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A Technique for Analyzing and Decomposing Inflation

I. INTRODUCTION

Although interest in the phenomenon of inflation is both long-standing and widespread, formal analysis has for the most part concentrated on analyzing and projecting broad price level aggregates, such as the wholesale and consumer price indexes and the national output deflators(as an excellent case study, see Eckstein, ed. 1972). Until recently this approach was quite successful, but in the last couple of years most macroeconomic models of price behavior have performed poorly. As is well known, the general inflation of the past two years has been accompanied by significant relative price adjustments and this, in turn, has led to very unusual relationships among the several different price indexes. It is our belief that an examination of the properties and biases of the different price

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indexes, as well as a detailed and disaggregated examination of their components, is necessary for a more complete understanding of the movement of prices over the recent period. In what follows, we will attempt to work out a procedure for this and then outline a preliminary attempt to analyze and decompose the inflation.

The behavior of prices over the past two years has been not only distressing to consumers but equally puzzling to economists and other analysts. The discontinuity in the rate of inflation was the first surprising feature. Over the past two decades, there has never been as rapid an acceleration in price level increases as over the past two years: the consumer price index increased 3.6 percent in 1972, 9.4 percent in 1973, and at an annual rate of 12.7 percent in the first six months of 1974. The last time such a large discontinuity in the rate of inflation occurred was during the Korean War period.

The second extraordinary feature of the recent inflation was that the different price indexes showed widely different rates of inflation. For example, over the entire two-year period July 1972–July 1974, the wholesale price index (WPI) rose 35.1 percent, the consumer price index (CPI) rose 18.2 percent, the seasonally adjusted GNP deflator rose 15.1 percent, and the wage rate of production or nonsupervisory workers likewise rose 15.1 percent. The puzzle is that the historical pattern of the relationships among these series is exactly the opposite, with wages usually rising the most rapidly, followed by the consumer price index and GNP deflator, which, in turn, have risen more than wholesale prices (WPI). What accounts for this inversion in the relationships?

With the WPI rising more than twice as fast as the price of domestic output (represented, say, by the GNP deflator), how is it possible that profits have not been enormously squeezed? This question seems particularly difficult to answer when it is considered that the wholesale sectors as defined by the Bureau of Labor Statistics (BLS) account for approximately one-half of the value added of the economy. As it turns out, much of the puzzle about the relative performance can be explained by the peculiar construction of the wholesale price index. In the next section, we consider the current index, show the bias involved in its construction, and present a preliminary version of an improved index.

A second aspect of this paper, which we deal with in section III, is concerned with accounting for, or decomposing, the inflation experienced in the wholesale sectors, that is, we present a technique for determining how much of the inflation was due to each of a list of exogenous sectors, for example, how much was due to wage rate increases, grain price hikes, or jumps in the price of crude oil? We

developed this approach in response to a notion that the recent inflation was somewhat different from previous inflationary episodes. The price increases seemed less strongly fueled by inflationary labor contracts and more concentrated among crude foods and materials. To some extent, all these vague notions are confirmed by the analysis.

II. PROBLEMS OF THE WHOLESALE PRICE INDEX

As stated above, most of the puzzling divergence among the published WPI, the CPI, and the GNP deflator can be explained by the peculiar, and we think faulty, construction of the WPI. The index includes a wide array of goods and services, although exactly which ones are included seems to have been determined in a rather ad hoc manner. These goods and services differ substantially in their stage of manufacture. The index itself is a compilation of a relatively large number of subindexes (or "price-relatives"). It can be represented as

$$WPI = \sum_{i=1}^{N} W_i P_i^1 \Big/ \sum_{i=1}^{N} W_i P_i^0; \quad \sum_{i=1}^{N} W_i = 1.00 \tag{1}$$

where W_i is the weight assigned to commodity classification i, P_i^0 is the initial or base-period price for that commodity classification, and P_i^1 is its current price. As the weights are not revised from month to month, but rather are determined by base-period characteristics of the sectors, the WPI is a Laspeyres index and thus generally tends to exaggerate inflation relative to a chain index.

There are, however, much more serious biases constructed into the index. One major flaw of the current WPI is that the weights are proportional to the value of total sales of the various sectors. The problem is that in aggregating the subindexes, price increases experienced by crude products are double and triple counted. For example, when the price of wheat rises, it will influence the WPI as a price increase of wheat, flour, and bread. The more stages of manufacture a crude item goes through, the greater the weight assigned to it. Conversely, the official WPI underweights price movements of items at later stages of manufacture. As long as all prices are changing in a more or less uniform manner, this problem of the WPI weighting system is not apparent. However, if the inflation is particularly acute among crude products and materials, as in the past two years, the index will badly exaggerate the increase in the level of wholesale prices.[1]

It seems to us that the current procedure followed by the BLS is indefensible on economic grounds.[2] It clearly has its roots in historical procedures, for it is only relatively recently that detailed input-output information has been available for construction of a more appropriate index. With the systematic collection of that information, there is no reason not to reconstruct the index in such a way as to avoid the problem of double counting.

In an earlier paper (Nordhaus and Shoven 1974), we presented two alternative indexes for a wholesale price index, one based on value-added weights, the other on net-output weights. The method of construction of value-added weights is self-explanatory. Net-output weights in principle aggregate the entire wholesale sector as if it were a single firm and treat the ratio of the price of that "wholesale firm" to the rest of the economy as the relevant concept. The weights, quite naturally, are proportional to the sales of the "wholesale firm" *to the rest of the economy*; they are "net-output weights" in the sense that they net out sales within the "wholesale firm." The rationale behind this weighting system is that the transaction prices and the circular flow within the "wholesale firm" are irrelevant to nonwholesale buyers; it is only the prices and quantities that exit from the "wholesale firm" that are important.

In this paper, we have presented only the net-output–weighted wholesale price index.[3] The reason for this is that an index with value-added weights may not accurately reflect prices if purchases of the "wholesale firm" from outside itself are significant and move differentially from prices within the wholesale sector. Consider, as an example, a rise in prices due only to an increase in the price of imported petroleum. To take the extreme case, assume that the domestic petroleum industry simply transships petroleum products and, therefore, has no value added. In such a scenario, a net-output price index would reflect the fact that wholesale prices have increased. However, with a value-added index, the petroleum industry would have a zero weight, and therefore the rise in petroleum prices would lead to no (direct) rise in the wholesale price index.[4] It seems to us that the WPI should reflect increases in the prices of "wholesale" goods from whatever source these price increases originate, and for that reason, we prefer a net-output WPI to a value-added index.

In order to compute the net-output weights we used a slightly updated version of the 1967 input-output (I/O) table published by the U.S. Department of Commerce, with the revisions being made in the import coefficients. This table is more recent than the one used in our previous article, and that fact has modified the com-

parability of the results somewhat. Imports were expanded to five rows and the columns were updated to be consistent with data available for the fourth quarter of 1972.

In the computation of our alternative net-output WPI, the major problem was caused by the lack of correspondence of the input-output sectors of the Department of Commerce with the sectors of the WPI subindexes. In fact, the WPI classification does not match the Standard Industrial Classification (SIC), the Standard Commodity Classification, the United Nations Standard International Trade Classification (SITC), or any other standard classification. This situation necessitated the construction of a concordance between the WPI sectors and the input-output sectors as no monthly price statistics are computed for the latter. This task has been completed, but imperfections in this concordance could introduce some errors into our analysis. The concordance we used is described in detail in Appendix B (on microfiche; see inside back cover).

We computed our net-output WPI for three separate nine-month periods: November 1970–August 1971, the pre-Phase I period; November 1972–August 1973, the same time span two years later, and the period in which grain and agricultural prices rose so substantially; and October 1973–July 1974, the most recent period for which complete data are available. We have also shown the results for the two-year period July 1972–July 1974. The results are given in the following tabulation; the official universe of industries is included:

Time Period	Official WPI (% increase)	Net-Output WPI (% increase)
11/70–8/71	3.61	2.49
11/72–8/73	17.73	12.75
10/73–7/74	16.58	14.30
7/72–7/74	35.09	28.42

In each of the three nine-month periods, the net-output WPI increased less, although the absolute difference is most significant in the November 1972–August 1973 case.

A second problem with the official WPI is that it excludes a very sizable portion of the economy. All services—public and private—are excluded, as are construction, publishing, transportation, communication, much of public utilities, and all of trade. Historically this selection has led to a downward bias, but the opposite was clearly the case in the period November 1972–August 1973. During that period, prices in the excluded sectors went up significantly less

than average; for example, in construction and printing and publishing, sectoral prices increased only 5.0 and 7.2 percent, respectively.

There is a real but not terribly profound question involved in the choice of sectors for inclusion in a wholesale price index. Historically, the United States WPI has covered mainly mining, foods, and manufacturing. The omission of services, construction, publishing, transportation, communication, public utilities, and trade was undoubtedly related to the unavailability of price data rather than to any deeply held conviction that these were not "true" wholesale industries. As with the problem of weights, the availability of broader and higher quality data makes the question of the universe of a wholesale price index open for discussion and revision. One possible candidate would be an "industrial" price index that would have the same universe as the widely used industrial production index. We admit that we see little intrinsic merit in a wholesale price index per se; rather the index is of interest insofar as it predicts future trends in the prices of final goods to consumers, firms, or to the economy as a whole.[5]

In attempting to construct a wholesale price index that contains a broader universe of industries, we have included all sectors classified by the Department of Commerce under agriculture, forestry and fisheries, mining, construction, manufacturing, communications, and utilities (these correspond to input-output sectors 1 through 68). We repeat that there is no clear justification for the exact delineation of sectors as regards inclusion or exclusion. Rather, we have tried to construct a broad index of the price level of the business sector of the economy. Using this universe, we calculated the percent change in a net-output–weighted index for the same four periods as above, and the results are displayed in the following tabulation:

		Net-Output WPI	
Time Period	Official WPI (% change)	Official Industries (% change)	I/O Sectors 1–68 (% change)
11/70–8/71	3.61	2.49	3.08
11/72–8/73	17.73	12.75	9.73
10/73–7/74	16.58	14.30	12.94
7/72–7/74	35.09	28.42	24.98

Analyzing the results, one sees that the narrow sectoral span of the official WPI gave a lower estimate of the rate of inflation in the first nine-month period, but resulted in a higher estimate over the

other three time intervals. The difference was particularly significant in the November 1972–August 1973 period, as was anticipated above. Comparing the performance of the broadly based net-output WPI with that of the official index, one can draw several conclusions. Most striking perhaps is that the official WPI indicated a rate of inflation 82 percent greater than the broadly defined net-output WPI during November 1972–August 1973. This was, of course, the time span in which grain prices increased so dramatically. A second result, perhaps equally important, is that while the official WPI indicated that the rate of inflation in the wholesale sectors was slightly lower during October 1973–July 1974 than November 1972–August 1973, the net-output WPI indicates the opposite—in fact, indicates the rate to have been some 33 percent greater.

To summarize, it is our opinion that the problems associated with the official wholesale price index should be high on the agenda for official review and revision. There can be differences of opinion as to the proper universe for a wholesale or industrial price index, but the weighting system currently used cannot be defended on economic grounds. In earlier periods, the peculiarities of the official index have not resulted in grossly distorted estimates of the rate of inflation. However, in the last two years, the index has significantly exaggerated price level movements, and consequently, its periodic announcement has probably done the economy a disservice.

III. DECOMPOSING INFLATION

In addition to the perplexing divergence between the WPI and CPI, which we now have gone a long way toward explaining, there still is the question of determining how much of the inflation was due either directly or indirectly to price increases of livestock and agricultural products, how much due to crude oil price increases, and how much was caused by wage rate hikes. In this section, we present a technique for decomposing the inflation, thereby providing some answers to these questions.

In order to accomplish this decomposition of the inflation, we divide the economy into two broad sectors, a "normal-pricing" sector and a "sensitive-pricing" one. We justify this procedure on the ground that firms in much of the economy appear to set prices essentially on the basis of normal, or cyclically adjusted, average costs of production.[6] There appears to be very little price reaction

in the normal pricing sector to changes in demand, at least within the range of variation observed over the postwar period. Rather, the response to an increase in demand is an increase in the quantity produced (or in backlogged orders), as well as an increase in the purchases of primary factors, labor, materials, and, eventually, capital. It is only if and when the increased demand for primary factors results in higher input prices that the normal-pricing firms raise their prices.

The second part of the economy is the price-sensitive sector. The prices of these goods are competitively determined. Many of them appear on commodity exchanges and often they are traded on world markets. In these sectors, prices are set by the traditional textbook principles of supply and demand, and these are indeed sensitive, sometimes very sensitive, to the evolution of demand. At present, we do not fully understand why this bifurcation of pricing phenomena occurs, nor is the exact delineation of the two sectors obvious. In what follows, however, we have taken the price-sensitive sector to be relatively small, including mainly crude materials. For the rest of the economy, we assume that the practice is that of normal pricing.

In order to implement our procedure, we have again made use of our slightly updated and revised version of the Department of Commerce's 1967 input-output table. We have assumed that the per-unit-of-output labor coefficients of the various sectors decline through time because of productivity increases. We assumed that the rate of labor productivity growth for each sector was equal to that estimated by Greenberg and Mark (1968) and Egbert (1968) for 1947–1964. All other coefficients are assumed constant over time. Let A be the direct unit input requirement matrix:

$$A = \begin{bmatrix} A_{11} & \cdots & A_{1n} \\ \vdots & & \vdots \\ A_{n1} & \cdots & A_{nn} \end{bmatrix} \tag{2}$$

where A_{ij} is the amount of input i required to produce one unit of output j. Then we know by definition of value added that

$$\vec{P} \equiv A'\vec{P} + \overline{VA} \tag{3}$$

where

$$\overline{VA} \equiv w\vec{L} + \vec{T} + \vec{\pi} \tag{4}$$

with $\vec{P}$ being the n-dimensional column vector of prices; $\overline{VA}$, the vector of value added per unit of output; $\vec{L}$, labor requirements per

TABLE 1 Listing of Exogenous Sectors

1. Livestock and livestock products	9. Stone and clay mining and quarrying
2. Other agricultural products	10. Chemical and fertilizer mineral mining
3. Forestry and fishery products	11. Imported crude foods
4. Agricultural, forestry, and fishery services	12. Imported manufactured foods
5. Iron and ferroalloy ores mining	13. Imported crude materials
6. Nonferrous metal ores mining	14. Imported semimanufactures
7. Coal mining	15. Imported manufactured goods
8. Crude petroleum and natural gas	

unit of output; w, the wage rate; $\vec{T}$, the vector of indirect business taxes per unit of output; and $\vec{\pi}$, the profit rate, including depreciation, by sector.

The interpretation of equation 3 is that prices equal materials costs plus labor costs, taxes, and profits. Solving that equation for the column vector of prices we obtain the following equation:

$$\vec{P} = [I - A']^{-1}\overrightarrow{VA} \tag{5}$$

which gives prices as a function of labor costs, indirect business taxes, and profits (or return to capital).

In contrast to the above procedure, we have split the input-output sectors into two classifications, the exogenous or price-sensitive sectors and the endogenous or normal pricing sectors. An exact list of our fifteen exogenous sectors is contained in Table 1. The cost or price of labor is likewise taken to be exogenous, even though it is clearly not competitively set nor is labor traded on world markets. We have assumed that the other two components of value added—indirect business taxes and profits—are constant per unit of output. Perhaps this is one defect of our procedure, as it would have been more in line with earlier studies to assume that profits are marked up on normal costs.

Consider a rearrangement of the matrix of per unit direct requirements (A) so that the fifteen exogenous sectors are numbered 1 through 15, and the remaining seventy-five, which are considered endogenous, are numbered 16–90. Thus, A is partitioned as follows:

$$A = \begin{bmatrix} A_{11} & \cdots & A_{12} \\ \vdots & & \\ A_{21} & \cdots & A_{22} \end{bmatrix} \tag{6}$$

where

A_{11} = 15 × 15 matrix of exogenous inputs into exogenous outputs;
A_{12} = 15 × 75 matrix of exogenous inputs into endogenous outputs;
A_{21} = 75 × 15 matrix of endogenous inputs into exogenous outputs (these coefficients are generally quite small);
A_{22} = 75 × 75 matrix of endogenous inputs into endogenous outputs

Let $\vec{P}_{ex}$ be a 15-dimensional column vector of exogenous prices, and let $\vec{P}_{en}$ be a 75-dimensional column vector of endogenous prices. For a given change in the prices of our fifteen exogenous products, $\Delta\vec{P}_{ex}$, and a change in the price of labor, Δw, equations 3 and 4 imply for the endogenous sectors that

$$\Delta\vec{P}_{en} = A'_{22}\Delta\vec{P}_{en} + A'_{12}\Delta\vec{P}_{ex} + \vec{L}\Delta w + \Delta\vec{T}_{en} + \Delta\vec{\pi}_{en} \tag{7}$$

Again, our hypothesis is that the input-output coefficients are constant except for the assumption made about labor productivity above and that there is no change in per unit taxes or profits, i.e., $\Delta\vec{T}_{en} = \Delta\vec{\pi}_{en} = 0$. We therefore can write our hypothesis in terms of the predicted changes in endogenous prices, $\Delta\vec{P}^*_{en}$, caused by the observed changes in the prices of the exogenous sectors, $\Delta\vec{P}_{ex}$, as follows:

$$\Delta\vec{P}^*_{en} = A'_{22}\Delta\vec{P}^*_{en} + A'_{12}\Delta\vec{P}_{ex} + \vec{L}\Delta w \tag{8}$$

Thus, our theory is that price changes in the endogenous sectors reflect cost changes due to exogenous price movements.[7] Solving equation 8 for $\Delta\vec{P}^*_{en}$, we obtain

$$\Delta\vec{P}^*_{en} = [I - A'_{22}]^{-1}[A'_{12}\Delta\vec{P}_{ex} + \vec{L}\Delta w] \tag{9}$$

Equation 9 gives the 75-dimensional column vector of predicted endogenous price changes, $\Delta\vec{P}^*_{en}$, as a function of the changes in the prices of the exogenous products and labor. The impact of each of the exogenous price changes can be evaluated separately, thus allowing a partial decomposition of inflation in the seventy-five endogenous sectors. Another procedure is to compare $\Delta\vec{P}^*_{en}$ with the observed price changes in these endogenous sectors, perhaps by aggregating both into price indexes.

Our interest, as in the previous section of the paper, is in the sectors that form the official and our revised WPI. Recall that the broadened universe of our WPI included input-output sectors 1–68. The first ten of these are the first ten of our exogenous sectors previously listed in Table 1. The remaining fifty-eight are among the seventy-five endogenous sectors of our model. To give an example of the richness of the technique, a detailed decomposition of the inflation in these fifty-eight sectors is shown in Table 2 for the nine-

(10)

month period November 1972–August 1973.[8] Clearly our hypothesis is far from perfect, in that the different observed rates of inflation are not perfectly predicted by the direct and indirect cost changes due to price changes in the exogenous sectors. For some sectors the model predicts quite well (note, for example, that, ΔP^*_{en} for item 4, food and kindred products, is 29.93 percent compared to the observed price change of 33.45 percent) while for others, for example, leather products (no. 23), the model does poorly. In order to judge how much of the observed variation in inflation across the fifty-eight endogenous sectors of Table 2 is predicted by our list of fifteen exogenous sectors plus labor, we computed the sample correlation coefficient, i.e.,

$$r = \frac{\sum_{i=1}^{58} (\Delta P^*_{en_i} - \bar{\Delta} P^*_{en})(\Delta P_{en_i} - \bar{\Delta} P_{en})}{\sqrt{\sum_{i=1}^{58} (\Delta P^*_{en_i} - \bar{\Delta} P^*_{en})^2 \sum_{i=1}^{58} (\Delta P_{en_i} - \bar{\Delta} P_{en})^2}} \tag{10}$$

The results for the four periods reported earlier were as follows (r ranges from $+1.0$ to -1.0):

11/70–8/71: +.4351	10/73–7/74: +.5339
11/72–8/73: +.6064	7/72–7/74: +.5952

Perhaps at this point we should emphasize that what our technique offers is an *accounting* for inflation and not an explanation or direct identification of its causes (such as incorrect monetary or fiscal policy). However, the results of the analysis do provide insight into the nature of the price increases (e.g., whether they are largely "labor cost-push," raw materials induced, or "demand-pull") and should be quite useful in suggesting the appropriate anti-inflationary policy instruments.

Returning to Table 2, one encouraging fact we note is that the residuals seem to center around zero, meaning that while the *variation* of price increases across sectors may have been only partially predicted, the *level* of inflation in these fifty-eight sectors has, in fact, been closely predicted. That is, price changes in our relatively short list of exogenous commodities did, on the whole, account for the level of inflation experienced during November 1972–August 1973 in the fifty-eight endogenous sectors that enter our revised WPI.[9] In order to analyze this factor more precisely and to report on the three other periods, we aggregated the data of Table 2 (and the analogous tables for the other time periods) and formed indexes for each of the various columns. In constructing these indexes, we took

TABLE 2 Decomposition of Inflation in Endogenous Sectors 1–58, November 1972 to August 1973

Sector	Actual % Price Increase (1)	Cost Increase due to[a] Exog. 1–4 (2)	Exog. 5–10 (3)	Exog. 11–15 (4)	Exog. 16 (5)	Exog. 1–16 (6)	Residual Col. 1 less Col. 6 (7)
1. New construction	5.359	0.741	0.330	0.746	1.823	3.639	1.720
2. Maintenance and repair construction	5.359	0.432	0.280	0.483	2.078	3.273	2.086
3. Ordnance and accessories	3.228	0.366	0.235	0.939	1.050	2.589	0.639
4. Food and kindred products	33.453	27.064	0.075	1.673	1.117	29.929	3.524
5. Tobacco manufactures	4.255	15.308	0.030	0.372	0.313	16.023	−11.768
6. Broad and narrow fabrics, yarn and thread mills	16.889	7.697	0.145	2.696	0.667	11.205	5.684
7. Misc. textile goods and floor coverings	3.633	5.123	0.169	2.760	0.671	8.723	−5.090
8. Apparel	2.934	2.590	0.081	3.120	1.516	7.307	−4.373
9. Misc. fabricated textile products	2.839	3.797	0.112	2.275	1.470	7.653	−4.814
10. Lumber and wood products, except containers	19.737	3.894	0.133	1.975	2.046	8.048	11.689
11. Wooden containers	10.270	1.675	0.109	0.924	2.491	5.198	5.072
12. Household furniture	4.657	1.336	0.143	1.228	0.415	3.123	1.534
13. Other furniture and fixtures	7.131	0.691	0.199	0.942	0.430	2.262	4.869
14. Paper and allied products, except containers	7.229	0.985	0.232	1.756	1.416	4.390	2.839
15. Paperboard containers and boxes	7.300	0.387	0.128	5.755	1.109	7.379	−0.079
16. Printing and publishing	2.402	0.562	0.110	0.601	2.469	3.743	−1.340
17. Chemicals and selected chemical products	9.585	0.722	0.845	2.040	−0.153	3.455	6.131
18. Plastics and synthetic materials	4.129	0.734	0.459	1.058	−0.198	2.053	2.077
19. Drugs, cleaning, and toilet preparations	0.676	1.179	0.179	2.053	−0.170	3.241	−2.566
20. Paints and allied products	6.001	2.546	0.400	1.500	−0.190	4.257	1.744

20.	Paints and allied products	6.001	2.546	0.400	1.500	−0.190	4.257	1.744
21.	Petroleum refining and related industries	16.352	0.180	4.287	1.877	−0.323	6.021	10.332
22.	Rubber and misc. plastic products	2.860	0.728	0.186	2.146	1.909	4.969	−2.109
23.	Leather tanning and industrial leather products	−5.602	8.491	0.136	2.998	1.651	13.275	−18.878
24.	Footwear and other leather products	1.465	2.243	0.090	1.987	2.126	6.445	−4.980
25.	Glass and glass products	−1.660	0.311	0.187	1.346	1.323	3.167	−4.827
26.	Stone and clay products	3.039	0.331	0.516	1.266	1.207	3.319	−0.280
27.	Primary iron and steel manufacturing	3.149	0.206	0.772	2.087	1.513	4.579	−1.430
28.	Primary nonferrous metal manufacturing	17.662	0.280	2.557	3.310	1.239	7.385	10.277
29.	Metal containers	3.356	0.506	0.450	1.187	1.430	3.572	−0.216
30.	Heating, plumbing, and structural metal products	4.435	0.328	0.450	1.642	1.476	3.896	0.539
31.	Stampings, screw machine products, and bolts	4.435	0.227	0.390	1.596	1.488	3.702	0.733
32.	Other fabricated metal products	3.511	0.280	0.394	2.135	1.347	4.156	−0.645
33.	Engines and turbines	2.475	0.258	0.320	3.012	1.253	4.844	−2.369
34.	Farm machinery and equipment	2.116	0.268	0.262	2.704	1.278	4.511	−2.396
35.	Construction, mining, and oil field machinery	4.038	0.266	0.269	0.940	1.405	2.881	1.157
36.	Materials handling machinery and equipment	2.413	0.292	0.301	0.929	1.505	3.026	−0.613
37.	Metalworking machinery and equipment	3.710	0.227	0.210	3.319	1.250	5.007	−1.298
38.	Special industry machinery and equipment	5.783	0.371	0.255	1.902	1.401	3.928	1.855
39.	General industrial machinery and equipment	3.325	0.317	0.306	1.299	1.427	3.349	−0.024
40.	Machine shop products	3.325	0.311	0.293	0.686	1.495	2.784	0.541
41.	Office, computing, and accounting machines	2.281	0.444	0.133	2.905	1.245	4.726	−2.446
42.	Service industry machines	2.281	0.391	0.352	1.071	1.378	3.193	−0.912

TABLE 2 (concluded)

Sector	Actual % Price Increase (1)	Cost Increase due to[a] Exog. 1–4 (2)	Exog. 5–10 (3)	Exog. 11–15 (4)	Exog. 16 (5)	Exog. 1–16 (6)	Residual Col. 1 less Col. 6 (7)
43. Electric industrial equipment and apparatus	1.884	0.372	0.330	0.983	1.157	2.842	−0.958
44. Household appliances	0.926	0.411	0.328	1.114	1.092	2.944	−2.018
45. Electric lighting and wiring equipment	1.859	0.329	0.334	0.906	1.058	2.627	−0.768
46. Radio, television, and communication equipment	−0.541	0.247	0.119	4.403	0.976	5.745	−6.285
47. Electronic components and accessories	1.899	0.322	0.188	3.358	1.074	4.942	−3.043
48. Misc. electrical machinery, equipment, and supplies	1.899	0.297	0.553	1.178	1.131	3.160	−1.261
49. Motor vehicles and equipment	1.709	0.260	0.205	4.598	0.652	5.716	−4.006
50. Aircraft and parts	1.709	0.339	0.231	1.140	1.077	2.787	−1.078
51. Other transportation equipment	3.840	0.391	0.258	3.947	0.797	5.393	−1.552
52. Scientific and controlling instruments	1.402	0.556	0.190	4.168	−0.412	4.502	−3.100
53. Optical, opthalmic, and photographic equipment	1.402	0.214	0.160	4.723	0.317	4.780	−3.378
54. Miscellaneous manufacturing	5.593	0.712	0.224	3.171	0.887	4.994	0.600
55. Transportation and warehousing	2.553	0.394	0.256	0.282	1.729	2.661	−0.108
56. Communications, except radio and TV broadcasting	1.915	0.172	0.045	0.122	−0.063	0.275	1.639
57. Radio and TV broadcasting	4.389	1.290	0.054	0.157	−0.085	1.416	2.973
58. Electric, gas, water, and sanitary services	2.848	0.232	1.112	0.112	−0.039	1.416	1.432

[a] Exogenous sectors 1–4 cover agriculture, livestock, forestry, and fisheries; 5–10, mining and domestic fuels; 11–15, imports; and 16 covers labor.

a set of weights (either the official WPI weights or our net-output weights) and applied them to the vector of observed or calculated price changes. The weights no longer sum to unity, since the fifty-eight sectors of Table 2 account for only 89.9 percent of the official weights and 97.0 percent of the net-output weights. The other weighted commodities are among our list of exogenous goods. The contribution of the endogenous sectors to the change in the WPI is

$$\Delta WPI_{en} = \sum_{i=1}^{58} W_i \Delta P_{en_i} \tag{11}$$

whereas the amount of inflation occurring in the endogenous sectors which is indirectly due to exogenous price changes is

$$\Delta WPI^* = \sum_{i=1}^{58} W_i \Delta P^*_{en_i} \tag{12}$$

This can be written in vector notation as

$$\Delta \overline{WPI}^* = \vec{W}'[I - A'_{22}]^{-1}[A'_{12}\Delta \vec{P}_{ex} + \vec{L}\Delta w] \tag{13}$$

where the weights are zero for components 59 through 75. Equation 11 simply aggregates column 1 of Table 2 into a price index using WPI weights, while equations 12 and 13 do the same thing for column 6. In similar fashion, aggregation can be accomplished for each of the other columns of Table 2.

The results of computing these aggregative indexes are summarized and displayed in percent terms in Table 3. To a large extent, the data in this table answer the questions concerning the composition of inflation. Wide differences are clearly shown. In the earliest period labor was a major contributory factor to inflation, even after we had made corrections for long-run productivity gains. Our list of sixteen exogenous sectors accounts for some 82 to 88 percent of the rather small amount of inflation evident during those nine months, with the residual probably due to the unfortunate construction of profits in our model. In the period two years later (November 1972–August 1973), labor's contribution (exog. 16) is greatly reduced, while agriculture, livestock, forestry, and fisheries (exog. 1–4) account for nearly two-thirds of the inflation. With the net-output weighting system, most of the effects of the price increases show up indirectly (as cost increases in other sectors), whereas with the official weighting system the direct and indirect impacts are comparable. Imports were also a major inflationary factor in this period, accounting for 16 percent of the change in the net-output WPI, largely because of the second and third devaluations of the dollar in early 1973. As we observed casually from Table 2,

TABLE 3 Decomposition of Inflation, Selected Aggregates, Various Periods, 1970–1974

	11/70–8/71		11/72–8/73		10/73–7/74		7/72–7/74	
	Official WPI	Broad Net-Output WPI	Official WPI	Broad Net-Output WPI	Official WPI	Broad Net-Output WPI	Official WPI	Broad Net-Output WPI
	Summary Statistics (percent change in WPI)							
Percent change in WPI	3.607	3.078	17.730	9.730	16.582	12.944	35.088	24.979
Amt. due *directly* to exogenous sectors	0.595	0.092	6.089	1.815	0.908	0.246	5.482	1.849
Amt. due to endogenous sectors	3.006	2.986	11.641	7.915	15.674	12.698	29.606	23.130
Amt. due *indirectly* to exogenous sectors	2.539	2.466	9.218	7.545	9.262	7.792	18.969	16.165
Unexplained residual	0.467	0.520	2.423	0.369	6.412	4.906	10.637	6.965

Decomposition of Wholesale Inflation (percent contribution of exogenous sectors)

Agriculture, livestock, forestry, and fisheries (exog. sectors 1–4)								
Direct	14.27	2.67	33.34	18.30	−1.32	0.48	10.84	6.28
Indirect	22.93	19.33	33.07	45.85	−2.73	−2.60	8.75	9.40
Mining and domestic fuels (exog. 5–10)								
Direct	2.40	0.31	1.00	0.36	6.79	1.42	4.80	1.12
Indirect	3.90	4.65	2.68	3.94	13.48	15.03	9.84	11.87
Imports (exog. 11–15)								
Indirect	14.71	15.34	11.01	16.44	37.12	35.61	24.36	24.66
Labor (exog. 16)								
Indirect	29.62	40.81	5.23	11.32	7.98	12.16	11.18	18.67
Total	87.83	83.11	86.33	96.21	61.32	62.10	69.77	72.00
Residual	12.14	16.93	13.67	3.79	38.68	37.90	30.32	28.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

SOURCE: Table 2; see accompanying text.

the list of exogenous sectors accounts for nearly all of the change in the wholesale price level (93 percent), using net-output weights.

The technique performs less satisfactorily in analyzing the most recent nine-month period, with the exogenous sectors accounting for only 60 percent of the inflation. The largest inflationary source was imports, accounting for 36 to 37 percent of the total, and this is largely due to the 118 percent rise in the price of imported crude materials. Labor continued to be a relatively minor factor, while agriculture, livestock, forestry, and fisheries actually were deflationary (a fact which the official index exaggerates). The 54 percent price increase in domestic crude oil and natural gas was also a large factor in wholesale inflation.

Clearly, our two-sector, cost-push model of wholesale inflation performed less well in this most recent period. Why? First, the enormous rise in the prices of refined petroleum products was way beyond what could be explained from the rise in crude oil prices according to our price data and input coefficients. While our model shows that the per unit costs of the petroleum industry were up 32.5 percent in those nine months, petroleum prices rose a staggering 77.7 percent, leaving an enormous unexplained residual of 45.2 percent. Part of the explanation may be that, although the price of "old" domestic crude oil was not allowed to rise beyond $5.25 a barrel, product prices rose to the marginal supply price, which in most cases was the import or "new" oil price of approximately $10.50 per barrel. The difference, of course, accounts for the enormous profit increases enjoyed by the oil companies over the past year (1974).

In order to determine the importance of the petroleum price hikes, we did another run of our model in which the price of refined petroleum products was taken as exogenous. Although this procedure is somewhat ad hoc, it can be rationalized as follows: we have taken the price of crude materials as exogenous, but in the case of petroleum the "old" domestic price was frozen. Since product price equalization apparently occurred, the difference between foreign crude prices and the domestic price should be included in the rise of the price of petroleum. Put slightly differently, the frozen price of $5.25 per barrel is a kind of political fiction. Since the oil companies were able to sell the product for a price corresponding to the free market price of about double that, the price freeze had little effect on product prices and merely transferred some of the windfall gains from crude producers to oil refiners. The simplest way to account for this in our analysis is to assume that the model correctly predicts the refined product price and to take the observed refined product price as exogenous.

The effects of this change on the results for October 1973–July 1974 and for July 1972–July 1974 are shown in Table 4. The detailed, disaggregated results for these periods, with the refined petroleum price taken as exogenous, appear as tables A.4 and A.5 in the appendix (on microfiche). Approximately 40 percent of our unexplained residual disappears for the most recent nine-month span, with the new list of seventeen exogenous sectors (those in Table 1 plus labor and refined petroleum products) now accounting for 78 percent of the wholesale inflation. While the percent contribution of "energy resources" to inflation is not explicitly separated out in Table 4, our analysis would indicate that the range of the figure over this time period is from 55 to 60 percent, including both domestic and imported resources. At the same time, the relatively large residual of 22 percent may indicate that some increase in the profit margins of our remaining fifty-seven endogenous sectors was experienced with the final and total elimination of wage and price controls.

The problem of petroleum prices is one reflection of a more serious omission in the technique used here, one that raises several questions for an open economy. The major sectors in which prices are controlled by external forces not taken into account here are those of export- or import-competing goods. Examples would include chemicals and iron and steel. Both of these are highly competitive industries engaged in international trade, and it is clear that, as with raw materials (although in a somewhat attenuated manner), pricing of many of these products is heavily influenced by world markets. It seems likely that movements of foreign prices of such exposed commodities—whether they be competing imports or exports—would lead to similar movements in the domestic prices of these goods (independent of changes in domestic cost factors).

It is likely that this problem with exposed sectors arose in several categories during the October 1973–July 1974 period. If we take as an arbitrary criterion residuals greater than plus or minus 15 percent (from Table A.4), the following eight sectors qualify during this period:

		Residual
18.	Plastics and synthetic materials	+49.819
22.	Leather and leather products	−23.967
9.	Miscellaneous fabricated textile products	−19.294
27.	Primary nonferrous metal manufacturing	+17.293
26.	Primary iron and steel manufacturing	+17.071
28.	Metal containers	+16.984
20.	Paints and allied products	+16.767
17.	Chemicals and selected chemical products	+15.984

Virtually all these industries are "exposed" to the winds of international trade and (except for leather) were in tight demand on world markets. In addition, there was a redirection of demand toward the United States following the 1973 dollar devaluations. So, in summary, it appears to us that the movement in the prices of these eight sectors was accompanied and perhaps heavily influenced by the movement in the world prices of these commodities.

This problem points out one of the chief difficulties in applying our two-sector model for open economies. There is a gray area between the exogenous and endogenous categories—the exposed export- and import-competing sectors—where pass-through pricing breaks down when severe structural shifts occur, such as divergent trends in exchange rate movements, or when relative price adjustments are different in different countries. At present, there does not appear to be any good way to allocate these exposed industries between the exogenous and endogenous categories, and this problem must be listed on the agenda for future work.

There are, of course, other factors that may have contributed to the residual movements in these eight industries. In the first place, the predictions of the model rest on input-output data which are basically seven years old; in addition, the price and input-output data are probably still not matched very well. A second factor was the final lifting of price controls over the past year (1974). We do not have precise information on how important these controls were in the different industries, but the results presented here are consistent with the notion that prices in a few industries were held below their market-determined levels. Finally, we have assumed that there was no movement in markup over cost; however, there may have been some increase in profit margins in those sectors experiencing strong demand. The aggregative data on the gross profits of nonfinancial corporations does indicate an increase in the ratio of before-tax profits to output from 13.8 percent in the third quarter of 1973 to 15.8 percent in the second quarter of 1974. At this stage, it is not possible to sort out how much of this increase was due to the petroleum sector, how much to an increase in inventory profits or underdepreciation due to original-cost basis, and how much to an increase in the markup of the endogenous sectors other than petroleum. Our preliminary view is that the residuals are in part due to increased profit margins (apart from petroleum), but this conjecture must be tested by further analysis.

TABLE 4 Decomposition of Inflation with Price of Refined Petroleum Products Taken as Exogenous, July 1972–July 1974 and October 1973–July 1974

	7/72–7/74		10/73–7/74	
	Official WPI	Broad Net-Output WPI	Official WPI	Broad Net-Output WPI
Summary Statistics (percent change in WPI)				
Percent change in WPI	35.088	24.979	16.582	12.944
Amount due *directly* to exogenous sectors	9.668	5.551	3.690	2.706
Amount due to endogenous sectors	25.420	19.428	12.892	10.238
Amount due *indirectly* to exogenous sectors	18.033	15.546	8.663	7.418
Unexplained residual	7.387	3.882	4.229	2.820
Decomposition of Wholesale Inflation (percent contribution of exogenous factors)				
Agriculture, livestock, forestry, and fisheries (exog. sectors 1–4)				
Direct	10.83	6.28	−1.32	0.48
Indirect	8.58	9.13	−2.68	−2.53
Mining and domestic fuels (exog. 5–10)				
Direct	4.79	1.12	6.79	1.42
Indirect	4.71	4.95	6.31	6.17
Refined petroleum				
Direct	11.93	14.82	16.77	19.01
Indirect	4.51	7.35	6.34	9.43
Imports				
Indirect	22.63	22.47	34.43	32.29
Labor				
Indirect	10.96	18.34	7.85	11.97
Total	78.94	84.46	74.49	78.24
Residual	21.06	15.54	25.51	21.76
	100.00	100.00	100.00	100.00

SOURCE: See accompanying text.

IV. CONCLUSION

We have presented an analysis of the official wholesale price index, the biases involved in its construction, and a preliminary improved measure of the price level of the wholesale sector. The issues involved here strike us as important, and we conclude that the official WPI has been a very misleading economic indicator during the last two years, as it has estimated the increase in the price level to have been some 40 percent greater than our improved measure indicates (35 percent versus 25 percent).

The second aspect of this paper has involved the development and use of a technique for decomposing the inflation in wholesale sectors into the factors accounting for it. Despite the problems with this approach that we have mentioned, we find the results it provides to be both useful and interesting. The contrasts between the recent and previous periods of inflation have been quantified. Many of the shortcomings of the analysis are not fundamental (for instance, an improved concordance between the price data and input-output sectors can be developed, and more up-to-date input-output tables are possible), and we anticipate making further refinements in the technique. Some extensions and improvements are less easily accomplished (such as accurately determining the appropriate lag structure). Despite this, we anticipate that further refinements will make disaggregated analyses such as this more useful in diagnosing and analyzing the sources and structure of inflation.

NOTES

1. We are by no means the first to point out this particular shortcoming of the WPI (see, for example, Eckstein and Fromm 1959 and Stigler 1961).
2. An index which is even more poorly constructed is the weekly index of crude materials prices, which is simply an unweighted geometric average of spot price relatives.
3. Note that a net-output–weighted price index and a value-added–weighted index would be identical if they covered the entire economy and the economy were closed.
4. Indeed, this is why the GNP deflator, essentially a value-added–weighted price index of domestic output, has been somewhat misleading as an economy-wide price index over the last year or so. It is conceptually quite different from a CPI and should be used accordingly.
5. In another piece of research, John Shoven and David Starrett are attempting to determine the best universe for a WPI and to confirm that an index thus constructed predicts future changes in the CPI better than the official WPI.

6. Evidence for this proposition goes back to Kalecki (1939). Recent confirmations, essentially for manufacturing, have been made by Eckstein and Wyss (1972) for the United States and by Nield (1963) and Godley and Nordhaus (1972) for the United Kingdom.
7. A similar approach to this sort of problem was taken by Eckstein and Fromm (1959) in their study of the direct and indirect impact of steel prices on inflation.
8. The corresponding results for the three periods October 1970–August 1971, October 1973–July 1974, and July 1972–July 1974 are displayed in tables A-1, A-2, and A-3, respectively, in Appendix A (on microfiche).
9. In contrast to a multiple regression procedure, this technique does not guarantee that the mean of the predicted values equals the mean of the observations.

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NOTE: Appendix A, "Detailed Decomposition of Inflation in Endogenous Sectors," and Appendix B, "The Construction of a Concordance between Available Price Data and Input-Output Sectors," are on microfiche on the inside back cover of the book. Duplicate copies of the fiche can be obtained from Microfiche Systems Corporation, 440 Park Avenue South, New York, N.Y. 10016.

COMMENTS

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Nordhaus and Shoven make two distinct points:

> The "all commodities" wholesale price index overstates the recent inflation because it double or triple counts the prices of basic commodities.
>
> Eighty to 85 percent of the recent inflation can be explained by the pass-through of hikes in these basic commodity prices and in wages.

Both points are, I think, indisputable, and well and clearly made. Relative to the first, I want to point out only that the Bureau of Labor Statistics agrees with the authors and does, in fact, publish a series with behavior very similar to that of the net-output–weighted index advocated by the authors. Relative to the second point, I shall indicate a few considerations that would further strengthen their argument.

I

The Bureau of Labor Statistics prepares several stage-of-processing price series. The table below shows the growth rates for four of these over the periods selected by Nordhaus and Shoven; it also includes for comparison the growth rates of the "commodities" component of the CPI and the Nordhaus-Shoven net-output indexes:

	Wholesale Price Index						
Period	All Commodities	Net Output	Finished Goods	Crude Materials	Intermed. Materials	Consumer Goods	CPI: Commodities
11/70–8/71	3.6	2.5	2.3	3.4	4.1	2.1	2.7
11/72–8/73	17.7	12.7	10.8	51.5	10.7	12.9	8.6
10/73–7/74	16.6	14.3	11.7	0.7	23.2	13.4	10.0
7/72–7/74	35.1	28.4	25.7	49.5	40.0	29.4	20.1

Conceptually, the Nordhaus-Shoven index should be close to the finished goods index, and the figures in the table show very similar movements, though the rise in the finished goods index seems to have been slightly slower. The explosion of the crude materials index during the second or "farm" period shows where the source of the inflation in that period lay. Similarly, the hump in the intermediate materials index in the "oil" months showed that the latter inflation had a different cause.

Nordhaus and Shoven also compare the WPI and the CPI. It would be more appropriate to compare the WPI finished consumer goods index with the CPI commodities series. The last two columns of the preceding tabulation show this comparison. One would expect that during the "farm" and "oil" inflations the CPI would rise more slowly than did wholesale prices simply because retailer and wholesaler labor costs were not going up as fast as were farm or oil prices. And, indeed, we find the CPI index rising by only two-thirds of the rise in the corresponding WPI index.

Clearly the BLS offers us some appropriate price indexes. Equally clearly, the press will go on emphasing the all-commodities index, for it is the most nearly all-encompassing. No single stage-of-processing index nor the net-output index will meet the needs of the press, for too many prices are left out. When the price of cotton goes up, *the* wholesale price index should reflect the change even before it shows up in the price of clothes. The original Nordhaus-Shoven use of value-added weights appears to me to come closer to filling the bill than does the net-output index. The trouble with the value-added index, as they point out in the present paper, is that it does not include imports. But why not include imports with "value added" equal to their value? Such an index would measure "prices paid by Americans and their export customers." That seems to be a reasonable concept, attractive to the press and acceptable to the specialist, and clearly better than the hodgepodge which now gets all the attention. Of course, we might need better import price indexes, but we need them anyway.

II

Nordhaus and Shoven have performed a valuable service by showing the great extent to which inflation can be accounted for by pass-through, via input-output relations, of changes in a few commodity prices. I urge the reader to note Tables 3 and 4 carefully and to

observe particularly that the residual as a percentage of total price changes is only 3.79 percent for the farm price inflation (Table 3) and only 21.76 percent for the oil inflation (Table 4). My comments will be directed to a few matters which may make these residuals, especially the second, even smaller.

The authors use rates of productivity growth estimated for the period 1947–1964. The rates by input-output industry are all available up through 1972 and show a considerable slowdown after 1964. This overestimate of labor productivity growth helps to explain why all the residuals are positive in tables 3 and 4.

Many of the largest errors in Table 2 and tables A.1–A.5 can be attributed to technical problems. For example:

Table	Sector	Error	Cause
4	5. Tobacco mfg.	−11.7	Tobacco growing has been aggregated with other crops whose prices rose more than its did. Tobacco growing is a separate sector in the 363-order tables of the Bureau of Economic Analysis.
2	6. Fabrics	+5.7	Cotton, which had extra large price increases, was aggregated with other crops. Again, BEA tables provide the separate cotton sector.
2	23. Leather	−18.9	Apparently, the authors used a table that included by-product sales, thereby implicitly assuming that the price of hides moved with the price of meat. It did not.
2	46. Radio and TV equip.	−6.3	Apparently imported radios and TVs have been considered an "input" into domestic radios and TVs, as have imported cars into domestic cars. This treatment would be all right if we were explaining consumer prices, but the WPI includes only the prices of *American-made* radios, TVs, or cars.
2	49. Motor vehicle	−4.0	
2	21. Petro ref.	10.3	If, as appears above, imported crude has been counted as an input into domestic crude and then the crude price taken exogenously as the WPI
A-2	21. Petro ref.	45.2	

Table	Sector	Error	Cause
			for domestic crude, the pass-through process has been strangled. The 8.721 increase due to imports appears to be just the influence of the imported refined products.
A-4	18. Plastics and syn.	49.8	BEA tables treat petrochemical feed stocks produced by petroleum refining as an input into sector 17, chemicals, which then sells them to 18, plastics and synthetics. Consequently, this major cost item to the plastics and synthetics industry was considered to have grown only by the 14.2 percent predicted for sector 17 instead of the 77.7 percent assumed for petroleum refining.

With these corrections, only two errors of more than six points remain in Table 2. The 11.7-point error for 10 (lumber) in the Table 2 results from a special lumber price cycle that has little to do with other prices. By January 1975, however, the lumber and wood products price was down to just 10 percent above the November 1972 level. Clearly, lumber belongs among the price-sensitive sectors, in which "prices are set by the traditional textbook principles of supply and demand" and therefore escape our analysis and must be made exogenous. Finally, there is the 10.3-point error on primary nonferrous metals. Greater detail might make clear what the problem is. Is it the price of gold?

Since Nordhaus and Shoven went to some considerable trouble to make up price indexes for input-output sectors, I gather that it is not as well known as it should be that David Gilmartin of the INFORUM project at the University of Maryland made up such series for a 185-sector table several years ago and that we keep them fairly well up to date. Researchers who need them should get in touch with us. We have used them to estimate distributed lag price equations which are now a part of our INFORUM model. I am, therefore, delighted that this fine paper shows the substantial explanatory power of this approach. What remains to do is to find some explanation for prices in those "traditional textbook" cases.

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