span. In the ten quarters of NEP (through 1973IV), there are five positive and five negative residuals. One is markedly larger (twice as large) and one is markedly smaller (almost zero) than 0.97. It thus appears that standard price behavior

FIGURE 1 **Estimated Residuals, Price Equation for Durable Manufactures, 1953III–1973IV**



SOURCE: Table 3.

prevailed in the sense that the ratio of prices to normal unit labor cost (adjusted for indirect taxes) changed as capacity pressures and trends changed, without any special effects evident from the control program. It is not to be assumed that controls were ineffective, but only that they did not alter the basic price-wage relationship. The basic movement of durable goods prices was upward in this most recent period, but nondurables showed practically no positive drift (before 1974).

TABLE 3 Estimated Residuals: Price Equation for Durable Manufactures, 1953III–1973IV (1958 = 100.0)

	Actual	Predicted	Residual	Percent Error
1953III	125.4126	125.8060	−0.3934	−0.3137
IV	123.3722	125.4495	−2.0773	−1.6838
1954I	124.0760	123.1132	0.9629	0.7760
II	123.7466	123.6375	0.1091	0.0882
III	124.8748	123.2437	1.6310	1.3061
IV	123.3665	124.5042	−1.1377	−0.9222
1955I	123.9643	123.6431	0.3212	0.2591
II	125.7042	124.5406	1.1636	0.9257
III	127.4427	126.1300	1.3127	1.0300
IV	129.4395	127.7663	1.6731	1.2926
1956I	129.1452	129.4465	−0.3013	−0.2333
II	128.0792	129.1316	−1.0524	−0.8217
III	125.9323	127.8497	−1.9174	−1.5225
IV	127.3130	126.2724	1.0406	0.8173
1957I	128.5383	127.4605	1.0778	0.8385
II	128.0407	128.2416	−0.2008	−0.1569
III	127.4938	127.6005	−0.1068	−0.0837
IV	126.2587	126.4548	−0.1961	−0.1553
1958I	124.2166	124.5767	−0.3601	−0.2899
II	121.4175	122.4966	−1.0791	−0.8887
III	120.7651	120.3612	0.4039	0.3344
IV	120.5551	120.3006	0.2545	0.2111
1959I	121.6083	120.6296	0.9787	0.8048
II	123.0978	122.1443	0.9536	0.7746
III	122.8239	122.7762	0.0477	0.0388
IV	121.8633	122.5775	−0.7142	−0.5861
1960I	120.9747	122.5491	−1.5744	−1.3014
II	118.7809	121.2742	−2.4933	−2.0991
III	118.5744	119.0243	−0.4499	−0.3794
IV	117.7539	118.4637	−0.7098	−0.6028

TABLE 3 (continued)

	Actual	Predicted	Residual	Percent Error
1961I	118.2795	117.3586	0.9209	0.7786
II	118.7195	118.2013	0.5182	0.4365
III	118.9835	118.8409	0.1426	0.1199
IV	118.6437	119.2680	−0.6243	−0.5262
1962I	117.9422	119.0230	−1.0809	−0.9164
II	118.7131	118.4495	0.2636	0.2221
III	118.6416	119.1371	−0.4955	−0.4177
IV	118.4379	119.0582	−0.6203	−0.5237
1963I	118.1565	118.9481	−0.7916	−0.6700
II	118.8988	118.8013	0.0976	0.0821
III	119.5757	119.3902	0.1854	0.1551
IV	119.6642	120.0176	−0.3534	−0.2953
1964I	120.8154	120.0330	0.7824	0.6476
II	121.9981	121.1262	0.8719	0.7147
III	121.3767	122.2236	−0.8469	−0.6978
IV	121.9204	121.5457	0.3748	0.3074
1965I	123.1586	122.3112	0.8474	0.6880
II	124.3382	123.4684	0.8697	0.6995
III	125.6508	124.5686	1.0822	0.8612
IV	126.2353	125.7332	0.5022	0.3978
1966I	127.7717	126.3893	1.3824	1.0820
II	127.5114	127.7793	−0.2679	−0.2101
III	127.3401	127.4034	−0.0634	−0.0498
IV	127.2633	127.0924	0.1710	0.1343
1967I	127.4125	126.5197	0.8928	0.7007
II	126.6686	126.4932	0.1754	0.1385
III	125.2273	125.7032	−0.4759	−0.3800
IV	125.6008	124.3657	1.2351	0.9834
1968I	124.5636	124.7522	−0.1886	−0.1514
II	123.7671	123.8074	−0.0403	−0.0325
III	122.4730	123.0098	−0.5368	−0.4383
IV	121.0939	121.8188	−0.7250	−0.5987
1969I	120.6635	120.6559	0.0076	0.0063
II	118.7186	120.2429	−1.5243	−1.2840
III	117.2443	118.5132	−1.2690	−1.0823
IV	118.0294	116.9108	1.1186	0.9477
1970I	118.3183	117.1710	1.1473	0.9697
II	116.6899	117.4107	−0.7208	−0.6177
III	114.3406	115.8010	−1.4604	−1.2772
IV	113.9969	113.0752	0.9217	0.8085
1971I	111.8324	113.0841	−1.2517	−1.1192
II	112.7720	111.2373	1.5347	1.3609

TABLE 3 (concluded)

	Actual	Predicted	Residual	Percent Error
III	113.0688	112.0307	1.0381	0.9181
IV	112.9439	112.3633	0.5807	0.5141
1972I	113.1587	112.4791	0.6796	0.6006
II	114.0812	113.0315	1.0497	0.9201
III	113.6471	114.1450	−0.4979	−0.4381
IV	112.7246	114.1034	−1.3788	−1.2232
1973I	113.0352	113.4429	−0.4077	−0.3607
II	114.7964	113.8138	0.9826	0.8560
III	113.5130	115.3444	−1.8314	−1.6134
IV	113.8616	113.9509	−0.0893	−0.0785

NOTE: Durbin-Watson statistic = 1.69145.

In the following estimated OLS equation the figures in parenthese are t ratios; the residuals are shown in Table 3:

$$\begin{aligned}(1-R)PXMD/NULCD &= \underset{(2.82)}{10.62} - \underset{(3.15)}{0.019t} \\ &+ \underset{(5.10)}{8.41}\ (CPMD - NCPMD)/NCPMD + \underset{(30.63)}{0.92}\ [(1-R)PXMD/NULCD]_{-1}\end{aligned}$$

$R^2 = 0.96$; $SEE = 0.97$; $DW = 1.69$

where

$PXMD$ = index of the price of output originating in durable manufacturing (1958 = 100)
R = average rate of indirect business taxes (federal)
$NULCD$ = normal unit labor costs (ratio of wage rate to twelve-quarter trailing average of productivity in durable manufacturing)
$CPMD$ = Wharton index of capacity utilization in durable manufacturing
$NCPMD$ = twelve-quarter trailing average of $CPMD$

Another way of looking at residuals is in single-equation extrapolation beyond the sample period, where observed values are substituted for the explanatory variables, and the residual differences between observed and estimated price are tabulated. It is standard practice in forecasting with the Wharton model to evaluate residuals in this manner for the eight quarters just preceding each new set of quarterly forecasts. The purpose of this calculation is to detect drift in behavioral patterns, structural change, or the influence of data revisions. While this procedure is now systematic, older

TABLE 4 Residuals from Equation for Manufacturing Price (Wholesale Price Index of Industrial Commodities)

Date Computed	Span	Quarter							
		1	2	3	4	5	6	7	8
5/21/74	'72II–'74I	−.044	−.054	−.065	−.074	−.079	−.097	−.093	−.069
3/25/74	'72I–'73IV	−.043	−.044	−.054	−.066	−.074	−.079	−.098	−.094
12/13/73	'71IV–'73III	−.042	−.043	−.044	−.055	−.066	−.075	−.082	−.100
9/21/73	'71III–'73II	−.033	−.042	−.043	−.045	−.056	−.068	−.078	−.084
6/14/73	'71II–'73I	−.036	−.031	−.038	−.045	−.055	−.065	−.075	−.061
3/19/73	'71I–'72IV	−.001	.002	.014	.009	.014	.010	.007	.002
12/26/72	'70IV–'72III	.005	.012	.014	.018	.005	.017	.012	.015
8/21/72	'70III–'72II	.006	.005	.012	.014	.018	.006	.017	.013
6/12/72	'70II–'72I	.003	.006	.005	.009	.011	.014	.001	.015
3/20/72	'70I–'71IV	.007	.003	.006	.005	.009	.011	.014	.001
12/16/71	'69IV–'71III	.004	.006	.004	.008	.008	.012	.014	.017
5/26/71	'69II–'71I	.002	.000	.003	.006	.003	.006	.004	.010

records do not exist and, therefore, the values tabulated in Table 4 are given only for the period since May 1971. Each row in the table has two reference times: the date at which the residuals are computed and the period for which the residuals are computed.

There is a break in the tabulated values because a new price equation was introduced in April 1973 in order to take better account of the inflationary impact of import prices under exchange devaluation, to make better estimates of normal unit labor costs, and to sharpen the nonlinear effects of capacity utilization. Prior to April 1973, the price equation used generally underestimated actual prices. After the new equation was introduced, the residuals turned negative, indicating that the new equation overestimated prices.

With the old equation, the residuals show no regular tendency to grow. The residual for the fourth quarter of 1971 is generally quite small. This period has the full effect of the freeze and Phase II. It is the first full quarter after the introduction of NEP (August 15, 1971). The residuals get larger in absolute value after the beginning of 1973, but as they are all negative, they do not show the effects of growing inflation that the price equation might have failed to reflect.

The Mark IV residuals for all separate price equations in the control period provide information both on extrapolation and on aspects of the effectiveness of the controls. Table 5 contains residuals for individual quarters from 1971III through 1974II for each price variable by sector of origin, and the period is blocked off into NEP "phases." The sample period ends in 1971II for these calculations; they postdate those for Mark IV above in that they incorporate some recent data revisions.

This is a mixed pattern. Contract construction shows the restraining influence of wage agreements in that industry through the early part of the extrapolation period. The results are largely negative (price restraint) in agriculture, nondurable manufacturing, finance, and services but are positive or mixed in other sectors. In most cases, these tabulations refer to price movements in relation to wage rates; therefore, it is worthwhile to look into the wage patterns also. In addition, there is a general feeling that NEP was more strongly directed at wage restraint than at overall restraint of prices or nonlabor factor incomes.

Residuals from wage rate equations in the Wharton model, Mark IV, extended beyond the sample, from 1971III through 1974II, are given in Table 6. As in the case of prices, the special wage agreements in the construction sector show through clearly.

TABLE 5 Residuals for Price Variables by Sector of Origin, Wharton Model, Mark IV, 1971III–1974II

NEP Phase	Year and Quarter	Agriculture	Mfg. Durables	Mfg. Nondurables	Transportation	Communication	Electricity and Gas	Contract Construction	Trade	Finance, Insurance, Real Estate	Services
I	1971III	−4.8	1.2	−0.8	−1.3	1.8	0.4	−5.6	0.2	−1.2	−0.9
	IV	1.6	0.7	−1.4	0.8	−0.6	2.0	−2.6	−0.7	−1.3	−1.2
II	1972I	−6.7	0.8	−0.9	0.5	1.3	3.8	−1.3	−2.8	−2.4	−3.7
	II	−2.8	1.1	−0.4	0.2	0.2	2.3	−4.2	−1.3	−4.5	−3.6
	III	−0.3	−0.6	−1.7	−0.1	1.6	1.5	−0.6	−0.7	−2.6	−2.8
	IV	−2.6	−1.6	−1.6	−1.0	2.9	2.5	2.7	0.5	−3.2	−2.2
III	1973I	−6.9	−0.6	−3.0	−0.2	3.5	4.2	3.8	−0.4	−6.3	−7.9
	II	−1.6	0.9	−1.2	1.0	3.9	3.1	5.1	1.1	−3.3	−3.6
	III	−3.4	−2.1	−1.4	−0.2	4.8	2.8	−4.8	0.3	−3.5	−3.7
	IV	−0.2	−0.2	0.0	1.6	6.7	6.2	−7.4	1.9	−2.4	−0.3
IV	1974I	−29.3	1.8	−0.4	1.9	8.7	11.2	−11.2	1.4	−2.8	−3.6
	II	−30.5	2.9	−6.0	1.6	7.6	10.5	−7.2	1.8	−2.4	−1.9

TABLE 6 Residuals for Wage Variables by Sector of Origin, Wharton Model, Mark IV, 1971III–1974II

NEP Phase	Year and Quarter	Agriculture	Mfg. Durables	Mfg. Non-durables	Regulated Sectors	Mining	Contract Construction	Trade	Finance, Insurance, Real Estate	Services
I	1971III	−.034	.000	.014	.116	.132	−.025	.002	−.008	.031
	IV	.005	−.034	−.012	.018	.260	−.165	−.011	−.010	−.001
II	1972I	.032	.031	.031	.095	.100	−.104	.037	.023	.047
	II	−.015	−.014	.003	−.020	.153	−.022	−.002	−.004	.013
	III	−.105	−.002	.006	−.013	.289	−.105	.007	−.004	−.005
	IV	−.024	.021	.010	−.018	.202	.007	−.002	−.020	−.011
III	1973I	.096	.018	.046	.082	.325	−.062	.022	.025	.044
	II	.025	.009	.002	−.044	.092	−.190	.029	−.073	−.017
	III	−.001	.009	−.003	−.072	.122	−.056	.016	−.026	−.020
	IV	.060	−.012	−.019	−.040	.050	−.181	.010	.009	−.008
IV	1974I	−.016	−.026	−.014	−.014	.192	−.084	.002	−.043	.016
	II	.157	.073	.067	−.070	.147	−.244	.034	−.060	.007

There are predominantly negative residuals in the wage estimates for this sector. The results in mining are for persistent positive residuals. Most other sectors are mixed, although the regulated and finance sectors tend to have negative residuals. There is no clear evidence here that unduly depressed wage rates held down prices or that wage rates were even associated directly with high prices during the NEP period.

If the sample is extended through 1974II so that NEP-phase periods are included, the corresponding tables of residuals are liberally sprinkled with plus and minus entries across all sectors. There is not even a definite tendency for contract construction to have almost all negative residuals. This sector does, however, have strongly negative price residuals through most of Phase II, a period that ended during the last part of 1972.

It is one thing to fit a single equation with small random residuals or even to extrapolate a single equation with correct values for the explanatory variables, and quite another to simulate a whole system with estimated values for all endogenous variables. Three generations of Wharton models have been simulated over historical sample periods, some covering all or part of the period of price acceleration (from 1965 on) within the simulation period and some covering the acceleration period alone.

For reference, let us consider the second generation of Wharton models.[10] For a simulation horizon of one quarter, the root-mean-square error of the GNP deflator in index points for 1949II–1964IV was 0.48; for two quarters, 0.74; for three quarters, 0.89; and for four quarters, 0.99. For the corresponding complete system for Mark III, next generation, for 1960I–1970I, the figure for a one-quarter horizon was 0.25; for two quarters, 0.39; for three quarters, 0.52; and for four quarters, 0.71. This latter is probably a more difficult period to reproduce because it includes the accelerating inflation, but more effort was directed at price determination because of the recognition of forecast difficulties in the applications of the older model. The errors for Mark III are uniformly lower than those of the earlier-generation model. For the earlier acceleration period, 1965I–1970I, alone, the twenty-quarter dynamic simulation of Mark III generated a root-mean-square error of 1.24 index points.

In the extension of the simulation horizon to cover eight quarters, rather than four, the error grows to about one full index point. In extrapolation, however, the error is much larger—about two to three times as large as the within-sample errors. Extrapolation of the Mark III model over the period 1970II–1972IV generates the following root-mean-square errors:

Simulation Horizon (quarters)							
1	2	3	4	5	6	7	8
0.72	0.96	1.04	0.80	1.02	1.41	1.99	2.73

In the first year of extrapolation, it is necessary to reckon with an error of at least one full index point in an inflationary period. In the second year ahead, this error allowance must amount to at least two full index points. It will be seen, below, that these limits are too narrow in application to genuine ex ante prediction during the much stronger inflationary period extending to early 1974.

The latest generation of Wharton models is just being introduced, and preliminary simulations of complete systems show the prevalence of errors amounting to over two full index points in the second year of two-year simulations. The period covered is one of accelerating inflation. When these calculations are extended beyond the range of Table 7, right up to the double-digit periods in 1974, the errors get larger—as much as five index points. A strong effort has been made to improve the mechanism of price determination in the model, but a sizable error persists. Errors greatly in excess of two index points do not occur with any frequency through 1973, but in 1974 the price explosion exceeds model capabilities, and truly large errors appear. The largest discrepancies occur right after the termination of controls, but complications of oil prices, oversized trade deficits, and dollar weakness are not to be neglected in the analysis and in the attempt to draw definite conclusions about the reasons for the underestimate of inflation.

The preceding tabulations have dealt with performance after the fact, either in the sample-fitting period or in a period after that of the sample extrapolation period, but both are hypothetical exercises. It is interesting to examine how well the model as a whole could genuinely predict the rate of inflation in realistic forecast situations. Detailed records are available for Wharton model forecasts from 1967. The forecasts were made regularly from 1963 on, but careful record keeping was not instituted in the earlier years. Some summary statistics are available, but period-by-period forecasts from the "control" solutions are difficult to recover systematically before 1967. The tabulation figures in Table 8 are grouped by quarters into annual forecasts in order to make the presentation more compact. The quarterly record is available but is no more illuminating than the annual results made at each year's end for two years into the future.

TABLE 7 Wharton Model, Mark IV: Actual and Simulated Values of the GNP Deflator

Year and Quarter	Actual	Simulated				
1964I	108.2	108.3				
II	108.5	108.6				
III	109.1	109.2				
IV	109.6	110.1				
1965I	110.2	110.3	109.8			
II	110.7	111.1	110.6			
III	111.0	111.8	111.4			
IV	111.5	112.6	112.1			
1966I	112.4		113.4	112.7		
II	113.5		114.3	113.4		
III	114.5		115.4	114.5		
IV	115.4		116.3	115.2		
1967I	116.2			115.8	115.6	
II	116.8			116.4	116.2	
III	118.0			117.2	116.9	
IV	119.4			118.5	118.1	
1968I	120.4				118.2	119.8
II	121.6				118.9	120.6
III	122.9				120.0	121.8
IV	124.3				121.0	122.9

1969I	125.6	124.2	125.5			
II	127.2	126.3	127.8			
III	129.1	128.6	130.2			
IV	130.9	130.6	132.3			
1970I	132.9		134.7	132.8		
II	134.4		136.3	134.1		
III	135.8		137.9	135.4		
IV	137.9		139.9	136.7		
1971I	139.5			137.9	138.8	
II	141.1			139.3	139.8	
III	142.0			140.7	141.1	
IV	142.7			142.0	142.2	
1972I	144.6				143.6	144.5
II	145.3				144.7	145.7
III	146.5				146.2	147.3
IV	148.0				147.4	148.4
1973I	149.9					151.8
II	152.6					154.6
III	155.7					159.4
IV	158.9					161.7

The annual story is one of consistent underestimation of inflation, improving at each year's one-year-ahead revision of the prior two-year-ahead forecast but generally yielding a figure below the actual inflation rate. The figures in Table 8 are for the GNP deflator, which gives a good summary picture of inflation running ahead of the model.

In 1970 and 1972 the one-year-ahead prediction was quite close, but in the other years, there was a consistent underestimate. The largest inflationary increment, in 1973–1974, was seriously understated in terms of the level of the variable predicted, but the *increment* between the two years was much closer to the actual amount because both years were systematically biased. This is an example of the general finding that forecasts of change are more accurate than forecasts of level if the latter are systematically biased. This is what has happened in forecasting price movements in recent years.

The main conclusions would not be different if we were to tabulate the results by quarters rather than by years. General results for the whole period, in quarterly forecasting, are shown in Table 9. These show small size and growth of errors in change form but larger error values in level form, especially for the second year of a two-year forecast horizon. A closer examination of the period since the imposition of controls is given in the second and fourth lines of the table. That this is a more difficult period to predict is shown by the enlargment of the error values in most cases. Two years ahead, errors have been as large as four to five index points, while the error of prediction of change has usually been under 1.5

TABLE 8 **Wharton Model: Year-End Predictions of Annual Values of GNP Deflator, 1967–1973 (1958 = 100)**

Release Date for Prediction	Annual Prediction Period						
	1968	1969	1970	1971	1972	1973	1974
11/12/67	120.7	123.3					
12/23/68		125.2	128.4				
11/26/69			134.2	137.7			
12/10/70				139.3	142.8		
12/21/71					146.4	152.5	
11/29/72						150.6	155.8
12/21/73							164.8
Actual	122.3	128.2	135.2	141.3	146.1	154.3	170.2

TABLE 9 Wharton Model: Root-Mean-Square Error in GNP Deflator (1958 = 100)

Period	Prediction Horizon (quarters) 1	2	3	4	5	6	7	8	First Yearly Average
					Level of GNP Deflator				
1967I–1974I	0.44	0.98	1.76	2.64	3.41	4.11	4.66	5.10	1.35
1971II–1974I	0.46	1.07	1.96	2.96	3.69	4.07	4.04	3.79	1.48
					Change in GNP Deflator				
1967I–1974II	0.44	0.69	0.96	1.06	1.06	1.19	1.19	1.20	0.66
1971II–1974I	0.46	0.82	1.25	1.31	1.37	1.47	1.47	1.50	0.74

index points. The kind of inflation surprises that have disturbed most people—householders, business people, and public authorities—have been unexpected additional rates of five or more index points; therefore these short-run errors are serious. An upper limit of tolerable error should be about 1.5 index points, preferably one index point; therefore, room for improvement exists.

The sensitivity of complete-system solution to external shocks in the form of world price changes is of interest in trying to associate domestic price changes with those in world markets. Accordingly, the Wharton model forecast that was released on July 31, 1974, was chosen as typical. It was used as a baseline case, and four major external prices in the system were changed—the price index of imported goods, the price index of imported services, an average of foreign consumer price indexes, and the price index of world trade. The first is an important explanatory variable in the equation for goods imports and the next two are significant in the imports of services. The fourth index is an important explanatory factor in the export equation. The differences in the exogenous inputs can be seen in Table 10.

In the table the level and growth rate of external prices in the disturbed solution were set so that the input values at the end of the simulation (eight quarters later) would be 98 percent of the baseline cases in all four instances. These lower values reduce the corresponding price indexes of the baseline case by 4.4 to 4.8 index points. The results on a central price variable, the price deflator of output originating in manufacturing, are shown in the last two lines of the table. The price was chosen because it is more sensitive to external import prices. The GNP deflator hardly changes, certainly

TABLE 10 External Price Variables and Manufacturing Deflator in the Wharton Forecast, July 31, 1974
(1958 = 100)

	1974II	1974III	1974IV	1975I	1975II	1975III	1975IV	1976I
Price of imported goods								
Baseline	200.2	207.5	212.0	216.3	220.3	224.4	228.3	232.3
(Disturbed)	(199.7)	(206.4)	(210.4)	(214.1)	(217.4)	(221.0)	(224.2)	(227.5)
Price of imported services								
Baseline	204.7	209.7	213.7	217.7	221.7	225.7	229.7	233.7
(Disturbed)	(204.2)	(208.6)	(212.0)	(215.5)	(218.9)	(222.2)	(225.7)	(229.0)
Foreign consumer prices								
Baseline	200.4	205.2	209.6	213.7	217.5	221.5	225.2	229.0
(Disturbed)	(199.9)	(204.2)	(208.0)	(211.6)	(214.9)	(218.2)	(221.4)	(224.6)
World price								
Baseline	198.0	202.7	207.0	211.1	215.0	219.0	222.8	226.6
(Disturbed)	(197.6)	(201.8)	(205.6)	(209.2)	(212.4)	(215.9)	(219.1)	(222.2)
Mfg. deflator								
Baseline	137.7	141.2	144.3	147.4	150.1	152.7	155.4	158.3
(Disturbed)	(137.6)	(141.1)	(144.2)	(147.1)	(149.8)	(152.3)	(154.8)	(157.6)

not significantly, between the two solutions. This is partly because of the negative treatment of imports in adding up the elements of the GNP.

There is a distinct lowering of the price of domestic manufactures if world prices are lowered. The more that external prices are lowered through time, the more domestic prices come down. At the end of the simulation horizon (eight quarters later), when external prices are 98 percent of baseline values, simulation results for the manufacturing deflator come down to 99.6 percent of the baseline case: a fall of approximately 2 percent in external prices results in a fall of approximately 0.4 percent in an important domestic price. Most other deflators of output originating do not change significantly.

DEFICIENCIES AND POTENTIAL IMPROVEMENTS

The recent inflation has been unkind to economists generally. No matter who among them might claim that they saw inflation coming as far back as 1965, they probably did not even consider its present magnitude as a likely possibility. This remark applies to economic analysts generally, whether they be econometricians or non-econometricians, or whether they use monetary tools, fiscal tools, productivity tools, or any other general approach to analysis of the economy. Inflation was underestimated in severity, duration, and general time shape.

In many respects this is a professional failure, and it should provoke a response. To me, the natural response is not to ask for a complete revamping of theoretical and statistical tools of economic analysis, although some popular writers have jumped to this conclusion. As I look at the problem from the viewpoint of econometric model building and attempts to forecast inflation, together with many other performance characteristics of the economy, I see a continuing need to make model formulations more detailed and richer in terms of all the processes that can be accommodated. We have come a long way in the past twenty years in integrating monetary and interindustry materials into econometric models. By themselves, they add to the areas of understanding of the inflation (and other) problems. We have not yet fully integrated national income, input-output and flow-of-funds (F/F) accounts into one complete model although we have made paired combinations of national income accounts (NIA) with I/O and NIA with F/F. As our data and understanding of model building progress, we are gradually achieving this grand synthesis. Our NIA systems provide us with the markups on labor and capital costs and capacity pressures; our I/O systems add markups on materials costs (especially strategic and imported materials); finally, our F/F systems show longer-run influences of money and credit conditions. The present inflation combines all these aspects.

Naturally, any model that encompasses all these factors will have to be large and detailed. This places us in the thousand-equation range. We are just learning how to handle such systems efficiently, and I really believe that this is the route to follow, instead of looking for some breakthrough observation gained by respecification or manipulation of small macro models. Inflation, or price movements generally, are never purely a demand phenomenon, a cost phenomenon, or a monetary phenomenon. The situation always involves a strong mixture of several aspects. It is not generally possible to identify some particular line of the inflationary process in a pure form.

Any narrow approach that concentrates on money supply is going to miss some big influences coming from basic materials markets or industrial capacity pressures. A focus solely on wage movements will be equally liable to failure. We have witnessed so many inflation avenues in the data, modeling, and performance since 1965 that it should be clear that we will have to allow for a wide variety of channels in a large-scale model. This means building more realism and detail into our existing systems and not attempting to build some new macro theory or to add a twist to an existing one.

Given that future econometric research on the price formation sectors of national models should continue along existing lines but be elaborated in detail, as I have argued in this paper, there is still a technical question remaining to be answered: Should we look back historically on the period 1965–1974 in future time series data samples as one that was so disturbed that significant use of dummy variables would be recommended in order to make the equations conform more closely to reality?

This type of question has been finessed, not entirely legitimately, for the Korean War period by starting up most time series investigations in econometric model building after 1954. After that period, there were Kennedy-Johnson guidelines, the Vietnam War, the various phases of NEP, the Soviet wheat deal, and the oil crises. At the time of occurrence of these momentous events, special care and adjustment were made to price-wage equations in order to interpret contemporaneous movements in the economy. Retrospectively, however, we do not find a need for widespread use of dummy variables in order to eliminate outlying observations for the estimation of price equations covering the whole period from 1954 through 1974. It is possible that equations in some specific sectors, like the contract construction sector, would show improvement if these special periods, particularly the eras of Vietnam and NEP, were "dummied out," but the general nature of our findings suggests that these periods will not appear to be so unusual in historical perspective. This is what we are finding in price-wage equations fitted to the whole span.

NOTES

1. Otto Eckstein, ed., *The Econometrics of Price Determination* (Washington, D.C.: Board of Governors of the Federal Reserve System, 1972).
2. *Trade-off* is a better expression for what is meant than *Phillips curve* because the latter usually refers to a structural relation between wage change and unemployment.
3. A. A. Hirsch, "Price Simulations with the OBE Econometric Model"; G. de Menil and J. J. Enzler, "Prices and Wages in the FR-MIT-PENN Econometric Model"; S. H. Hymans, "Prices and Price Behavior in Three U.S. Econometric Models." For the trade-off curve from the Wharton model, see G. I. Treyz, "An Econometric Procedure for Ex Post Policy Evaluation," *International Economic Review*, June 1972, pp. 212–222.
4. W. D. Nordhaus, "Recent Developments in Price Dynamics," in Eckstein, ed., *The Econometrics of Price Determination*.
5. This set of relationships was suggested by E. C. Hwa.
6. J. Duesenberry et al., eds., *The Brookings Quarterly Econometric Model of the United States* (Amsterdam: North-Holland, 1965) and Ross S. Preston, *The Wharton Annual and Industry Forecasting Model*, Studies in Quantitative Economics, no. 7 (Philadelphia: University of Pennsylvania, Economics Research Unit, 1972). Also see Chapter 12, below, on the CANDIDE model of Canada.
7. T. Matuszewski, "Partly Disaggregated Rectangular Input-Output Models and Their Use for the Purposes of a Large Corporation," in A. Bródy and A. P. Carter, eds., *Input-Output Techniques* (Amsterdam: North-Holland, 1972).
8. Systems with Cobb-Douglas production functions have been constructed by M. Saito, "An Interindustry Study of Price Formation," *Review of Economics and Statistics*, February 1971, pp. 11–15. The CES system has been worked out in linear form by B. G. Hickman and L. Lau, "Elasticities of Substitution and Export Demands in a World Trade Model," *European Economic Review* 4 (1973):347–380. This was developed for international trade analysis, but has been adapted for the I/O problem by Ross S. Preston. A translog specification has been proposed by Jorgenson in E. A. Hudson and D. W. Jorgenson, "U.S. Energy Policy and Economic Growth, 1975–2000," *Bell Journal of Economics and Management Science*, Autumn 1974, pp. 461–514.

9. In the 1966 and 1968 versions of the Wharton model, the price of manufacturing output was more central than in the present (Mark III) version introduced in 1970. In the latter, the price of output of the regulated sector and, also, the price of commercial output assumed some importance in overall price determination. In Mark IV, the newest version, there are many more sector prices.
10. L. R. Klein and M. K. Evans, *The Wharton Econometric Forecasting Model*, 2nd enlarged ed. (Philadelphia: University of Pennsylvania, Economics Research Unit, 1968).

COMMENTS

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In this paper, Klein reviews ten very difficult years. In part, his paper, like many others at this conference, is an exercise in economic history, for he looks at the evidence concerning the effects of the various game plans, NEPs, and phases of economic policy over the last decade. And his paper is in part a postmortem for econometric models as well as for economic policy, for he reviews the price predictions generated by econometric models over the decade. He also advances certain methodological suggestions as to how we might proceed to do better in the future.

It is fair to say that this was not econometrics' finest hour. The basic structure, summarized by Klein early in his paper, customarily involves one equation relating price changes to labor costs per unit of output and capacity utilization, and another explaining wage changes in terms of unemployment and the speed of inflation. Such a system was not well equipped for analyzing the cost-push effects of currency devaluation and the Organization of Petroleum Exporting Countries (OPEC). Klein reports that the control program did not influence the basic price-wage relationship. However, he does report that the construction industry did indeed exercise restraint. Klein presents evidence showing that the successive refinements of the Wharton model led to improved predictive accuracy, but the annual story is one of consistent underestimation of inflation. Using the most recent Wharton model, Klein presents a two-year simulation showing that a 2 percent moderation in the rate of increase in the price of imports would slow the U.S. inflation by about 0.4 percent.

Perhaps the most intriguing aspect of Klein's paper concerns his buoyant optimism about the future for large-scale econometric models. At the beginning of the paper, he suggests that we should not magnify contemporary problems, and indeed suggests that every decade, not just the one under review, has had its share of disrupting factors to befuddle the analyst. He does not argue that present problems can be patched up with a mendacity parameter reflecting the White House climate, and he warns against any attempt to "dummy out" recent experience. Klein rejects single-cause explanations, pointing out that inflation has involved a mixture of cost-push, demand, and monetary elements. He does argue that we are gradually approaching a Grand Synthesis involving the integration of national income, input-output, and flow-of-funds accounts into one complete model in the thousand-equation range. The Grand Synthesis may involve a structure approaching the complexity of microsimulation models advocated by Guy Orcutt. While the track record for input-output quantity forecasts is such as to suggest that we should not be overly optimistic about the usefulness of these techniques in predicting price movements, Klein will allow for substitution effects by making the input-output coefficients responsive to changes in relative prices. Critics of Klein will doubtless argue that even 999 equations would be too many. My own view is that we should not shave too closely with Bishop Occam's razor. Because of the successive revolutions in computer technology, an econometric model composed of 1,000-plus equations may be no more mind-boggling today than the twelve-equation Model III that Klein published in 1950. But in an era in which research funds are again in short supply, it is interesting to observe that techniques of analysis that competed in earlier decades for foundation support are now appreciated as complementary modes of analysis.