

4-1-1974

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SIXTH INTERNATIONAL CONFERENCE ON INPUT-OUTPUT TECHNIQUES

22-26 April, 1974.

A COMPUTABLE MODEL FOR ANALYSING PRICE CHANGES
IN AN INPUT-OUTPUT SYSTEM

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1. INTRODUCTION

This paper describes a model for the dynamic analysis of price changes in an economy. The model comprises two sets of relations - an open input-output system and equations which close the model. The two sets of relations are tested by comparing the actual changes in prices and costs in Australia from 1969 III to 1973 II with those predicted by each set of relations.

The model is basically a closed input-output system which describes the transmission of price changes between different industry sectors and, in addition, relates changes in costs of production (inputs into the input-output system) to changes in final prices (as determined by the input-output system). Prices are determined by a mark-up on historical costs of production, and prices of outputs of industries, and of sales to final buyers are, therefore, based on costs of production in a previous period. This results in a dynamic input-output system in which increases in costs are passed on as increases in selling prices of industries, after a delay. The model is closed by adding equations which express changes in some costs of production (wages and profits) to previous changes in prices of sales to final buyers.

The system is simulated by the computer, and for initial values of prices and costs, and for current values of exogenous prices and costs which are not determined by the input-output system (flexible prices), the program provides a sequence of monthly prices of intermediate transaction of industries, and prices of sales to final buyers.

Essentially, prices are determined by a cost plus system of pricing, and the inflationary process is the result of attempts by wage earners and businesses to maintain their relative shares of income following an initial exogenous shock affecting directly either wages, profits or prices. Some allowance is also made, however, for the influence of demand factors on wages and prices.

The structure of the model follows closely the standard two-equation system which has been extensively employed in recent years in quantitative studies of the generation of inflation. A prototype of this system, as formulated by Lipsey and Parkin (4), is as follows.

$$(1) \quad P = f(W(r), M(s), Q(t))$$

$$(2) \quad W = f(U(u), P(v), S(w))$$

where P = the proportionate rate of change of an index of prices
 W = the proportionate rate of change of wages or earnings
 M = the proportionate rate of change of import prices
 Q = the proportionate rate of change of output per head
 U = some function of the percentage of the labour force unemployed; and
 S = some measure of the aggressiveness of the trade unions.
 r, s, t, u, v and w are lags in quarters.

In the present model equation (2) is divided into two equations which describe cost and demand factors separately. The major innovation in this paper, however, is the use of input-output data to estimate the form of the relationship in equation (1), instead of relying on econometric methods of regression. Finally, the properties of the model, and conclusions about the determinants of inflation, are studied by computer simulation of the system instead of the usual econometric or analytical methods.

In recent years two different studies have used input-output data or methods to analyse price changes over time. Leontief (3) has used the dynamic inverse to show the dependence of current prices on past "prices" of value added, while Godley and Nordhaus (1) have computed the delay in passing on changes in "prices" of value added and of inputs into manufacturing, to wholesale selling prices for a number of manufacturing industries in Britain. The present model, however, differs from both these systems. In Leontief's model, the dynamic element is the capital gain or loss incurred by changes in the replacement cost of assets as prices change, and he assumes that selling prices are based on current prices of materials and services plus or minus the capital gain or loss. In the present model, prices are assumed to be based on historical costs of production. The Godley and Nordhaus model assumes a similar pricing method to that adopted in the present study, but their approach requires data of net sector prices, which are not available in Australia.

As well, their study is confined to manufacturing industries, presumably because the necessary sector price indexes are not available for other industries.

The plan of the paper is as follows. The next two Parts develop the relationships expressed by equations (1) and (2), above, and give the results of simulating the two parts of the model over a past period. The conclusions of the paper are summarised in Part 4.

2. THE INPUT-OUTPUT RELATIONS

(a) General

The input-output system is used to determine the relationship between changes in costs of industries and the subsequent changes in prices of sales to final buyers (see equation (1) in Part 1 of this paper). This relationship is usually estimated by econometric methods of regression employing time series data. Coefficient values estimates obtained by this method are, however, generally unreliable and sensitive to the sample period. A study by Pitchford (5), using Australian data, illustrated the problems encountered in estimating the parameters of the equation, and his conclusions about the unreliability of the estimates are confirmed by the results obtained by the present writers in fitting a simple cost-price equation to recent data for Australia. (Haig and Wood (6)).

All the equations estimated over the period 1967 III to 1972 II provided a good explanation of the changes in retail prices, but the values of the coefficients varied with the assumed length of lag. As well, re-estimation of the equations with additional data lead to quite different values of the coefficients. The estimation problem arises from the fact that all the series of data show a general upward trend over the period. This leads to high multicollinearity in the estimates of the coefficients for the independent variables, which makes the estimates of the coefficients and the standard errors

unreliable. In particular, it makes it difficult (or impossible) to estimate the lag structure of the variables. The standard econometric methods appear to be of little use in estimating the values of the coefficients in the equation relating changes in retail prices to previous changes in prices of wages and import costs.

The use of the input-output data to estimate the relationship between changes in costs and changes in prices avoid these problems of estimation. The coefficients of the variables and the appropriate lag structures are obtained implicitly by the simulation of a model, constructed from input-output data, of actual flows of prices and costs between industries and final buyers.

As well, the input-output procedure is based on an assumption about the theory of business behaviour, whereas the econometric approach simply uses the apparent identity between the income and expenditure sides of the national income accounts. However, the theory of business behaviour adopted in this study is fairly rudimentary and relies on simple assumptions about the pricing policies of business and the rate of transmission of costs between industries. These assumptions are described below. It may be noted that the predictions of the model can be compared with actual price changes, and this provides some sort of overall test of the appropriateness of the model, including the reasonableness of the assumptions.

The input-output coefficients are assumed constant. Since the model is simulated only over a period of 4 or 5 years, this assumption is probably reasonably accurate. However, the input-output data are for 1962/63, which is the latest year for which official input-output data are available. All the price series calculated by the model are bases, therefore, on constant 1962/63 weights, and it would obviously have been preferable to have adopted a more recent period as the base year.

(b) The Determination of Prices

The main features of the model are illustrated by a flow diagram (Chart 1). In this chart different blocks are used to represent groups of industries and transactions and these blocks are linked by lines to show the transmission of costs and prices from the cost of ultimate inputs and between industries.

Blocks 1 and 5 represent the inputs and outputs of the model. Block 1 shows the payments for primary inputs of wages, imports and duty, and Block 5 the value of sales to final buyers (personal consumers). Profit margins are assumed constant and changes in profits of industries are related to changes in prime costs covering wages, imports and duty and purchases from other industries. Profit is determined, therefore, endogenously by the model. Sales to final buyers in the present model includes only personal consumption expenditure and this paper does not analyse the changes in the prices of other items of final expenditure, since they do not lead to further changes in industry costs or prices.

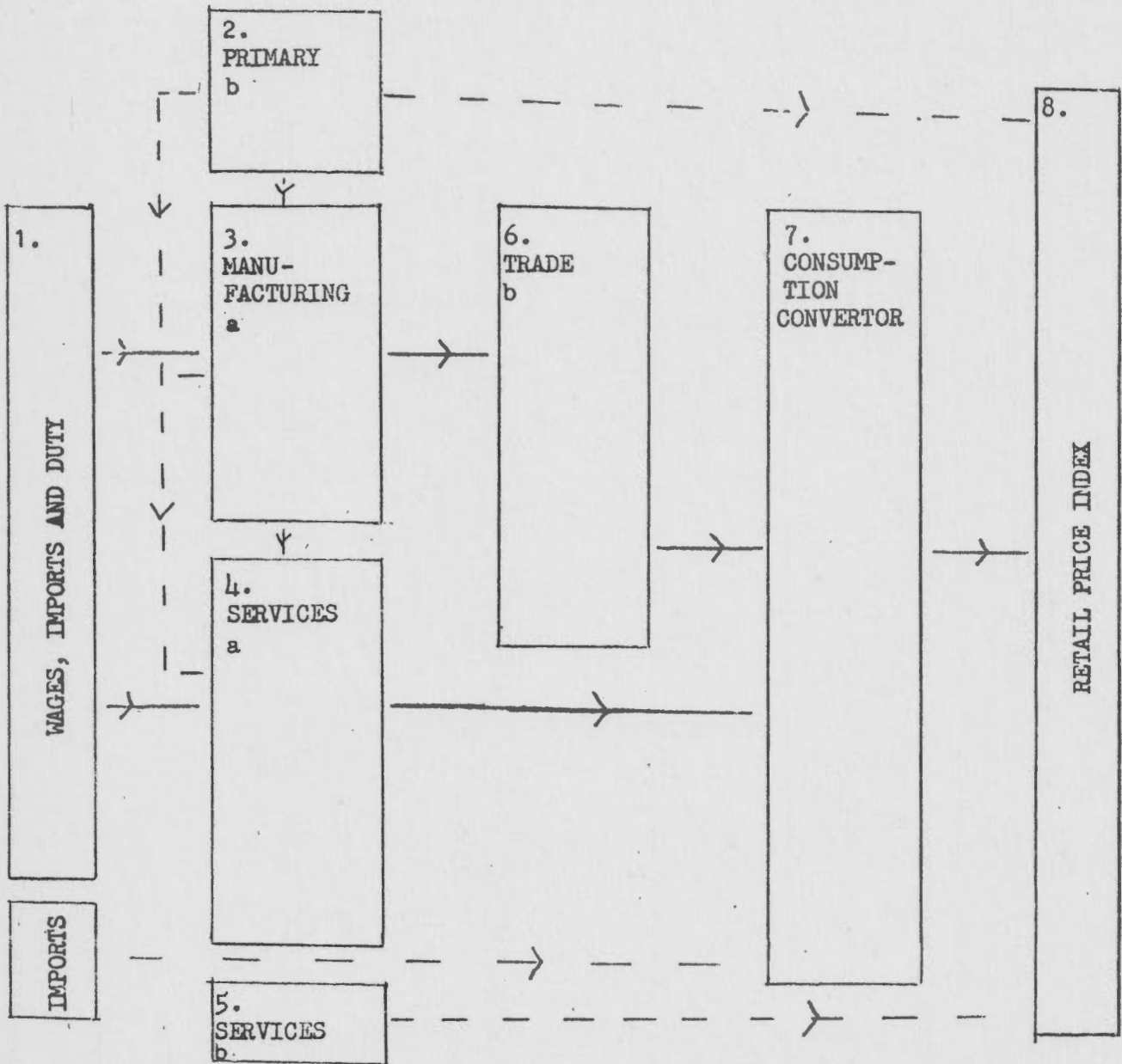
Blocks 2 to 6 represent groups of industries - the primary, manufacturing, services and trade industries. The method of calculating the selling prices from costs for each of these groups of industries is described in the following paragraphs.

Primary These industries cover agriculture, pastoral and mining. The prices of output sold to other industries and to final buyers are assumed to be exogenous, and determined by world prices or seasonal conditions.

Manufacturing Prices are assumed to be determined by applying a constant per cent mark up to the historical cost of goods sold, which comprise the purchases from other industries, imports and duty, and the costs of wages per unit of output. Purchases from the service industries and profit are assumed to be included in overhead costs. Thus selling prices do not vary directly in response to changes in the prices of items of services, or

CHART 1

THE INPUT-OUTPUT RELATIONS



a = Prices determined by the model

b = Prices exogenous

depreciation, interest, etc.

Costs of materials are assumed to be passed on by the period of stock turnover, and costs of wages by the period of turnover of work-in-progress. Thus material costs are assumed to enter only at the initial stage of production, while wage costs are assumed to be spread evenly over the stage of production of work-in-progress.

The period of turnover is calculated by relating the value of inputs or outputs of industries to the value of stock held. For those industries where intra-industry transactions were comparatively unimportant, use was made of data of stocks by stage of processing, and ratios were calculated separately for raw materials, work-in-progress, and finished goods. This procedure allows for progressive increases in the value of stocks as they pass through the stages of production. The periods of turnover for each component were obtained by relating the value of stocks to the value of inputs, to the average value of outputs and inputs and to the value of output, respectively. The values of output excluded profit. The average length of lag in passing on increases in costs of materials was obtained by summing the length of turnover for each of these classes of stocks. It was assumed that labour cost was spread evenly over the period of work-in-progress, and the length of lag in passing wages costs on was derived as the sum of the period of turnover of finished goods plus half the period of turnover of work-in-progress stock.

For those industries where intra-industry transactions amounted to more than 25 per cent of the cost of materials used in production (the industries of chemicals, textiles, paper and wood industries), one overall period of stock turnover was estimated by relating the value of stocks to the total sales (excluding intermediate sales and profit). An attempt was made, however, to estimate the length of the turnover of work-in-progress, in order to correctly allocate the cost of wages to production. This was done by first estimating the period of turnover of stock which represented raw materials and finished goods to the industry, by assuming that the ratio

of all raw materials and all finished goods to the value of all inputs and outputs (excluding profit), applied to the inputs and outputs excluding intra-industry transaction. The length of turnover of work-in-progress was then calculated by subtracting the estimated period of turnover of stocks of goods which represented raw materials and finished goods to the industry from the estimated total period of turnover of stocks. The length of lag in passing on labour costs was assumed to equal the average of this period plus the period of turnover of finished goods.

The estimated periods of transmitting materials and wages costs by industries are shown in Table 1.

TABLE 1

NUMBER OF MONTHS DELAY IN PASSING ON INCREASES IN COSTS

	MANUFACTURING INDUSTRY		TRADE
	MATERIALS	LABOUR	
Chemicals	5	1	4
Petroleum Products	3	1	3
Glass, Clay and other Non-Metallic Products	5	1	8
Metal and Metal Products	7	2	4
Leather and Leather Goods	7	1	7
Textiles	3	1	6
Clothing and Footwear	2	1	6
Food Manufacturing	2	1	2
Beverages and Tobacco Products	8	1	2
Paper and Paper Products, Printing and Publishing	6	1	5
Wood, Wood Products and Furniture	3	1	6
Other Manufacturing	3	1	6

Changes in wages costs are converted to changes in costs per unit of output by dividing the computed increase in wages by the average rate of increase in labour productivity, again calculated separately for each industry.

Trade Selling prices are obtained by applying a constant per cent mark-up to the price of goods bought for resale. The turnover period for sales to final buyers is obtained as the sum of the average stock turnover period for wholesalers and retailers, and this is assumed to represent the lag in passing on increases in costs to consumers. The period of turnover is calculated separately for the products of each industry and these are shown in Table 2. No information is available of the delay in inter-industry transactions and it is assumed nil.

Other Services Changes in prices of other services do not affect manufacturers cost of production, (and hence selling prices of these industries) but do enter into the changes in the retail price index. The selling price of output of service industries is calculated in the same way as selling prices of manufacturers. It is assumed that costs are passed on after one month. Comparison of changes in retail prices of services and of goods suggests that prices of services are passed on much more quickly than those of goods. The actual period assumed - 1 month - is not based on direct evidence.

These assumptions are sufficient to construct a model for the transmission of costs between industries and to final buyers. The model also includes a "consumption converter" (Block 7) which reclassifies changes in prices of sales to personal consumers by industry category to the components in the official retail price index. The changes in prices of these components are then added by using the weights of the components in the official retail price index. Changes in prices of sales to final buyers are therefore converted to changes in the official retail price index.

The flows of exogenous costs and prices are indicated by broken lines. They are identified as follows.

- (1) Average earnings and the price of imports and duty (Block 1)
- (2) Prices of output of the agricultural industry (wool and food products) and forestry and mining industries (including basic metals). (Block 2) These prices are costs of inputs used by industries, but they include also the price of unprocessed food and natural gas, in the official retail price index.
- (3) Prices of some output of services, comprising rent, and radio and T.V. licences. (Block 5)

(c) Equations for the Input-Output Relationships

The equations in the model are set out below.

In these equations, the subscript *i* refers to the industries where selling prices are determined by the model and the subscript *h* to categories of the official retail price index. The list of industries and consumption categories are set out in Appendix 1, and the concepts and sources of data for the variables and parameters are given in Appendix 2.

The model first generates the cost of materials in sales, as the sum of selling prices of industries in previous periods, determined by the model, the exogenous prices and the price of imports plus duty.

(Equation 1)

It then works out the cost of sales of each industry (Equation 2) and the selling price of sales (Equation 3). Cost price changes are then computed (Equation 4) and applied to the value of purchases by wholesalers from manufacturers in the previous period (Equation 5). Then the change in the cost of imports (including duty) is added on to abtain the increase in total prices of imports, the value is multiplied by the indirect tax rate on industry output soldy by consumers, the wholesale and retail margin is added on and the industry output allocated to categories of personal consumption (Equation 6). The final set of equations (7 and 8) simply add up the prices of items in each consumption category, including the items where prices are determined endogenously.

1. Equations Explaining Prices of Intermediate Purchases (at basic values)

$$IN_1 = \left(\sum_{i=1}^{11} FM_{1i} \right)_{t-j} + AG_1 + FO_1 + MI_1 + IM_1 + ID_1$$

where IN = the cost of inputs

FM = the industry by industry flow matrix, for those industries
where selling prices are determined by the model.

AG = the cost of purchases from agriculture

FO = the cost of purchases from forestry

MI = the cost of purchases from mining

IM = the price of imports

ID = the price of duty

Note - the lengths of the lags j differ between industries

2. Cost of Production Equations

$$CP_1 = \left[(IN_1 \times MU(p)_1) + W_1 \times L/P_1 \right]$$

where CP = the cost per unit of output

W = average earnings

P = the rate of increase in labour productivity

MU(p) = the mark-up on purchases of goods

3. Equations Explaining Selling Prices

$$SA_1 = CP_1 \times MU(c)_1$$

where MU(c) = the profit mark-up on costs per unit of output

4. Price Increase per Unit of Output

$$PR_i = SA_i(t) / SA_i(t-1)$$

where PR = the price increase per unit of output

5. The Price of Purchases by Wholesalers

$$WS_i = WS_i(t-1) \times PR_i(t)$$

where WS = the unit price of purchases by wholesalers

6. The Price of Sales at Retail Prices of Industry Products and Imports Allocated Directly to Consumers

$$C_i = (WS_i + IMC_i) (T_i + MU(s)_i) \times DIST_{ih}$$

where C = the price of sales of the products of industries and imports

IMC = the price of imports allocated directly to consumers

T = the rate of commodity tax

MU(s) = the wholesale and retail mark-up

DIST = proportion of retail sales of each industry to each consumption category

7. The Retail Price of Each Category of Consumption

$$TC_h = \sum_{i=1}^{18} C_{hi}$$

where TC = the retail price of each category of consumption

8. The Retail Price Index

$$TC = \sum_{h=1}^{13} TC_h + TCX$$

where TC = the total price of consumption goods

TCX = the price of items determined exogenously

3. THE CLOSED MODEL

The model is completed by the addition of two equations which form the link between the change in prices, determined by the input-output system - and the change in costs, which enters as an input into the system.

One equation completes the cost plus, or wage-price spiral, by making nominal wages a function of prices. The second equation explains the wage drift, or the excess of actual over nominal wages, in terms of excess demand for final goods. This equation introduces demand elements into the explanation of inflation.

The first equation simply reflects the fact that nominal or negotiated wages are in fact fixed by reference to the cost of living, as measured by the official retail price index. The main difficulty is to determine the length of the delay between increases in cost of living and the level of negotiated wages. In estimating this equation, different lengths of lag were assumed, at nil, and one to three quarters. In addition, a dummy variable is included to pick up the effect of a substantial increase in award wages awarded by the Commonwealth Arbitration Court early in 1971. The best fit was obtained by following equation, allowing for a two quarter lag between changes in retail prices and nominal wages.

$$(1) \quad NW = -27.676 + .733 CP_{-2} + 2.726 D$$

(9.14) (26.11) (7.00)

$$D.W. = 1.69 \qquad R^2 = .996$$

where NW = nominal wages (mean value, 58.0)
CP = index of retail prices (mean value, 114.7)
D = dummy variable, taking the value 0 before 1971 I, and 1 in 1971 I and later periods.

Estimation of this equation obviously runs into the same problems due to the trend in the data, which affects estimation of the equation (1), in Part I. The fit is only marginally better using a lag of 2 periods - F values, for example, were 1780, compared with values of 1415 for a lag of 1 period, and 1126 for a lag of 3 periods. However, there are reasons for accepting a 2 period lag. There is a delay before price indexes are published and there is a further delay before the wage rates are adjusted for changes in prices.

The justification for explaining the wage drift by the excess of wages and salaries over the money value of sales of consumers' goods in a particular period rests on three main assumptions :- (1) That there are significant changes over time in the ratio of wages and salaries to the money value of sales of consumers' goods, (2) that this leads to a bidding up of wages above the nominal levels and (3) that other sources of excess demand are relatively unimportant.

- (1) The explanation for differences in the timing of changes in money wages and the money value of sales of consumers' goods, is provided by the open input-output model, described in the previous part of this paper and by the relationship expressed by equation (1). Exogenous increases in wages lead to a rise in prices in a subsequent period, after this increase in costs is transmitted through the system of input-output relationships and wholesalers and retailers to final buyers. Similarly, an exogenous increase in prices of final output (as a result, perhaps, of changes in external prices) are reflected in wages costs after a period of time. In fact, the notion of the wage-price spiral implies that changes in wages and prices in any one period are not closely related, except, perhaps, in particular circumstances, or where the effect of the period is so long that differences in timing on the series is smoothed out.
- (2) Nominal or negotiated wages are expressed, by equation (1), as a function of previous levels of retail prices. Equation 1 then implies that these wages are bid up by the excess demand. Strictly, the effect of excess demands would be met first by a decline in inventories, increasing order books, etc. Subsequently, wages would be bid up as employers attempt to increase the employment to meet the increased demands, and finally the effect of excess demand would lead to reduced levels of unemployment. As a consequence, the effect on wages would be felt after a delay, and the extent of this would be modified by the current level of

unemployment. Accordingly, the mechanism would allow for some lag before excess demand is reflected in a bidding up of the nominal wages, and experiments were made in estimating the equation to determine whether or not there was a significant lag.

The current level of unemployment was also tried as an additional explanatory variable, and was found to be significant and is included as an explanatory variable in this equation. The mechanism suggested also implies that excess demand does not lead to an appreciable increase in profit margins; in this event there would be no point in measuring excess demand in terms of the excess of wages and salaries over the money value of the sales of consumers' goods in a particular period. This assumption underlies the open input-output system described in the preceding part of the paper. The mechanism also implies a good deal of homogeneity in the demand for labour; that is, that an increase in the demand for final goods leads to a general rise in wages.

- (3) Traditional (Keynesian) explanations of excess demand, of course, trace the demands to increase in real spending by public authorities and on investment goods, (as well as on consumption goods) and allows for the leakage through imports. In the mechanism suggested in this paper, changes in these other components of final expenditure are ignored; it simply assumed that they are less important in a period of inflation than the effect of excess spending power available for personal consumption.

A test of the reasonableness of this explanation of actual wages is provided by the fit of the equation expressing the ratio of money wages to the value of sales of consumers' goods, to the ratio of money wages to the nominal or negotiated wages. The fit of this equation is as follows, using changes in the retail price index as a measure of the changes in the value of sales of consumer goods.

$$(2) \quad \begin{array}{r} \text{AE/NW} = 1.469 + .000424 (\text{AEI/CP})_{-2} - .0160 \text{UM}_{-2} \\ (78.55) \quad (3.50) \quad (1.54) \end{array}$$

$$\text{D.W.} = 1.49 \qquad R^2 = .469$$

where AE = average earnings (seasonally adjusted)
NW = nominal wages
AEI = index of average earnings (seasonally adjusted)
CP = index of retail prices
UM = male unemployment rate (seasonally adjusted)

(b) A Test of the Model

A Comparison of the actual changes in retail prices, as measured by the official index of retail prices, with changes predicted by the model is given in Chart 2 and Table 2. The predicted prices are obtained by simulating the model using actual values of exogenous variables - average earnings, prices of imports and duty, the price of purchases by industries from the primary industries, and actual prices for some components of the retail price index. The simulation is dynamic; that is, no correction is made for differences between actual and predicted prices in any period in predicting prices in the next period. The simulation starts at 1969 III (details of the components of retail prices are only available from 1969) and extends to 1973 II.

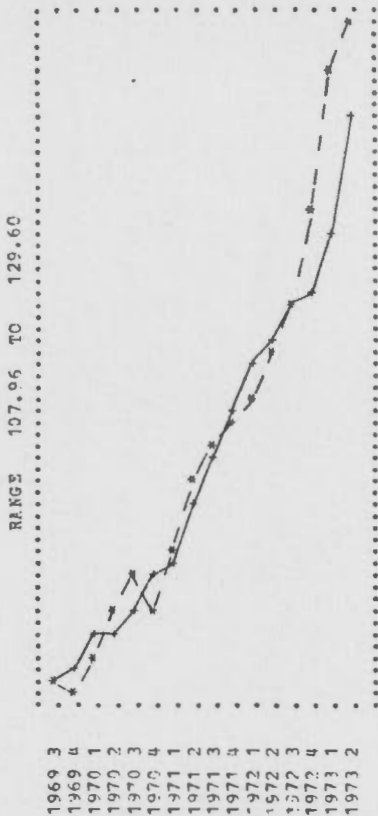
The chart also shows the endogenous values of average earnings, based on the calculated values of retail prices. The regression equations are used to estimate average wages only from 1969 I; up until that time actual average wages were used in the simulation of the input-output model.

The model was constructed to examine the determinants of the change in the total price index, and not the components of the price index. However, there were considerable differences in the rates of increase in prices of the components of the index, and comparison of the predicted and actual change in these components provides a more useful test of the model than comparison of the changes in the total price index.

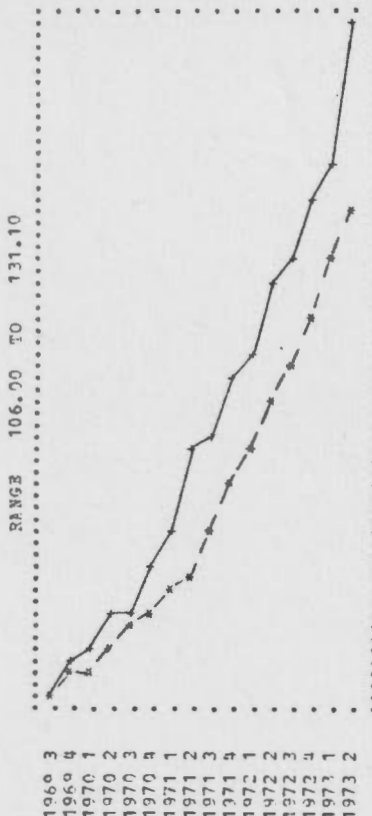
CHART 2
 ACTUAL AND PREDICTED PRICES
 (1966-67 = 100)

ACTUAL ———
 PREDICTED - - -

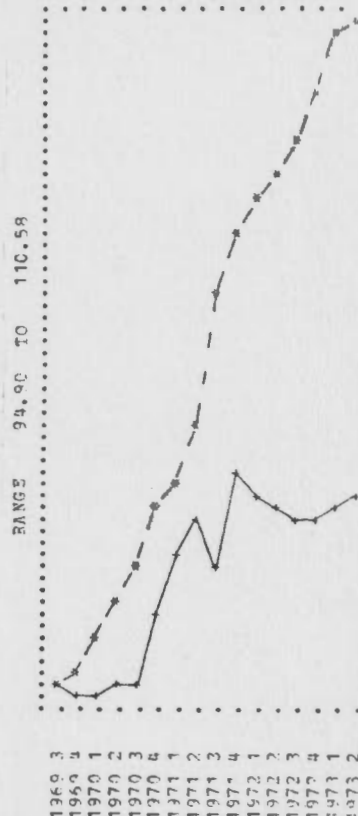
(1) PROCESSED FOOD



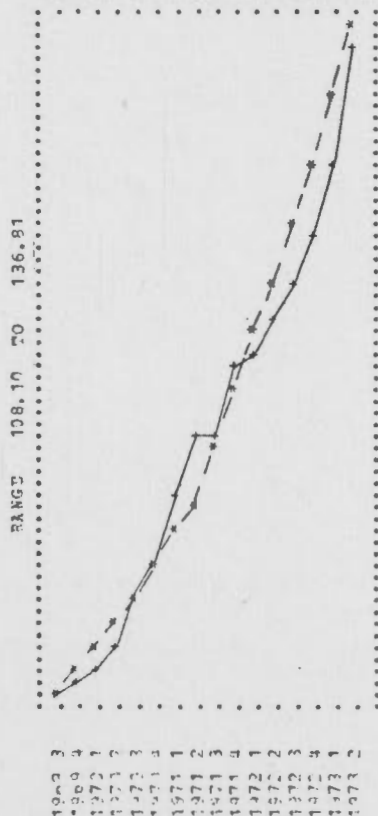
(2) CLOTHING



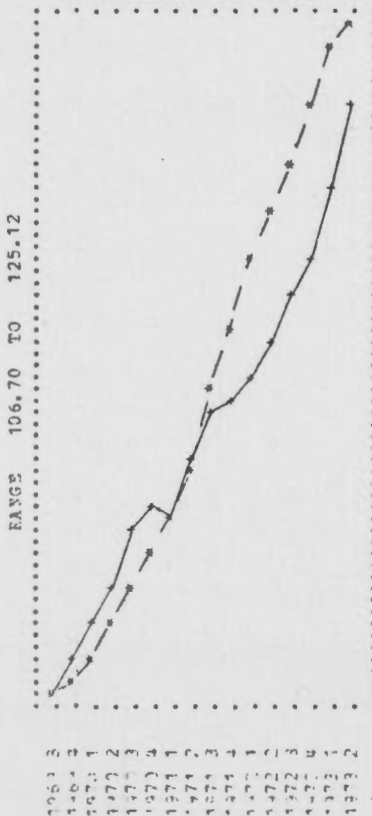
(3) HOUSEHOLD APPLIANCES



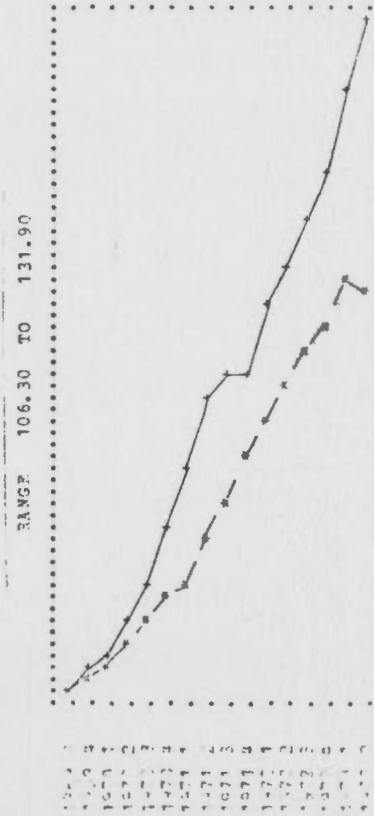
(4) FURNITURE AND FLOOR COVERINGS



(5) OTHER UTENSILS (HOUSEHOLD)

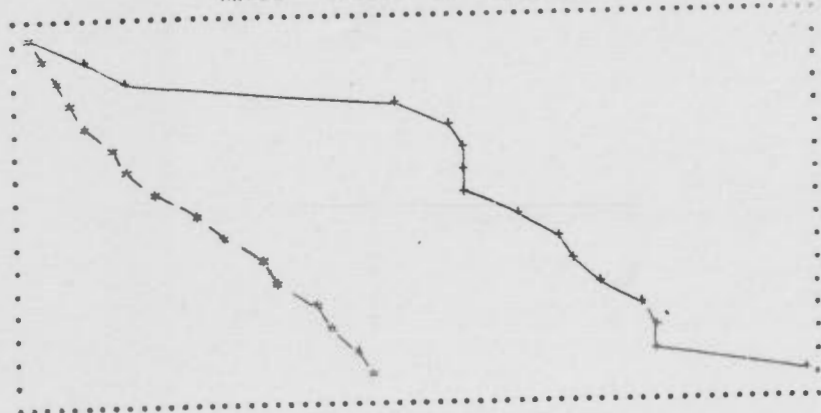


(6) PERSONAL REQUISITES



RANGE 108.60 TO 155.80

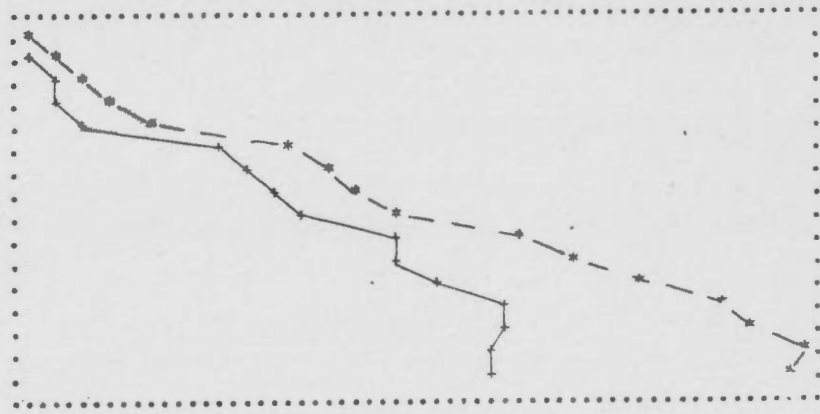
1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(10) NEWSPAPERS, MAGAZINES

RANGE 105.10 TO 125.47

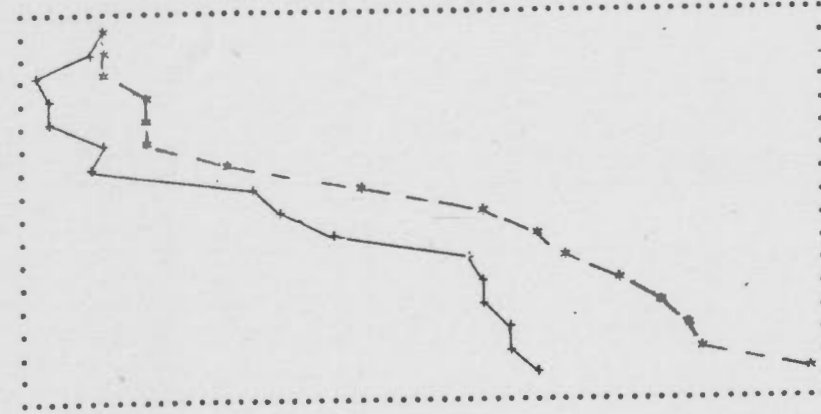
1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(7) MOTORING (GOODS)

RANGE 104.10 TO 116.14

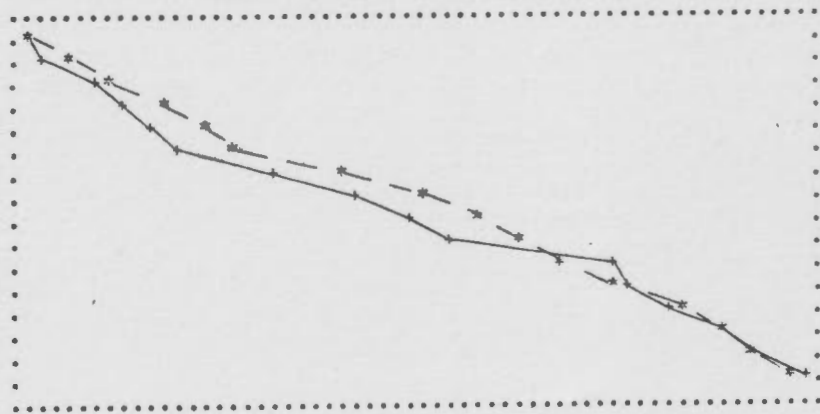
1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(11) FUEL, LIGHT

RANGE 121.70 TO 158.60

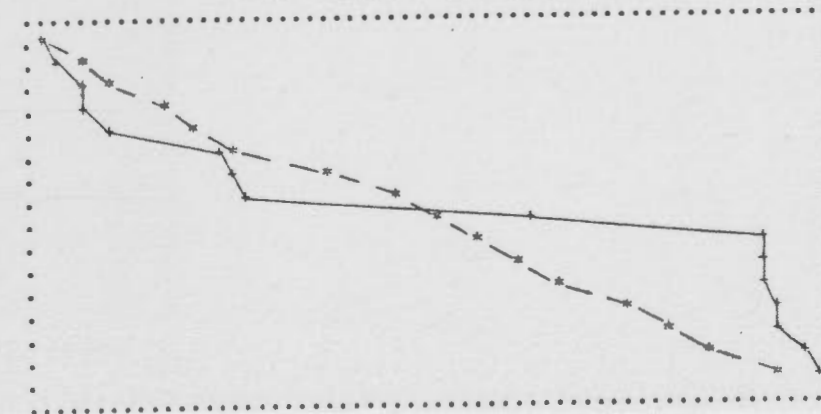
1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(8) MOTORING (SERVICES)

RANGE 114.00 TO 154.30

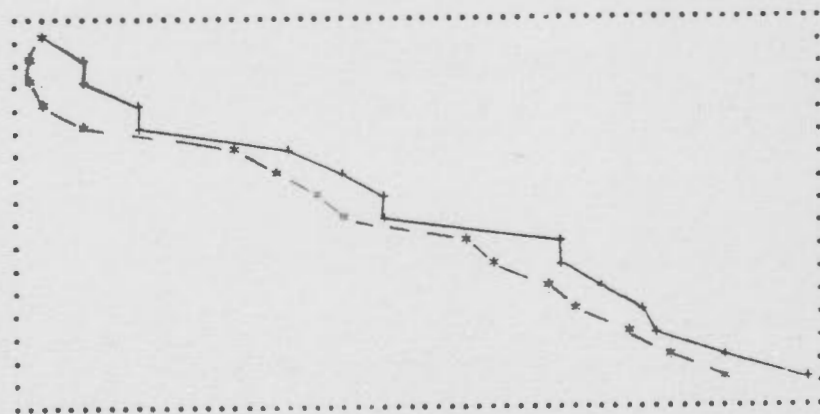
1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(12) FARES AND POSTAL

RANGE 104.77 TO 136.20

1969 3
1969 4
1970 1
1970 2
1970 3
1970 4
1971 1
1971 2
1971 3
1971 4
1972 1
1972 2
1972 3
1972 4
1973 1
1973 2



(9) TOBACCO, CIGARETTES, BEER

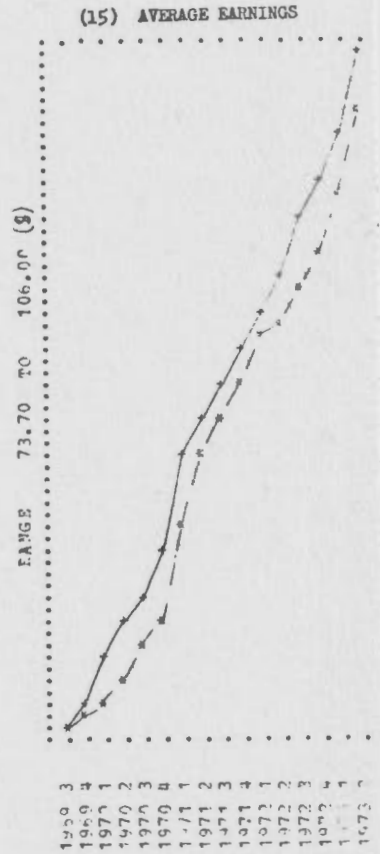
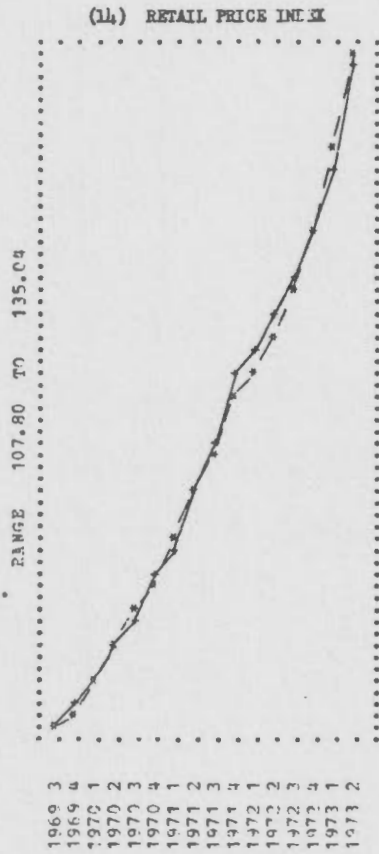
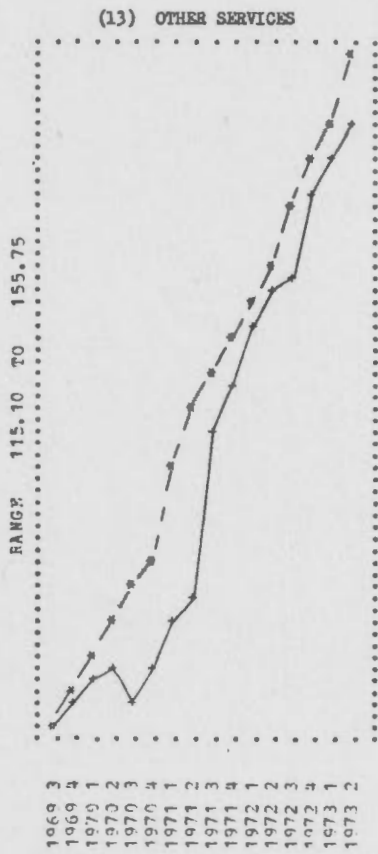


TABLE 2
ACTUAL AND PREDICTED PRICES
(1966-67 = 100)

	ACTUAL	SOLUTION	RESIDUALS	ACTUAL	SOLUTION	RESIDUALS	ACTUAL	SOLUTION	RESIDUALS
	(1) PROCESSED FOOD			(2) CLOTHING			(3) HOUSEHOLD APPLIANCES		
1969 3	108.200	108.200	0.0	106.000	106.000	0.0	95.300	95.300	0.0
1969 4	109.600	107.957	0.643	107.200	106.684	0.536	94.900	95.478	-0.578
1970 1	109.700	109.260	0.440	107.900	107.091	0.809	94.900	96.234	-1.334
1970 2	109.700	110.754	-1.054	108.900	107.779	1.121	95.200	97.073	-1.873
1970 3	110.800	111.690	-0.890	109.200	108.448	0.752	95.200	97.987	-2.787
1970 4	111.800	110.802	0.998	110.900	109.252	1.648	96.900	99.303	-2.403
1971 1	112.100	112.391	-0.291	112.200	109.899	2.311	98.200	94.830	-1.630
1971 2	114.200	114.689	-0.489	115.100	110.265	4.835	98.900	101.708	-2.808
1971 3	115.600	116.008	-0.408	115.700	112.272	3.428	97.900	104.257	-6.357
1971 4	116.900	116.848	0.052	118.000	113.968	4.032	100.100	105.535	-5.435
1972 1	118.500	117.283	1.217	118.800	115.229	3.571	99.700	106.437	-6.737
1972 2	119.300	118.925	0.375	121.300	116.797	4.503	99.400	107.130	-7.730
1972 3	120.400	120.662	-0.262	122.200	118.214	3.986	98.900	107.939	-9.039
1972 4	120.800	123.572	-2.772	124.300	119.992	4.308	99.100	108.925	-9.825
1973 1	122.900	128.022	-5.102	125.700	122.168	3.532	99.200	110.323	-11.123
1973 2	126.400	129.604	-3.204	131.100	124.205	6.895	99.600	110.581	-10.981
	(4) FURNITURE AND FLOOR COVERINGS			(5) OTHER UTENSILS (HOUSEHOLD)			(6) PERSONAL REQUISITES		
1969 3	108.100	108.100	0.0	106.700	106.700	0.0	106.300	106.300	0.0
1969 4	108.500	109.017	-0.517	107.600	107.098	0.592	107.100	106.711	0.389
1970 1	109.100	110.071	-0.971	108.600	107.686	0.914	107.800	107.265	0.535
1970 2	109.900	111.125	-1.225	109.700	108.620	1.080	109.000	107.212	1.788
1970 3	112.100	112.260	-0.160	111.300	109.553	1.747	110.300	108.794	1.506
1970 4	113.400	113.860	-0.460	111.800	110.680	1.120	112.400	109.740	2.660
1971 1	114.900	114.958	-0.058	111.700	111.464	0.236	114.700	110.449	4.251
1971 2	119.300	116.102	3.198	113.200	112.787	0.413	117.700	111.982	5.718
1971 3	119.000	118.852	0.148	114.400	115.046	-0.646	118.500	113.567	4.933
1971 4	122.400	121.170	1.230	114.900	116.772	-1.872	118.600	115.353	3.247
1972 1	122.800	123.488	-0.688	115.500	118.507	-3.007	121.100	116.779	4.321
1972 2	124.100	125.889	-1.789	116.300	120.051	-3.751	122.500	118.176	4.324
1972 3	125.600	128.243	-2.643	117.800	121.247	-3.447	124.400	119.234	5.166
1972 4	127.700	130.593	-2.893	118.500	122.809	-4.309	126.000	120.441	5.559
1973 1	131.000	133.588	-2.588	120.600	124.375	-3.775	129.100	121.801	7.299
1973 2	135.900	136.813	-0.913	122.700	125.122	-2.422	131.900	121.559	10.341
	(7) MOTORING (GOODS)			(8) MOTORING (SERVICES)			(9) TOBACCO, CIGARETTES, BEER		
1969 3	105.100	105.100	0.0	121.700	121.700	0.0	105.200	105.200	0.0
1969 4	105.100	105.801	-0.701	122.400	121.604	0.796	107.000	104.774	2.226
1970 1	105.700	106.481	-0.781	125.000	125.736	-0.736	107.200	104.916	2.284
1970 2	105.800	107.134	-1.334	126.400	127.989	-1.589	109.100	105.580	3.520
1970 3	106.700	108.141	-1.441	127.300	129.837	-2.537	109.400	107.216	2.184
1970 4	110.200	111.753	-1.553	128.900	131.470	-2.570	115.100	112.985	2.115
1971 1	110.700	112.795	-2.095	133.200	136.804	-3.604	117.600	114.474	3.126
1971 2	111.400	113.781	-2.381	137.300	140.174	-2.874	119.100	116.342	2.758
1971 3	112.100	114.694	-2.594	140.000	142.886	-2.886	119.300	117.517	1.783
1971 4	114.600	117.986	-3.386	141.500	145.077	-3.577	126.300	122.271	4.029
1972 1	114.900	119.475	-4.575	149.300	146.956	2.344	126.400	123.397	3.003
1972 2	115.900	121.288	-5.388	150.000	149.442	0.558	128.000	125.563	2.437
1972 3	117.600	123.216	-5.616	152.400	152.464	-0.064	129.000	126.775	2.225
1972 4	117.500	124.077	-6.577	154.500	154.869	-0.369	130.400	129.067	1.333
1973 1	117.400	125.466	-8.066	155.900	156.017	-0.117	133.100	130.739	2.361
1973 2	117.300	125.218	-7.918	158.600	158.023	0.577	136.200	132.142	4.058
	(10) NEWSPAPERS, MAGAZINES			(11) FUEL, LIGHT			(12) FARES AND POSTAL		
1969 3	108.600	108.600	0.0	105.100	105.100	0.0	114.000	114.000	0.0
1969 4	112.000	109.159	2.841	104.900	105.159	-0.259	114.600	115.799	-1.199
1970 1	114.300	110.179	4.121	104.100	105.045	-0.945	115.000	117.842	-2.842
1970 2	130.700	111.381	19.319	104.400	105.742	-1.342	115.800	120.161	-4.361
1970 3	133.000	112.100	21.900	104.400	105.895	-1.495	117.800	121.936	-4.136
1970 4	135.000	113.402	21.598	105.100	105.811	-0.711	121.200	123.504	-2.304
1971 1	135.000	114.347	20.653	105.000	106.943	-1.943	123.900	124.763	-0.863
1971 2	135.200	116.183	19.017	107.400	109.129	-1.729	124.500	132.201	-7.701
1971 3	138.500	114.529	23.971	107.800	111.034	-3.234	139.400	134.577	4.823
1971 4	140.500	120.135	20.365	108.700	111.952	-3.252	139.400	136.761	2.639
1972 1	141.400	122.522	18.878	110.900	112.260	-1.360	151.600	138.618	12.982
1972 2	143.300	123.753	19.547	111.100	113.140	-2.040	151.600	140.957	10.643
1972 3	146.000	125.840	20.160	111.100	113.856	-2.756	152.500	144.131	8.369
1972 4	146.800	126.822	19.978	111.400	114.243	-2.843	152.500	146.616	5.884
1973 1	148.000	128.464	19.536	111.500	114.514	-3.014	153.700	148.780	4.920
1973 2	152.400	129.336	23.064	111.900	115.143	-3.243	154.300	152.038	2.262

	ACTUAL	SOLUTION	RESIDUALS
(13) OTHER SERVICES			
1967 3	115.160	115.100	0.0
1969 4	116.260	117.010	-0.810
1970 1	118.000	119.098	-1.098
1970 2	119.000	121.481	-2.481
1970 3	116.300	123.383	-7.083
1970 4	118.900	125.155	-6.255
1971 1	121.200	130.690	-9.490
1971 2	123.000	134.199	-11.199
1971 3	122.600	136.536	-3.936
1971 4	135.700	139.728	-3.028
1972 1	139.200	140.717	-1.517
1972 2	141.300	143.088	-1.788
1972 3	142.500	146.459	-3.959
1972 4	147.500	149.265	-1.765
1973 1	149.000	151.771	-2.171
1973 2	151.600	155.751	-4.151

	ACTUAL	SOLUTION	RESIDUALS
(14) RETAIL PRICE INDEX			
197.800	107.800	107.800	0.0
109.700	108.466	108.466	0.232
109.800	109.697	109.697	0.103
111.200	111.132	111.132	0.068
111.900	112.404	112.404	-0.504
114.000	113.619	113.619	0.381
115.200	115.383	115.383	-0.183
117.200	117.250	117.250	-0.050
119.200	118.999	118.999	0.201
122.000	121.011	121.011	0.989
123.300	122.092	122.092	1.208
124.400	123.617	123.617	0.783
126.100	125.719	125.719	0.381
127.700	128.078	128.078	-0.378
130.400	131.444	131.444	-1.044
134.700	135.044	135.044	-0.344

	ACTUAL	SOLUTION	RESIDUALS
(15) AVERAGE EARNINGS (\$)			
73.700	73.700	73.700	0.0
75.100	74.062	74.062	1.038
76.900	74.734	74.734	2.166
78.800	76.185	76.185	2.615
80.100	77.806	77.806	2.294
82.000	79.038	79.038	2.962
86.900	83.202	83.202	3.698
89.300	86.844	86.844	1.036
90.200	88.453	88.453	1.747
91.700	90.138	90.138	1.562
93.300	92.123	92.123	1.177
95.200	93.079	93.079	2.121
98.100	94.602	94.602	3.498
100.000	96.498	96.498	3.502
102.200	99.300	99.300	2.900
106.000	103.387	103.387	2.613

One source of difference between the actual and predicted prices for components of the price index is the use of overall average price indexes to measure the changes in cost of inputs to industries, instead of the actual changes in costs for each industry. Price indexes of costs by individual industries in Australia are not readily available. It might be assumed, however, that the use of average indices leads to errors in prices of output of individual industries (and hence on the components of the retail price index), but the error will tend to be offsetting in the total index.

Other sources of difference between the actual and predicted prices will be the result of (1) mistakes in the specification of the model, including the assumptions of a constant mark-up on cost and that prices are based on historical cost, and (2) to errors in the estimates of the parameter in the model, including the rate of productivity change, the period of stock turnover, and the calculation of mark-ups and tax rates. Ideally, it would be desirable to reduce the possibility of type (2) errors as far as possible, which would then enable a check to be made on the pricing assumptions in the model. However, the reliability of the parameter estimates is considerably affected by limitations in the data available. For example, official indexes of industrial production are not available in Australia, and there are differences between the industrial classification of output and stocks of goods. No attempt is made to analyse the predictions of the model in any details, and the following comments are intended simply to refer to some possible reasons for major differences in the actual and predicted prices for some components.

The model predicted the increase in total retail prices (14) and in the major components of the retail price index - processed food (1), clothing (2) and other services (13), which together make up about 40 per cent of the weight of the total price index.

The predicted total price change, however, includes the prices of items predicted by the model plus the actual prices of rent, unprocessed food, natural gas and radio and T.V. licences. The actual prices contribute about 20 per cent of the weight of the total index and their inclusion therefore leads to

a somewhat spurious accuracy in the prediction of the total price change.

In the case of clothing, the model underpredicted the increase in prices in 1970/17; in this period wool prices fell by about 13 per cent, and it is possible that this fall in prices was not passed on fully to consumers leading to an increase in profit margins of manufacturers and/or distributors.

Of the other components, the discrepancy between actual and predicted prices of fares and postal (12) and newspapers and magazines (10) is obviously explained by the discontinuity in price changes. The transport industry is largely government owned, and there was a substantial once-for-all increase in fares on public transport in 1971. The actual changes in the prices of newspapers and magazines is again largely due to a once-for-all increase in the price of newspapers in 1970.

The other major discrepancies are in the prediction of prices of household appliances (3) and personal requisites (6). In the 1970's local manufacturers of household appliances were subject to intense competition from overseas, which led to continued requests for tariff protection. It seems not unreasonable to expect a squeeze in profit margins in this period, which would explain the lower than predicted increase in prices. The underprediction of the prices of personal requisites and medicines is difficult to explain. It could, however, be due to an overstatement in the allowance for the productivity change in the production of proprietary medicines and other household products. The index of industrial production of chemicals used in this model covers both industrial and household products, and it may be that the rate of productivity change was greater for industrial chemicals than for proprietary medicines and other household products.

Comparison of the actual and predicted levels of average wages is shown in (15). Overall the changes in the actual and predicted values are quite similar, except that in the first two quarters, the model underpredicts the increase in average wages. This may be due to the effect of initial values. Endogenous estimates of wages are included in the model only from 1969 I; up to that period, actual values of wages were used to simulate the model. In 1969 I, however, the equations underpredicted the level of actual wages, and this resulted in an

apparent initial fall in the level of wages, and this had the effect of dampening the rates of increase in wages until 1970 I.

Additional investigation of the pricing policies in individual industries and further analysis of the available data would no doubt lead to improvements in the reliability of the model for the purpose of predicting changes in individual components of the retail price index. However, the model as it stands does provide a good prediction of the total change in retail prices over the period, and of the prices of the principal components of the index. This would appear to justify the use of the model for the purpose of this study -- to investigate the determinants of the change in retail prices over the period.

4. Conclusions

The aim of this paper was to formulate a closed input-output system for the purpose of analysing the determinants of changes in prices. The model comprises two separate sets of relations which describe an open dynamic input-output system and regression equations which link changes in the price of sales to final buyers (retail prices) to the cost of primary inputs (average earnings). Results were given of the simulation of these two parts of the model in Part 3 (b) of the paper.

The system described in this paper has two advantages over the traditional methods of analysing changes in prices using the static input-output model. First, it provides a method for analysing the time path of the effects of changes in primary inputs on the price of intermediate transactions and the price of final output. Secondly, the model is closed and hence provides a self-generating mechanism for analysing changes in prices and costs over a particular period for given initial values and actual values of exogenous variables.

The complete model has not yet been simulated. The results of the simulations of the separate parts of the model suggest, however, that it will provide a useful system for the analysis of price changes over time. It is proposed to apply the model to examine the effects on prices of intermediate transactions and the

price of final output of (1) changes in costs of primary inputs and (2) economic policy changes affecting directly wages or costs, including changes in tax rates and statutory increases in nominal wages.

APPENDIX 1

1. LIST OF INDUSTRIES

Selling prices determined by the model -

1. Chemicals
2. Petroleum Products
3. Glass, Clay and other Non-Metallic Products
4. Fabricated Metal Products
5. Transport Equipment
6. Other Machinery and Equipment
7. Leather and Leather Goods
8. Textiles
9. Clothing and Footwear
10. Food Manufacturing
11. Beverages and Tobacco Products
12. Paper and Paper Products, Printing and Publishing
13. Wood, Wood Products and Furniture
14. Other Manufacturing
15. Gas, Electricity and Water
16. Health, Education and Welfare and Entertainment and Personal Services
17. Motor Vehicle Repairs and Service
18. Transport, Storage and Communicators

Selling prices assumed exogenous -

1. Agriculture
2. Forestry
3. Mining (including base metals)
4. Rent

Selling prices determined as a mark-up on purchases -

1. Wholesale and Retail Trade

2. LIST OF CONSUMPTION EXPENDITURE CATEGORIES

Prices determined by the model -

1. Processed Food
2. Clothing
3. Household Appliances
4. Furniture and Floor Coverings
5. Other Utensils (Household)
6. Personal Requisites and Proprietary Medicines
7. Motoring (Goods)
8. Motoring (Services)
9. Tobacco, Cigarettes, Beer
10. Newspapers, Magazines
11. Fuel, Light (excluding Natural Gas)
12. Fares and Postal
13. Other Services

Prices assumed exogenous -

1. Unprocessed Food
2. Rent
3. Radio and T.V. Licences
4. Natural Gas

APPENDIX 2

CONCEPTS AND SOURCES OF DATA

1. The Basic Data

(a) Input-Output Relations

The input-output coefficients used to distribute increases in costs and prices between industries are based on data given in Table 8, in the official national income publication for 1962-63 (which is the latest year for which official input-output data are available). This table is a 40 industry table in which entries are at basic values and imports directly allocated to using industries. The table is slightly condensed by combining several industry groups together and estimates are made of intra-industry transactions, which are not shown in this table, from other official data.

In this table, entries are at basic values, and in order to convert the values to retail prices it was necessary to add on to the basic values the commodity taxes and distribution margins on sales by wholesalers and retailers to consumers. This information is set out, for 1962-63, in Table E, of the official national income publication. As described in the text, allowance was made for changes in tax rates (see Part 2 (d) of this Appendix for details of the calculation of tax rates). Retail and wholesale margins (exclusive of commodity taxes) were assumed constant.

(b) Consumers' Expenditure by Industry and Commodity

The changes in prices of outputs of industries sold to final consumers were converted into prices of components of the official retail price index by a "consumption convertor" or matrix of consumers' expenditure by industry and commodity. This cross-classification is not published for 1962-63, but it is available from the 1958-59 table (Table A, of the 1958-59 input-output publication). The coefficients derived from this table were assumed to be constant over the period of this study.

2. Exogenous Variables and Parameters

(a) Prices

Prices of imports are derived from the monthly import price index published by the Reserve Bank. The price of duty is obtained by dividing the value of duty by a series of the quantities of imports (calculated by dividing the value of imports by the Reserve Bank price index of imports). The price of wages is the official index of average earnings per male unit by quarters, seasonally adjusted, interpolated to months.

Industry prices comprise prices of wool, other farm prices, prices of timber and metal prices. Prices of wool and other farm produce received by farmers are quarterly index series published by the Bureau of Agricultural Economics, which are interpolated to months. The price of metals is an official monthly index of a "price index of metallic materials used in the manufacture of fabricated metal products". The selling price of output forestry is derived from an official index of the price of timber used in housebuilding.

Prices of components of the Consumer Price Index which are exogenous are taken from the official publications. The official figures are for quarters and are interpolated to obtain monthly figures.

(b) Rate of Change of Labour Productivity

The rate of change in labour productivity is the cumulative average rate of change per month from 1968/69 to 1972/73. The rate of change of productivity for industrial manufacturing industries is calculated from data of industrial production of industries published by the A.N.Z. Bank, and employment by industry published by the Commonwealth Statistician. Productivity change in the service industries is assumed to be one-third of the rate for all manufacturing industry (See Haig (2)).

(c) Mark-ups

The mark-up on purchases by individual manufacturing industries from other industries and on imports is estimated as the ratio of intermediate purchases from the trade and transport industries to the total purchases of goods, including imports. The mark-up differ for industries but the same mark-up is assumed to apply

on purchases from all industries and imports.

Selling price is calculated by applying a constant mark-up to prime costs for each industry. Prime costs cover purchases of all goods and unit wages costs.

These mark-ups are calculated from data of inter-industry transactions given in Table 8 of the 1962/63 input-output publications.

The wholesale and retail margins on sales by industries to final consumers are based on values of purchases by wholesalers and the distributive margins on sales to consumers given in Table E of the 1962/63 input-output publication.

(d) Rates of Commodity Taxes

The rates of tax at the beginning of the period were calculated from data in Table E of the 1962/63 publication. No allowance was made, therefore, for changes in rates of tax between 1962/63 and 1969.

Allowance, however, was made for changes in rates from 1969 and 1974, using data contained in the Commonwealth Budget statements.

The main changes in rates since 1969 have been as follows:-

1970-71 Budget

- (i) Increases in rates of customs and excise duties on cigarettes, cigars and manufactured tobacco, and on wine and motor spirit and some other petroleum products.
- (ii) Removal of the duty on spirits used to fortify wine
- (iii) Increases in the rate of sales tax from 25 per cent to 27½ per cent on certain goods. These goods are principally cars and station wagons and radios, T.V. sets, etc.

1971-72 Budget Increases in the rates of customs and excise tax on cigarettes, cigars and other manufactured tobacco.

The effect of these changes in tax rates was estimated from data of estimated revenue from taxes, given in the Commonwealth Budgets and, in the case of the increase in rates of sales tax, by applying the rate on estimated sales of the products affected.

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