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Farm and Retail Food Prices

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This paper analyses the relationship between monthly observations on farm level and retail level prices of three meats, seven fresh vegetables, five fresh fruits, eggs and cereals over the 1970's. *A priori* reasoning and results of Sim's casuality tests suggest that in most cases changes in farm prices cause changes in retail prices rather than the reverse or a simultaneous relationship. Markup price relationships are estimated. Most of the variation of retail prices is explained by the current farm price, lagged farm prices, a wage variable, and last period's retail price of a substitute product.

I. Introduction

In recent times fluctuations in food prices have received attention because of their effects on general economic performance as well as their effects on the distribution of income. With a weight of 20.84 per cent in the Consumer Price Index, changes in retail food prices have direct and indirect effects on levels of inflation, wages and other measures of macroeconomic performance. Sharp rises in food (and energy) prices in the 1970's were of concern to macroeconomic policy makers and analysts with the shift of interest from demand side problems to supply side shocks. Of course, falls in food prices might be expected to have beneficial influences on the wider economy. Food expenditure represents just under 19 per cent of private consumption expenditure for the average Australian household and more for those on lower incomes. Levels of retail food prices clearly have important direct effects on real household income and household well-being. Similarly, farm level food prices directly influence the level and variability of farm income. The speed and magnitude with which retail and farm prices at the different stages of the food marketing chain adjust to shifts in conditions of supply and demand provide a useful guide to the allocative efficiency of the market and is a traditional area of market analysis.

The purpose of this paper is to examine the dynamic patterns of adjustment of retail and farm prices for meats, fresh fruits, fresh vegetables, eggs and cereal products during the 1970's using monthly price data. The analysis is directed to an understanding of the contribution of farm food prices and non-farm input costs to changes in retail food prices; adjustment lags in price changes due to price levelling, price averaging and other causes; asymmetrical responses of retail price changes to rising and falling farm prices; and the relative price elasticities of demand at retail and farm levels. Section II provides background information on historical price patterns and the results of previous studies. A structural model describing the demand for and supply of a food product at the retail and farm levels is described in section III. Within the

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context of the structural model the section discusses simplified models including markup models. Unfortunately not enough data are available to estimate the structural model. Section IV reports the results of causality tests suggested by Sims (1972) to evaluate the hypothesis that farm prices cause retail prices. Estimates of markup models where retail food price is regressed on current and lagged farm prices, the wage rate, a substitute product retail price, seasonal dummy variables and a dummy variable for farm price increases are reported in section V. A final section discusses implications of the analysis for the effects of food prices on inflation, for efficiency of the food marketing system, and for the distribution of the consumer dollar between marketers and farmers.

II. Background

Data on trend movements and the variability of nominal retail and farm prices of selected food products over the 1970's are shown in Table 1. The prices refer to the Sydney market for three meats, seven fresh vegetables, five fresh fruits, eggs and cereal products. For purposes of comparison data are shown also for the food component of the CPI, the total CPI, and minimum average weekly wages. Details of the particular series are given in the Appendix. The products are a selected rather than a comprehensive or random sample of food products. Because of measurement and sampling errors, care is required in the interpretation of particular absolute values. However, within the context of our primary interest in movements of the price series over time, the data available for use in this study are regarded at least as reasonable proxy variables.

Table 1: Characteristics of Monthly Prices of Selected Food Products over the Period 1972–1981

Product and level	Units	Average values		Annual change (%)	Coefficient of variation (%)
		1972	1981		
Beef—					
retail	cents/kg	113.9	300.6[b]	12.1	37.9
farm	cents/kg	67.1	173.3[b]	11.8	54.6
Pork—					
retail	cents/kg	115.3	329.5[b]	13.1	32.2
farm	cents/kg	59.0	163.3[b]	12.7	38.2
Lamb—					
retail	cents/kg	86.0	271.4[b]	14.5	34.4
farm	cents/kg	38.4	123.6[b]	14.7	38.5
Beans—					
retail	cents/kg	64.5	199.5	12.0	38.6
farm	cents/kg	34.1	100.1	11.4	40.3
Peas—					
retail	cents/kg	49.7	231.7	16.6	49.1
farm	cents/kg	27.3	97.1	13.5	43.2
Potatoes—					
retail	cents/kg	23.6	98.6	15.4	46.4
farm	cents/kg	5.9	22.4	14.3	44.2

Table 1—continued

Product and level	Units	Average values 1972	Average values 1981	Annual change (%)	Coefficient of variation (%)
Onions					
retail	cents/kg	46.3[a]	120.2	11.2	55.0
farm	cents/kg	21.4[a]	60.1	12.2	80.5
Carrots					
retail	cents/kg	22.7	91.8	15.0	40.6
farm	cents/kg	7.7	32.4	15.5	53.9
Pumpkin					
retail	cents/kg	26.0[a]	64.8	10.7	37.1
farm	cents/kg	12.8[a]	20.9	5.6	50.4
Tomatoes					
retail	cents/kg	61.3	178.0	11.2	36.7
farm	cents/kg	38.2	84.8	8.3	38.8
Bananas—					
retail	cents/kg	47.0	109.0	8.8	35.5
farm	cents/kg	27.8	49.3	5.9	36.6
D. Apples—					
retail	each	4.9	19.3	14.7	54.2
farm	each	4.4	10.8	9.4	44.2
G.S. Apples—					
retail	each	4.1	14.3	13.3	47.9
farm	each	3.2	7.3	8.6	42.0
Oranges—					
retail	each	3.9	13.4	13.1	47.5
farm	each	2.0	4.1	7.4	27.2
Pears—					
retail	each	4.6	13.1	11.0	50.3
farm	each	3.4	6.5	6.7	37.4
Eggs—					
retail	cents/doz.	66.2[c]	133.7[d]	8.1	21.3
farm	cents/doz.	44.6[c]	98.6[d]	9.2	21.6
Cereal—					
retail	1966–7 = 100	139.8[a]	342.7	10.5	26.0
farm	$/tonne	67.9[a]	158.7	9.9	26.4
CPI—food	1966–7 = 100	119.2	327.4	10.6	..
CPI total[e]	1966–7 = 100	125.5	329.9	10.1	..
Wage rate	$/week	64.4	200.8	12.0	..

[a] Data for 1973.
[b] Data for May, 1979 to April, 1980.
[c] Data for July, 1972 to June, 1973.
[d] Data for July, 1980 to June, 1981.
[e] Data is for quarters only.

Sources of the data are described in the Appendix.

All price series reported in Table 1 exhibit upward trends over the 1970's. At the aggregate level the food component of the CPI rose at a slightly faster rate (an average of 10.6 per cent per annum from 1972 to 1981) than the total CPI (10.1 per cent) and both of these were exceeded by the annual growth rate for male minimum weekly award wages (12.0 per cent). Clearly the time periods of comparison are important, but it is reasonable to conclude in the context of long-term trends that retail food prices and non-food prices moved upwards at similar rates over the 1970's.

For most of the individual food products shown in Table 1, retail prices rose at a faster rate than farm prices over the 1970's. Only for four of the seventeen products was this not the case and even then the differences in average annual growth rates were small. The marketing margin to cover costs of storage, transport, processing and distribution of the food products has been increasing both in absolute terms and as a share of the consumer's food dollar. Possible reasons for the observed pattern include an increase in the demand for marketing services and increases in the costs of providing marketing services relative to the farm product.[1]

An indication of the variability of the prices is given by the percentage coefficient of variation. Comparing retail and farm prices, the percentage coefficient of variation for farm prices is greater in the case of the meats, most of the vegetables (except peas and potatoes), eggs and cereals, and is less in the case of most of the fruits (except bananas). Relative stability of the retail prices is consistent with the practices of price levelling and averaging whereby marketers absorb some of the short-term fluctuations in farm prices in changes in the marketing margin.[2]

A comparison of the absolute values of the retail price and farm price series in Table 1 gives only a guide to the magnitude of the marketing margin. Problems of definition and systematic measurement errors may be important. Even so, the data confirm the importance of the marketing margin. For many of the products in Table 1 over half of the consumer's retail food dollar goes to the provision of marketing services.[3] Because of the importance of the marketing margin, changes in the costs of providing marketing services significantly influence both retail and farm food prices.[4]

Previous studies of retail and farm prices of foods in Australia have canvassed some of the questions raised in this paper. At the individual commodity level most work has looked at farm, wholesale and retail prices of meats (Woodward 1968; Griffith 1974 and 1975; Naughtin and Quilkey 1979; Prices Justification Tribunal 1978). The more recent studies concluded that price levelling and price averaging were important and that over the longer term (variously estimated to be from one month to several quarters) farm and retail prices moved together. Costs of non-farm inputs, measured by wage rates, and turnover influenced the marketing margin. Forsyth (1975) found evidence of short-term price levelling and some price averaging in a study of farm and retail prices of different varieties of apples. The PJT (1979) reported evidence tendered to it of cross-product subsidization and price averaging by processors, wholesalers and retailers of food products. Also, prices of baskets of food products were increased in response to rising costs and labour was found to be the major cost item as a share of value added.

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[1] Formal models developing these points are described by Gardner (1975) and Fisher (1981).

[2] Parish (1967) provides an excellent discussion of price levelling and averaging, and Griffith (1974) and Naughtin and Quilkey (1979) focus on the particular case of meat marketing.

[3] Taking food as an aggregate, about two-thirds of the consumer's food dollar goes to marketing services and one-third to the farmer. With the exception of cereals, the products in Table 1 are towards the less processed end of the spectrum.

[4] For a formal presentation of the argument see Gardner (1975).

Most studies of the price setting behaviour of Australian manufacturers, including food processors, have used variants of a cost markup model (Hancock 1976; Gregory 1978; Hall 1980; Saunders 1981). Output prices responded to cost increases, usually with some lags, and most of the adjustment occurred within one or two quarters. Conflicting results were obtained on the effect of excess demand. Hall's results for the food and drink manufacturing industry are of most relevance to this study; prices were significantly influenced by expected average costs, unexpected changes in average costs, and excess demand as measured by the unexpected change in inventories.

Several recent studies of U.S. food prices are of interest in terms of the methodology and the results (Heien 1980; Lamm and Westcott 1981; Ward 1982). A price markup model underlies each study. Causality tests gave mixed results; Heien found that for most commodities wholesale prices caused retail prices, Lamm and Westcott found that for most commodities farm prices caused retail prices, and Ward found that wholesale prices caused both retail and farm prices. In each study lags were found in the adjustment of changes in retail prices to price changes lower in the food chain with most adjustment being completed within a few months. While Heien found no evidence of asymmetrical responses of retail prices to farm price rises and falls, Ward concluded that wholesale price falls were passed on more quickly and to a greater extent than rises. Increases in costs of non-farm marketing inputs, particularly wages and for some products energy and packaging costs, were found to be important causes of rising retail food prices in the U.S. in recent decades.

III. Models

A fairly general structural model of the determination of retail and farm food prices would have supply and demand equations and price adjustment equations to reflect adjustment lags and short-run disequilibrium behaviour. For illustrative purposes, consider the following model—

(1) $RD_i = f(PR_i, PR_j, Y, S)$

(2) $RS_i = f(PR_i, PF_i, C)$

(3) $FDD_i = f(PR_i, PF_i, C, RI_{i,t-1})$

(4) $FDE_i = f(PF_i, X)$

(5) $FD_i = FDD_i + FDE_i$

(6) $FS_i = f(PF_i, S, Z)$

(7) $PR_i = f(RD_i - RS_i, RI_{i,t-1}, PR_{i,t-1})$

(8) $PF_i = f(FD_i - FS_i, FI_{i,t-1}, PF_{i,t-1})$

(9) $RI_i = RI_{i,t-1} - (RD_i - RS_i)$

(10) $FI_i = FI_{i,t-1} - (FD_i - FS_i)$

where *RD* is retail demand, *RS* is retail supply, *FDD* is demand for farm product for domestic food, *FDE* is demand for farm product for export, *PR* is retail price, *PF* is farm price, *RI* is retail inventory, *FI* is farm inventory, *Y* is income, *S* is seasonal conditions, *C* is cost of non-farm inputs used in providing marketing services, *X* is an index of export demand shifters (e.g. overseas income, exchange rate) and *Z* is an index of farm supply shifters (e.g. input costs). Equations (1) and (2) describe demand and supply at the retail level. Demand at the farm level (5) is the sum of derived demand for domestic food (3) and export demand (4). Farm supply is given by (6). The price equations (7) and (8) allow for short-term disequilibrium in the retail and farm markets. Identities for inventories are given in (9) and (10). Reduced form equations for retail food prices and farm food prices would express the prices as functions of: retail demand shift variables (income, competing product prices, seasonal conditions); costs of non-farm inputs used in providing marketing services (wages, energy prices); export demand shift variables (overseas income, exchange rates); farm supply shift variables (input costs); beginning inventory levels; and lagged prices.

In practice not enough data are available to estimate the complete structural model. There are no data on quantities or inventories for fresh fruits and vegetables for periods as short as a month. Measures of household income are available only on a quarterly basis. The task of compiling seasonal variables relevant to the monthly supply of fruit and vegetables, and to a lesser extent the meats, would be very large. Considerable specification and data problems would be involved in obtaining satisfactory measures of the export demand shift variables.[5] For these reasons it was necessary to impose additional *a priori* restrictions to obtain estimable equations.

A static equilibrium model is one special case. Here retail and farm demand and supply clear each period to determine retail and farm prices. In the above model there would be no inventories and the price functions become redundant so that the model is given by equations (1) to (6) plus the identities $RD_i = RS_i$ and $FD_i = FS_i$. Assuming constant returns to scale and competitive behaviour in the marketing sector, Gardner (1975) and Heien (1980) show that the retail price can be specified as a static markup rule,

(11) $PR = \alpha \text{ PF} + \beta \text{ C}$

where, as before, *PR* is retail price, *PF* is farm price and *C* is an index of cost of non-farm inputs, and α and β are parameters. Further, in the special case where the elasticity of substitution between the farm product and the non-farm inputs in producing the retail product is zero, the parameters α and β will be constant. Where the elasticity of substitution is non-zero these parameters are functions of the two input costs *PF* and *C*. For the individual commodities studied in this paper, and especially the individual vegetables and fruits, it seems reasonable to assume that the elasticity of substitution is low and that constant parameters in (11) is a tolerable simplification. Alternatively, equation (11) might be given a more *ad hoc* justification along the lines of Heien (1980, p. 11) "An operationally more realistic theory is one where store managers apply a markup over costs for each product in order to arrive at a price".

[5] Although, as noted by a reviewer, export demand is important for only some of the commodities analysed (beef, apples, pears), and this problem should not be exaggerated.

Dynamic and disequilibrium elements of behaviour can be added to the markup model. The inclusion of lagged as well as current values of the prices in (11) would allow for partial adjustment of retail price changes to cost changes. In particular, significant lagged farm price changes would imply price levelling behaviour which has been found in other studies. A dummy variable procedure can be used to test for significant asymmetrics of price response. This model is the dynamic price markup model used by Heien (1980) and Ward (1982). Others have added additional variables to represent the effects of demand pressures. Lamm and Westcott (1981) included the retail prices of substitute products under the argument that a rise (fall) of a substitute retail product price would induce marketers to increase (reduce) a product's retail price, *ceteris paribus*, more than in the event of no change in the substitute product price. Alternatively, such a specification could be interpreted as a reduced form version of equations (1), (2) and (7), without the inventory term, in which the retail price is a function of current and past farm prices, costs of non-farm inputs and demand shift variables. To proceed with estimation most studies treat the farm price as a predetermined variable.

In this study two versions of the markup model to explain retail prices will be estimated. The first is the simple dynamic markup model of Heien (1980) and the second follows Lamm and Westcott (1981) by the inclusion of demand pressure or shift variables. Algebraically,

(12) $PR_{i,t} = f(PF_{i,t}, PF_{i,t-1}, \ldots, PF_{i,t-r}, D_t, W_t)$

(13) $PR_{i,t} = f(PF_{i,t}, PF_{i,t-1}, \ldots, PF_{i,t-r}, D_t, W_t, PR_{j,t-1}, Y_t, SD_{1,t}, \ldots, SD_{11,t})$

where PR is retail price, PF is farm price, D(= 1 if $PF_{i,t} - PF_{i,t-1} \geq 0$ and = 0 otherwise) is a dummy variable to indicate periods when farm prices rose, W is wage rate, Y is income, and SD_{kt} (= 1 if month k and =0 otherwise) are seasonal dummy variables. The number of lags on farm prices are determined by considerations of model fit (detailed in section V). Tests of symmetry of price response to farm price rises and falls are made by testing for significance of the estimated coefficient on the dummy variable D.[6] The wage rate W is used as a proxy variable for the cost of non-farm inputs C. Labour is the most important input and little data by commodity level were available on other input costs. In equation (13) the lagged rather than the current value of the substitute product retail price is used to avoid problems of simultaneity bias.[7] A set of dummy variables for months are included to test for additional effects of seasonality due to costs and demand not already captured by the model. For purposes of estimation all explanatory variables are regarded as predetermined. The following section provides some support for the assumption that in (12) and (13) current farm prices, in addition to the other variables, can be regarded as predetermined.

[6] Alternatively, the hypothesis could have been tested using a slope dummy variable as in Heien (1980) or preferably by a procedure such as Ward's (1982) that allows for effects on both current and lagged farm prices.

[7] In preliminary experimentation, estimates using either the current or the lagged value gave similar results.

IV. Causality

The direction of causation between farm and retail food prices is canvassed from three directions: *a priori* considerations, previous studies, and the results of Sims (1972) tests on the sample data used in this study.

The structural model described in equations (1) through (10) indicates a joint or simultaneous determination of farm and retail prices. However, consider in more depth the point of impact of market disturbances and adjustment patterns to these disturbances. Shifts in the retail demand due to, say, changes in income and competing product prices would have their first observable impact on the levels of retail inventory and/or retail prices. By contrast, shifts in the conditions of farm supply due to, say, seasonal conditions and input costs would have their first impact on farm prices. In time, the farm price changes would be translated into retail price changes. For the food products analysed in this paper it is reasonable to argue that the number and particularly the magnitude of disturbances affecting, in the first instance, farm price far exceeds those affecting the retail price. That is, changes in seasonal conditions affecting supply and changes in world commodity trade affecting export demand are more pronounced and frequent than are changes in income and competing product prices affecting retail demand. In the case of cereals and eggs, government intervention imposes a degree of exogeneity to farm prices.[8] These observations about the food markets suggest that in reality the majority, but certainly not all, price changes begin at the farm level and then are transmitted to the retail level.

Empirical tests of the direction of causation have been couched in a general framework based on predictability.[9] Variable x is said to cause variable y if current values of y can be better predicted by using past values of x than by not doing so, given that all other relevant information, including past values of y, is used in both cases. If both x causes y and y causes x there is a jointly causal or simultaneous relationship. If neither x causes y nor y causes x the variables are said to be independent. Several techniques, including cross-spectral, Box-Jenkins and regression procedures, have been used in empirical applications. There is debate about the appropriateness of the different procedures, particularly concerning representation of "all other relevant information", and all the procedures are subject to sampling errors.

A number of published studies, mainly with U.S. data, generally support the hypothesis that farm prices lead retail prices. Studies of U.S. food prices by Heien (1980), Lamm and Westcott (1981) and Ward (1982) used Sims' (1972) regression technique (described below). With monthly observations Heien found that wholesale prices led retail prices for most (57 per cent) of the commodities he studied; for 9 per cent the causation ran from retail to wholesale, for 21 per cent the two prices were independent, and for 13 per cent

[8] Even if allowance is made for policy reaction functions it is reasonable to argue that in the context of a time interval of a month there will be lags in any policy adjustment because of inertia and lags in decision-making procedures.

[9] Granger (1969) is credited with developing the formal technique. For surveys of the issues and procedures see Pierce (1977) and comments on this paper, Geweke (1981) and Hernandez-Inglesias and Hernandez-Inglesias (1981).

there was a simultaneous relationship. Lamm and Westcott reported similar findings with quarterly data on farm and retail prices. In a study of monthly prices for fresh vegetables Ward found that wholesale prices led both retail prices and farm (or shipping point) prices. From a cross-spectral analysis of monthly prices of pigmeats in N.S.W. Griffith (1975) tentatively concluded that auction (or farm) prices led retail prices.

Sims' regression procedure was applied to the data series described in Table 1 and the Appendix to assess the direction of causation between monthly retail and farm prices over the 1970's for selected meats, fresh fruits, fresh vegetables, cereals and eggs. Five steps were involved. First, the data series were filtered to remove trends and to obtain stationary series. The results reported in Table 2 are for the filter

$$a_t = z_t - 1.5z_{t-1} + .562z_{t-2}$$

where z is the raw data which has been transformed into natural logarithms and a is the filtered series, used in the rest of the causality analysis.[10] Second, ordinary least squares regressions were run for each retail (farm) price on the current value, four future values and eight lagged values of the farm (retail) price,[11] the wage variable and the monthly dummy variables. Third, the regressions were rerun without the future values. Fourth, using the estimated error sums of squares of steps three and four, F-tests were performed to test the hypothesis that the future variables as a group had no influence on the dependent variable. Table 2 reports the calculated F statistics. An asterisk indicates those cases where the null hypothesis could be rejected at the five per cent level.

Table 2: Tests of Causality Hypotheses[a]

Product	F-Statistic for		Implied Causality
	Farm on Retail	Retail on Farm	
Beef	3.73*	.45	Farm causes retail.
Pork	3.92*	.79	Farm causes retail.
Lamb	1.73	2.71*	Retail causes farm.
Beans	3.94*	1.20	Farm causes retail.
Peas	5.09*	1.36	Farm causes retail.
Potatoes	1.13	2.03	Independent.
Onions	3.48*	.49	Farm causes retail.
Carrots	2.84*	.31	Farm causes retail.
Pumpkin	2.16	1.01	Independent.
Tomatoes	1.40	1.62	Independent.
Bananas	.75	1.52	Independent.
D. Apples	.12	2.13	Independent.
G.S. Apples	.06	1.16	Independent.
Oranges	.60	1.02	Independent.
Pears	.72	.51	Independent.
Eggs	.35	1.27	Independent.
Cereal	.75	1.02	Independent.

[a] See text for a description of the test and interpretation of the results.

[10] Limited experimentation with alternative filters for the beef and bean prices was undertaken. These were first differences of the absolute values and the logarithmic values, and values of 1.0 and 0.5 as well as 0.75 for w in the filter $a_t(w) = wz_t - 2wz_{t-1} + w^2z_{t-2}$. Results with the alternative filters did not change the interpretation of the test with respect to causality, but the values of the F-statistics were influenced.

[11] The lead and lag periods were chosen arbitrarily.

Fifth, the implications of the tests for the pattern of causality were drawn and these are reported in the last column of Table 2. According to the Sims test, under the hypothesis that the dependent variable does not cause the independent variable the coefficients on future period independent variables would be zero. Only for one of the seventeen commodities, lamb, did the tests reject the hypothesis that the retail price does not cause the farm price. An unanticipated result was the number of commodities for which the hypothesis that farm prices did not cause retail prices was not rejected. The results in Table 2 imply that farm and retail prices were independent for ten of the seventeen commodities. This is a higher proportion than was found in the studies of U.S. food prices. Pierce (1977) in his survey article noted many findings of independence between economic variables using Sims tests. He attributed the lack of sufficient independent variability of economic data as a key reason for the high proportion of independence results. This reason also applies to the data used for Table 2. Also, it is recognised that considerable controversy surrounds the test procedures and the interpretation of the results.

Combining the *a priori* information, the results of causality tests on our data and the results from related studies, it is tentatively concluded that the direction of causation of food prices is primarily from farm to retail prices rather than vice-versa or a simultaneous relationship. In the case of eggs and cereals, farm prices are administratively determined. With the other products the more frequent and pronounced market disturbances associated with seasonal conditions and overseas market demand have their initial impacts on farm prices which, in turn and with some lags, are transmitted to retail price changes. The causality tests provide little support for the argument that retail prices cause farm prices. They provide some, but not overwhelming, support for the argument that farm prices cause retail prices. Because of the on-going debate about the appropriateness and meaning of these tests they have to be interpreted with due caution. For the purposes of estimation of equations (12) and (13) the causality analysis is used in the next section to support the simplifying assumption that current as well as lagged farm prices are predetermined explanatory variables in the context of equations explaining monthly retail food prices.

V. Estimated Model

This section reports estimates of the markup models (12) and (13). The simple cost markup model (12) regresses each retail food price on current and lagged farm prices, a dummy variable for current period farm price rises, and wages as an index of costs of non-farm input costs.[12] Equation (13) includes these variables plus measures of demand pressures and shifts, income, last period's retail price of a substitute product and monthly dummy variables. Monthly data were used. A number of further adjustments and operational rules were required.

Selection of the lag length for the farm prices was hampered by the high levels of correlation between the current and lagged farm prices. To minimise the risk of specification errors a free form procedure was used. Additional lags were added to the equation until the sum of the estimated coefficients on the

[12] Additional dummy variables were added to the equations for apples and pears for periods of controlled atmosphere storage and for oranges for periods when navel oranges were sold. In estimation none of these additional variables were found to have a significant effect and they have been omitted from the results presented in this paper.

farm price variables (that is the long run effect) stabilised or if the variable had a significant coefficient; all previous period variables were retained.[13]

To lessen already severe problems of multicollinearity[14] only one competing product retail price was included in equation (13). A subjective and arbitrary choice of "closest substitute" product was made. The estimated coefficient on the cross-price term should be interpreted as a rough measure of the effect of demand pressures associated with competing products in general and not just that of the specific product.

In the case of equation (13) it was not feasible to include the income variable. Only quarterly data were available on household income. It is likely that the included wage variable and income would be highly correlated. Hence, the estimated coefficient on the wage variable in (13), but not in (12) where income is excluded *a priori,* includes the effect of income as well as marketing costs. Because the income elasticity of demand for many of the products is low (see, for example, Richardson's (1976) survey), the magnitude of any bias of the wage coefficient, a positive one, would be small.

Initial estimates of most of the equations by ordinary least squares revealed severe first order autocorrelation.[15] In many cases the Durbin–Watson statistic was less than unity. Typical patterns of the computed residuals indicated long periods—over twelve and up to twenty months—of consistent under- or over-estimation and there were similar patterns for closely related products within the meat, vegetable and fruit groups. The equations were reestimated with a first order autoregressive correction. Differences in the mean coefficient estimates using the two estimators were small in most cases. After correction for first order autocorrelation the residuals appear to be serially independent.[16]

Preferred estimates of the simple markup model, equation (12), and of the augmented markup model with demand pressure, equation (13), are shown in Table 3, while Table 4 reports derived elasticity estimates for the augmented markup model (in the cases of eggs and cereals only the simple markup model was estimated because of the absence of close-substitute product prices). A comparison of equations (12) and (13) suggests a preference for the augmented markup model. In six of the fifteen equations a significant positive cross-price effect was obtained, for another four it was positive but not significantly different from zero (at the 0.05 significance level), and for five it was negative and not significantly different from zero. In most cases addition of the cross-price terms had a small effect on the other coefficient estimates—the total farm price effect was reduced (increased) in the case of nine (six) commodities and the wage coefficient was reduced (increased) in the case of eight (seven) commodities. Demand pressures as well as farm and non-farm input costs significantly influenced retail food prices during the sample period.

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[13] The procedure draws on Hatanaka and Wallace (1979). A principal interest is obtaining an unbiased estimate of the long-run effect of farm prices. Leaving the lag function too short causes biases and making it too long, while causing no bias, results in efficiency losses.

[14] For most likely candidates the partial correlation coefficient exceeded 0.8.

[15] Similar problems were encountered in the comparable U.S. studies by Heien (1980) and Lamm and Westcott (1981).

[16] In addition to the Durbin-Watson statistics reported, tests were made for higher orders of serial correlation by estimating a correlogram for selected products (beef, beans, potatoes, bananas, oranges and eggs) for lags of one to twelve months.

Table 3: Estimated Regression Equations for Markup Model (12) *and Demand Pressure Markup Model* (13) *for Monthly Retail Prices of Selected Food Prices over* 1971–1981.

Commodity and equation		Farm prices				Wage	Cross-price	Monthly dummies	rho	R^2	D.W.
		PF_t	PF_{t-1}	PF_{t-2}	PF_{t-3}						
Beef	(12)	.2463	.4946	.1621	.2960	.5480			.8191	.85	2.39
		(.0791)	(.0883)	(.0895)	(.0825)	(.0755)			(.0606)		
	(13)	.2463	.4671	.1352	.2830	.4527	.0929	N	.8063	.86	2.41
		(.0790)	(.0913)	(.0926)	(.0835)	(.1021)	(.0742)		(.0626)		
Pork	(12)	.1758	.5928			.9070			.9476	.40	2.17
		(.1035)	(.1084)			(.2001)			(.0285)		
	(13)	.1713	.4299			.7362	.4003	N	.6244	.94	2.06
		(.0913)	(.0981)			(.0814)	(.0334)		(.0787)		
Lamb	(12)	.4414	.2951	.2948	.2083	.6429			.7073	.84	1.85
		(.0819)	(.0888)	(.0894)	(.0856)	(.0869)			(.0686)		
	(13)	.3340	.2172	.1326	.0896	.6122	.2999	Y	.4848	.91	1.80
		(.0754)	(.0860)	(.0893)	(.0804)	(.0477)	(.0456)		(.0857)		
Beans	(12)	.9998	.1420			.4113				.91	1.66
		(.0745)	(.0732)			(.0533)					
	(13)	.9231	.0409			.1983	.2363	N		.92	1.85
		(.0754)	(.0721)			(.0696)	(.0504)				
Peas	(12)	.8813	.4647			.5597			.5697	.79	1.93
		(.0878)	(.0887)			(.0911)			(.0777)		
	(13)	.8628	.5104			.6336	−.0877	Y	.5911	.78	1.98
		(.0881)	(.0923)			(.1066)	(.0574)		(.0760)		
Potatoes	(12)	.0946	−.0211	.9197		.3119			.6147	.51	2.10
		(.2426)	(.2488)	(.2427)		(.0407)			(.0734)		
	(13)	.8834	−.0703	.8851		.2794	.0947	N	.5979	.53	2.09
		(.2459)	(.2600)	(.2488)		(.0618)	(.1263)		(.0748)		
Onions	(12)	1.2784	.2071	.1321		.0676			.4420	.92	1.90
		(.0664)	(.0824)	(.0664)		(.0258)			(.0874)		
	(13)	1.2908	.2037	.1409		.0876	.0553	N	.4602	.92	1.92
		(.0672)	(.0822)	(.0669)		(.0323)	(.0517)		(.0871)		
Carrots	(12)	.7853	.4905	.1589	.1894	.2244			.6186	.80	2.06
		(.0803)	(.0819)	(.0830)	(.0801)	(.0261)			(.0711)		
	(13)	.8136	.4818	.1773	.2625	.2419	−.0434	N	.6238	.81	2.04
		(.0271)	(.0779)	(.0819)	(.0852)	(.0271)	(.0192)		(.0709)		
Pumpkin	(12)	.7890	.3463	.1663		.2207			.7129	.75	2.19
		(.0713)	(.0747)	(.0709)		(.0305)			(.0679)		
	(13)	.7838	.3417	.1628		.2114	.0258	N	.6863	.76	2.19
		(.0720)	(.0760)	(.0716)		(.0317)	(.0375)		(.0706)		

Table 3—continued

Commodity and equation		Farm prices				Wage	Cross-price	Monthly dummies	rho	R^2	D.W.
		PF_t	PF_{t-1}	PF_{t-2}	PF_{t-3}						
Tomatoes	(12)	.9771	.3114			.3265			.5013	.71	1.90
		(.0809)	(.0790)			(.0593)			(.0781)		
	(13)	.9538	.2922			.2086	.3010	N	.4425	.74	1.91
		(.0808)	(.0787)			(.0831)	(.1579)		(.0814)		
Bananas	(12)	.9813	.2571			.2359			.3811	.89	2.05
		(.0653)	(.0654)			(.0233)			(.0853)		
	(13)	.9925	.3030			.1521	.9927	Y	.3514	.92	2.00
		(.0600)	(.0595)			(.0317)	(.3218)		(.0878)		
D. Apples	(12)	.3559				.0861			.6468	.51	2.50
		(.0757)				(.0115)			(.0703)		
	(13)	.3545				.1017	.2204	N	.7265	.42	2.47
		(.0745)				(.0163)	(.1116)		(.0629)		
G.S. Apples	(12)	.3737	.1034			.0623			.5663	.58	2.33
		(.1014)	(.1013)			(.0079)			(.0754)		
	(13)	.3311				.0349	.3036	N	.1926	.83	2.09
		(.0790)				(.0071)	(.0555)		(.0903)		
Pears	(12)	.3774	.2730			.0613			.6325	.43	2.18
		(.1077)	(.1077)			(.0104)			(.0707)		
	(13)	.3884	.2603			.0693	.0734	N	.6615	.40	2.17
		(.1086)	(.1077)			(.0139)	(.0791)		(.0686)		
Oranges	(12)	.8629	.4120			.0466			.6728	.47	2.27
		(.2082)	(.2080)			(.0088)			(.0680)		
	(13)	.7620	.3423			.0237	−.0719	N	.4383	.72	2.05
		(.2079)	(.2089)			(.0094)	(.0744)		(.0837)		
Eggs	(12)	1.0151				.1218			.8166	.96	2.05
		(.0447)				(.0205)			(.0551)		
Cereal	(12)	.5011				1.2185			.5719	.97	2.11
		(.1146)				(.0814)			(.0836)		

Notes:

[1]All equations estimated by an autoregressive model except beans where ordinary least squares is used. rho is the estimated first order autoregressive parameter.

[2]Numbers in parentheses are estimated standard errors.

[3]The estimated constant term is not shown.

[4]The particular cross-price variables are: beef-lamb; pork-beef; lamb-beef; beans-peas; peas-beans; potatoes-carrots; onions-potatoes; carrots-tomatoes; pumpkin-potatoes; tomatoes-carrots; bananas-oranges; D. apples-G.S. apples; G.S. apples-D. apples; pears-D. apples; oranges-G.S. apples.

[5]In the column "Monthly Dummies" a "N" indicates no significant coefficients and the variables were deleted. A "Y" denotes that some monthly dummy variables were significant. The significant monthly dummies (relative to December) are: lamb April, August, September; peas June, September; bananas June.

Changes in farm prices have had significant effects on retail prices of all commodities analyzed in Table 3. In the majority of cases there were significant lagged price as well as current price affects. For thirteen of the seventeen commodities the lag was one month or more. For six commodities lagged effects of at least two months were estimated. For no commodity was significant additional explanatory power or an increase in the total farm price effect obtained by adding lags longer than three months. These results are consistent with previous findings of price levelling behaviour by food marketers. For no commodity was the estimated coefficient on the dummy variable for farm price rises significantly different from zero and the variable was deleted from the estimated equations reported in Table 3. This simple test does not support a hypothesis of asymmetrical responses to rises and falls in farm prices. All estimates of the total or long-run farm price effect on retail price shown in Table 4 are less than unity and most include the range 0.4 to 0.6 in a 95 per cent confidence interval. One implication of these estimates is that the price elasticity of demand for food for domestic consumption at the farm level was significantly less than at the retail level with a mean estimate of around one-half the retail elasticity.

Table 4: Derived Elasticities for Demand Pressure Markup Model and Homogeneity Test for Stability of Estimated Equations

Commodity	Elasticity of Retail Price with respect to			F—statistic for Stability Test
	Total Farm Price	Wage	Cross Price	
Beef	.57 (.09)	.36 (.09)	.09 (.07)	3.20†
Pork	.43 (.06)	.44 (.05)	.31 (.03)	3.13†
Lamb	.35 (.04)	.46 (.04)	.30 (.05)	1.18
Beans	.49 (.05)	.20 (.07)	.23 (.05)	1.01
Peas	.65 (.09)	.67 (.11)	.09 (.06)	3.03†
Potatoes	.49 (.10)	.66 (.10)	.09 (.11)	1.33
Onions	.67 (.02)	.21 (.08)	.05 (.04)	0.73
Carrots	.56 (.06)	.56 (.07)	.04 (.02)	1.65
Pumpkin	.52 (.04)	.65 (.10)	.03 (.05)	5.80†
Tomatoes	.56 (.04)	.26 (.10)	.14 (.07)	1.62
Bananas	.69 (.05)	.28 (.06)	.10 (.03)	2.57†
D. Apples	.31 (.07)	.35 (.06)	.45 (.06)	6.55†
G.S. Apples ..	.22 (.05)	.55 (.11)	.24 (.11)	4.30†
Pears	.40 (.10)	.74 (.15)	.16 (.18)	2.51*
Oranges	.53 (.14)	.41 (.08)	.08 (.08)	1.75
Eggs	.75 (.03)	.16 (.03)		2.24
Cereal	.22 (.05)	.71 (.05)		2.25*

Notes:

[1]All estimates refer to equation (13) of Table 3, except for eggs and cereal which refer to (12).

[2]All elasticities are evaluated at average sample values of the dependent and independent variables.

[3]Estimated standard errors are shown in parenthesis. The standard error of total farm price was calculated as $PF/PR.V$, where PF and PR are average farm and retail price and V is the calculated standard error on the sum of the current and lagged farm price variables (using variance and covariance terms).

*Denotes significantly different from null hypothesis (constant parameters) at 5 per cent level and † at the 1 per cent level. The test is described in the text.

Higher wages were estimated to have a significant positive effect on all retail prices reported in Table 3. Labour costs are the most important part of non-farm input costs and the principal contribution of the estimated coefficient is as a measure of the effect of changes in non-farm input costs used in providing marketing services. As argued earlier, the estimated coefficient on the wage variable probably includes also some demand pull effect associated with higher incomes, however, this effect is unlikely to be very important for the commodities studied. Estimates of the elasticity of retail prices with respect to the wage rate are shown in Table 4. In all cases the estimate is significantly greater than zero and less than unity. Combining these elasticity estimates and the rising wage rates experienced during the 1970's— an average annual increase of 12.0 per cent (Table 1)— it is clear that rising wages have made a major contribution to rising retail food prices.

Only for three of the seventeen commodities did the inclusion of monthly dummy variables significantly add to the explanation of retail prices. Such results indicate that most of the seasonal variation of retail food prices can be explained by the seasonal variation of farm prices.

The final column of Table 4 reports the results of one test for the stability of the estimated coefficients over the sample period, the homogeneity test described by Brown, Durbin and Evans (1975). It tests for piecewise stability. Three sub-samples of equal observations were used to calculate the F statistic

$$F = \left(\frac{ESS_T - (ESS_1 + ESS_2 + ESS_3)}{ESS_1 + ESS_2 + ESS_3}\right) \left(\frac{T - 3k}{2k}\right)$$

where ESS_T is the error sums of squares for the regression estimated over the whole sample, ESS_i $(i = 1, 2, 3)$ is the error sums of squares of the regression for the ith sub-sample, T is the total number of observations and k the number of explanatory variables. Since the test applies to a specific type of parameter instability and the choice of the sub-samples is arbitrary, acceptance of the null hypothesis does not guarantee the absence of instability in other senses.

For just over half of the products the homogeneity test indicated problems of coefficient instability over the sample period. Further inspection of the estimated equations for the sub-samples lessens but does not diminish the impact of this disturbing result. First, the coefficients on the farm price variables, and particularly the long-run farm price effect, and on the wage variable remain fairly constant and they fall within the tight confidence interval band of the total sample estimates shown in Table 3. This result lends support to an important and stable influence of cost markup. Further, stability of these coefficients support the simplifying assumption of a very small or zero elasticity of substitution between the farm and non-farm inputs used in producing the retail food product. Second, there is considerable instability in the coefficient on the constant term. Third, the severe autocorrelation problems discussed earlier for the whole sample are greatly diminished with the estimated equations for the sub-samples.[17] These two points indicate the need for a richer model

[17] For just under a third of the sub-sample estimated equations the estimated rho coefficient was not significantly different from zero and in all but four cases the absolute value of the coefficient was less than that reported for the whole sample in Table 3.

specification. Possibilities include an explicit formulation of interrelationships involved in the marketing of groups of products, such as suggested by Holdren (1968), and the cross-product subsidization arrangements noted by the PJT (1979), and the addition of measures of turnover. Other reasons for the instability of the constant term include measurement errors and changes in market structure. Fourth, there is some instability of the coefficients on the cross-price variables. This suggests that the effect of demand pressures has been captured very approximately in this study and that these effects may vary over time. Even so, the cross-price effects were estimated to be significant in over a third of the sub-samples; what is in doubt is the magnitude of the effects.

Most of the variation in retail food prices can be explained by changes in current farm prices, lagged values of farm prices, wage rates and for some commodities the lagged retail price of a substitute product. For seven of the seventeen commodities the coefficient of determination exceeded 90 per cent and for fourteen of the seventeen it exceeded 75 per cent.

VI. Summary and Conclusions

A generalized price markup model provided a reasonable explanation of retail food prices. There were adjustment lags of several months between changes in farm prices and retail prices, apparently associated with price levelling behaviour. The elasticity of retail prices with respect to the total or long-run effect of farm prices was estimated to be between 0.4 and 0.6 for most products. Changes in wages had a significant effect on retail food prices, and for all commodities the elasticity of retail price with respect to wage rate fell within the zero-unity interval. The wage variable was primarily a proxy for costs of non-farm inputs; it may also represent some effect of rising incomes which could not be included because of the absence of data. For some commodities the demand pull effects of the lagged value of substitute retail product prices gave a significant additional explanation of retail food prices. The high level of autocorrelation in most equations and parameter instability in about half the equations suggest there are opportunities for a superior model specification. A potentially fruitful area for future work is to model strategies involving the pricing of groups of products. Most of the parameter instability was with the constant term coefficient and to a lesser extent with the cross-price term coefficients. The robustness and fairly tight confidence intervals of the estimated coefficients on the farm price and wage variables provide a solid basis for discussing the issues of food prices and macroeconomic performance, food market pricing efficiency, income distribution, and policy analyses.

Food prices and macroeconomic performance are interrelated and have important two-way effects. Changes in farm prices, whether caused by supply disturbances or export demand disturbances, lead to changes in retail food prices which are important components of the CPI. In turn, changes in the CPI affect wage demands, particularly with wage indexation, and also aggregate expenditure decisions. In a short-run context sharp rises in food prices add to inflationary pressures. But, by the same argument and accepting the evidence of symmetrical responses to price falls and rises, falls in farm prices facilitate the fight against inflation. Over the longer-run, retail food prices rose at about the same rate as the CPI during the 1970's.

The macroeconomy has direct and indirect effects on food prices. Costs of non-farm inputs used in storing, processing and distributing food products contribute over half of the retail costs. Using the wage rate as a proxy variable for the costs of non-farm inputs, and recognising that the coefficient on the wage variable likely also included a small effect for rising income pressures on demand, it was estimated that in the 1970's rising wages contributed more to higher retail food prices than did rising farm food prices. In addition, although not treated here, there are indirect effects of macroeconomic performance on farm production costs and the exchange rate. The interdependence of farm prices, wages and retail food prices, most clearly apparent with indexation but generally true, means that a change in one of these variables initiates a sequence of price and wage adjustments which multiply the initial effect.

The estimated equations provided mixed evidence about the efficiency of price transmission in the food markets. Changes in farm prices, both up and down, were reflected in changes in retail prices with the full adjustment occurring within three months. There was limited evidence of seasonal variation in retail prices additional to that caused by seasonal variation of farm prices. On the other hand, the problems of autocorrelation and instability of the constant term coefficient in many of the estimated equations implies that there were other systematic factors causing changes in retail prices which have not been captured in this study. Even so, changes in farm prices and non-farm input costs explain most of the variation of retail price changes over the 1970's.

The price markup model has some implications for the distribution of income. To a large extent the farm price is a residual return after costs of non-farm inputs have been met. Rises in the cost of these inputs will be passed on as lower farm prices and higher retail prices. Changes in farm prices are quickly reflected in changes in retail prices.

Finally, the relatively low elasticity of price transmission from farm to retail level means that in policy and other studies it is important to make explicit whether the retail or farm level domestic demand elasticity is used. At the sample means the elasticity of domestic demand with respect to farm price was found to be around a half of the elasticity of domestic demand with respect to the retail price.

Appendix: Data

Meat (beef, lamb and pork) data are from Division of Marketing and Economic Services, N.S.W. Department of Agriculture, using the procedure described by Griffith and Whitelaw (1974). The retail prices are a weighted average of selected cuts from a sample of Sydney retailers of meat. The farm price is an adjusted auction price based on prices recorded at the Homebush market. The series used are the "old" series from January, 1971 to June, 1981. All prices are in cents per kilogram.

Prices for fresh vegetables and fruit are from Division of Marketing and Economic Services, N.S.W. Department of Agriculture. The retail prices are based on samples of produce sold in selected suburbs throughout the Sydney Metropolitan area. Farm prices are collected from recorded sales at the Agents' and Growers' Sections of the Sydney Farm Produce Markets, Flemington. All vegetable prices have been converted to a cents per kilogram basis. The specific series used are; peas—N.S.W. peas; beans—N.S.W. beans; carrots—N.S.W. carrots; tomatoes—N.S.W. Marmande (Local and North Coast); pumpkin—N.S.W.; onions—brown from N.S.W., S. Australia and Queensland; potatoes—N.S.W. washed. The price series extend from January, 1973 to June, 1982 for onions and pumpkin and from January, 1972 to May, 1982 for the other vegetables.

Prices for bananas are on a per kilogram basis with the farm price being for hands (13 kilogram per carton). Prices for the other fruits are on a per unit piece of fruit. The specific series used are: oranges—N.S.W. Coastal and MIA per citrus pack (assuming 125 pieces of fruit); Granny Smith apples—N.S.W. per tray pack (assuming 120 pieces of fruit); delicious apples—N.S.W. per tray pack (assuming 120 pieces of fruit); pears—N.S.W. Williams and Packhams per case (assuming 120 pieces of fruit). In the case of oranges a dummy variable was used to distinguish between navels and valencias. For apples and pears a dummy variable was added for periods of controlled atmosphere storage. All fruit price series are for January, 1972 to June, 1982.

Eggs prices are from Gellatly and Davis (1982). The retail price is a weighted average price of different grades. The farm price is calculated as retail price less retail margin, wholesale margin and handling and selling charges. Both prices are in cents per dozen eggs and cover July, 1972 to June, 1981.

Prices for cereals are retail price—CPI for cereals with base 1966–1977 = 100, and farm price—home consumption price for wheat in dollars per tonne. The series extends from December, 1972 to March, 1982.

The wage variable is represented by the minimum weekly wage rate for adult males reported by ABS in *Wage Rates, Australia* (catalogue No. 6312.0) for all industry groups.

Clearly the price series are subject to sampling and measurement errors. While this study does not place or require accuracy about the absolute value of particular observations, it does assume that the variables provide good proxies for movements over time in the true values.

The data series used in the paper are available on request from the author.

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