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SUPPLY AND DEMAND RESPONSES FOR POULTRY MEAT IN AUSTRALIA*

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This study of poultry meat supply and demand responses has two objectives. The first is to help meet the needs of the Australian Bureau of Agricultural and Resource Economics for models for its commodity outlook and other work. The second objective is to quantify the effects on the poultry meat sector of a recent significant change in the domestic feed wheat marketing policy.

The paper commences with a review of changes in the poultry meat sector since about 1970, including a description of the new feed wheat policy and its relevance to the poultry sector. The review forms a basis for the formulation, estimation and interpretation of an econometric model of poultry meat supply and demand.

The Poultry Meat Sector: An Overview

The Australian poultry meat sector has been recently described in detail (Hunter 1981; Sargent 1983; Prices Surveillance Authority 1986). Hence, only changes and the current situation will be described briefly. Poultry meat refers to meat of chicken, duck, fowl, turkey and other poultry. Chicken meat is the predominant component, making up 90 per cent of total poultry meat. For this reason, and also because detailed information is unavailable on other poultry meats, emphasis in the review is on chicken meat.

Industry structure

The chicken meat industry may be viewed as consisting of two segments: the growers and the processors.

The main function of the growers is to raise day-old chicks to broiler stage, usually under contract to the processors. Under an 'all in — all out' system, the growers produce four to five batches of broilers a year. Normally, the birds are owned by the processors, who also determine the number of broilers to be raised by growers and thus the production of chicken meat. The number of growers in Australia has fluctuated around 600 in the past ten years.

The functions of the processors are to provide day-old chicks, feed mix and technical advice to the growers, to slaughter broilers and to sell the output to retailers. Leading processors own feed mills and breeding, hatching and slaughtering facilities. Concentration has been increasing in this segment of the industry. In 1981, four processors controlled about 70 per cent of Australia's chicken meat output (Hunter 1981). More recently, two processors have controlled 80 per cent of the output

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(*Australian Financial Review*, 25 October 1985, p. 4). Although high concentration has potential for anti-competitive conduct (Trade Practices Commission 1985), there is no evidence of such conduct. Also, as the current concentration is a recent feature for the period 1970 to 1986 as a whole, inter-firm conduct in the industry is assumed, for the purpose of this study, to be reasonably competitive.

Feed costs and the new feed wheat policy

The principal grain used in poultry feed mix is feed wheat. (Wheat substitutes, such as sorghum and triticale, are of less significance.) Feed grain accounts for more than half of the cost of producing feed mix, and the feed mix itself accounts for nearly half the total cost of producing a live broiler. Broiler growers, unlike pig and egg producers, do not mix their own feed. Instead, the growers receive feed mix from the processors, who obtain it from their own or other feed mills.

Since late December 1984, the price of feed wheat in Australia has been determined more competitively. Previously, wheat farmers were obliged to deliver all their wheat to the Australian Wheat Board; the Board determined the wheat price to the domestic market and was the sole legal seller of wheat. Under the Wheat Marketing Act of 1984, farmers now do not have to deliver feed wheat to the Board (though wheat for other purposes is unaffected). Buyers may obtain a permit from the Board to purchase feed wheat from farmers at a negotiated price. The new arrangements were expected to result in the saving of some marketing costs and, consequently, the price of feed wheat was expected to be higher for farmers and lower for buyers than under the previous system (BAE 1983; Gill 1984).

Detailed data are not available on how much feed wheat for poultry feed mix is purchased directly from farmers under permit and how much is purchased from the Wheat Board. Wheat Board data indicate that permit wheat accounted for 71 per cent of total Australian feed wheat sold for all uses during the period December 1984 to June 1985, rising to 91 per cent for the period December 1985 to June 1986. Confidential information obtained from several sources in the poultry industry suggests that of all feed wheat sold in Australia, about 40–45 per cent was used in the poultry industry.

The above information implies that, from 1985, the new marketing system for feed wheat will have reduced feed costs in the poultry industry. Therefore the supply function of the poultry meat industry will have shifted downward, implying a higher output, lower price and increased consumption of poultry meat.

Poultry meat production and consumption trends

Australia's output of poultry meat was about 134 kt in 1970 and 370 kt in 1986. Corresponding outputs of chicken meat are 115 kt and 335 kt. Thus, annual average growth rates are 6·2 per cent for poultry meat and 6·5 per cent for chicken meat — about 5 times greater than the growth rate of the Australian population.

During the period 1970 to 1986, the ratio of poultry meat price to feed mix price declined at an average rate of 3 per cent a year. However, the industry achieved considerable productivity growth (Nowland 1978)

which at least partly offset the decline in terms of trade, allowing poultry meat to remain competitive against other meats. But Nowland (1978, p. 20) also stated that productivity growth was unlikely to continue to be as rapid as in the past.

In the past 16 years, the average per person consumption of meat (total of beef and veal, lamb and mutton, pig meat and poultry meat) has changed very little. Consumption per person of poultry meat, however, has consistently increased 'due to price and income factors rather than to a change in preferences' (Martin and Porter 1985, p. 30).

Virtually all poultry meat produced in Australia is consumed locally. Only 1–2 per cent of the output is exported. Because of the ban on poultry meat imports, the domestic demand for poultry meat is met entirely from domestic supplies. This means that the total quantities of poultry meat supplied and demanded and the price are determined largely in the domestic market.

Estimation of the Supply and Demand Responses

Conceptual model, data and sample period

The model is conceived as consisting of two stochastic responses — aggregate supply of poultry meat output and demand for poultry meat per person — and an identity equating demand and supply. The output supply response is mainly a function of poultry meat price, price of inputs, technological change and seasonal factors. The demand per person is a function of poultry meat price, price of substitute meats, total consumption expenditure per person and seasonal factors.

Since the poultry meat production period corresponds to a quarter rather than to a year, and data on feed mix price were available only since 1970 or so, the model was constructed on a quarterly basis. The period chosen was 1971 (1) to 1986 (4).

The model was formulated at the slaughtering establishment (wholesale) level, because dependable data on poultry meat quantity and price are available at only this point in the marketing chain. Exports of poultry meat were not modelled because reliable quarterly export data were unavailable for a part of the period; however, exports have been negligible. Stocks of poultry meat could not be modelled because data were available only as at 30 June each year, and attempts to estimate quarterly stocks from these data were unfruitful. Lack of data also did not allow specification of the poultry demographic relationships in the supply response (for example, relationships between placements of eggs for hatching chicks through to number of broilers raised and output of chicken meat). Unfortunately, these data shortcomings remain insurmountable.

Estimation model and method

Using the conceptual model outlined above, a number of alternative model specifications were evaluated on the usual statistical criteria and for consistency of results with economic theory. Briefly, comparing static and distributed lag models, the latter were found to be preferable. It was also found that the dynamic quantity–price relationships were represented by the 'adaptive expectations' form of geometrically

distributed lags (Kmenta 1971, pp. 474–80). A test described by Rao and Miller (1971, p. 111) indicated that between simple linear and log linear functional forms, the former was preferable. On these bases, the estimation model chosen was:

Aggregate supply of poultry meat

$$(1) \quad SP_t = a_0 + a_1 SP_{t-1} + a_2 PM_t + a_3 PF_{t-2} + a_4 T + a_5 T^2 + a_6 D_2 + a_7 D_3 + a_8 D_4 + e1_t;$$

Demand for poultry meat per person

$$(2) \quad DP_t = b_0 + b_1 DP_{t-1} + b_2 PM_t + b_3 PS_t + b_4 CE_t + b_5 D_2 + b_6 D_3 + b_7 D_4 + e2_t$$

Identity

$$(3) \quad SP_t \equiv (DP_t \cdot POP_t)$$

where SP is output of poultry meat by slaughtering establishments; PM is real expected price of poultry meat; PF is real price of feed mix; T is time; D_2 , D_3 and D_4 are seasonal dummy variables for the second, third and fourth quarters of a calendar year, respectively; DP is demand for output of poultry meat per person (SP/POP); PS is real price of substitute meats; CE is real total consumption expenditure per person; POP is national population; a_0 to a_8 and b_0 to b_7 are the coefficients to be estimated; and $e1$ and $e2$ are error terms. Sources of data and detailed definitions are in the Appendix.

The lagged dependent variables on the right-hand side of equations (1) and (2) arose from the adaptive expectations formulation on PM (Kmenta 1971). The price variables PM and PF in equation (1) were specified individually rather than as a ratio PM/PF , as were the price variables in equation (2), because for the type of model formulated, this was theoretically more appropriate (see Chavas 1982). All price and expenditure variables in the model were normalised using the consumer price index as the deflator.

The assumption that the price of poultry meat (PM_t) was endogenous was verified by the Hausman (1978) test. The other endogenous variables in the model are SP_t and DP_t ; the remaining variables are pre-determined. Since PM_t was endogenous, two-stage least squares was used for consistent estimation of the model. Two-stage least squares is also consistent with the adaptive expectations formulation. The order and rank conditions for identifiability of the equations showed that the equations were identified. Estimated coefficients of the model, with their t -values in brackets, are:

Aggregate supply of poultry meat

$$a_0 - 61.639 (-1.60), a_1 0.854 (8.54), a_2 0.697 (2.02), \\ a_3 - 0.436 (-2.44), a_4 1.269 (2.48), a_5 - 0.007 (-2.18), \\ a_6 5.633 (4.27), a_7 4.791 (3.93), a_8 3.862 (3.12); \\ \bar{R}^2 = 0.96, DW = 1.93.$$

Demand for poultry meat per person

$$b_0 0.132 (0.06), b_1 0.372 (3.22), b_2 - 0.014 (-1.79), b_3 0.012 (2.84), \\ b_4 0.002 (1.97), b_5 0.114 (1.45), b_6 0.151 (1.75), b_7 - 0.057 (-0.36), \\ \rho = 0.479 (4.17); \\ \bar{R}^2 = 0.96, DW = 1.93.$$

The Cochrane-Orcutt procedure was used with two-stage least squares to correct for autocorrelation bias in the demand equation because the *DW* statistic for an earlier estimate of the equation was in the inconclusive region.

Since chicken meat constitutes the predominant component of the poultry meat sector, the opportunity was taken to formulate and estimate a model of chicken meat supply and demand. The model formulation process led to a chicken meat model which turned out to be identical to the poultry meat model. The chicken meat model can therefore be written simply by changing two notations in equations (1) to (3) of the poultry meat model, that is, by replacing *SP* with *SC* and *DP* with *DC*. *SC* is output supply of chicken meat by slaughtering establishments; *DC* is demand for output of chicken meat per person (*SC/POP*); and other notations, data period and estimation procedure remain as before. Estimated coefficients of the chicken meat model are:

Aggregate supply of chicken meat

$$a_0 - 38.038 (-1.20), a_1 0.833 (8.90), a_2 0.474 (1.68), \\ a_3 - 0.320 (-2.16), a_4 0.944 (2.56), a_5 - 0.005 (-2.00), \\ a_6 4.029 (3.69), a_7 2.355 (2.29), a_8 2.634 (2.50); \\ R^2 = 0.97, DW = 2.10.$$

Demand for chicken meat per person

$$b_0 0.192 (0.09), b_1 0.412 (3.53), b_2 - 0.013 (-1.84), b_3 0.010 (2.63), \\ b_4 0.002 (1.95), b_5 0.084 (1.20), b_6 0.040 (0.51), b_7 - 0.102 (-0.71), \\ \rho = 0.412 (3.46); \\ R^2 = 0.96, DW = 1.91.$$

Similar models of other poultry meats, such as duck and turkey, were not formulated because of the minor role of these meats, and data shortcomings.

Interpretation of the estimated models

The estimated equations imply that the poultry meat output supply of slaughtering establishments is a function of the expected price of poultry meat PM_t , the past price of poultry feed (PF_{t-2}), productivity, proxied by time (T) and time squared (T^2), and seasonal effects (D_2 , D_3 and D_4). The lag of two quarters obtained on feed price is reasonable, considering the time needed for arranging purchases of feed components, preparing and distributing mixed feed to growers, raising birds and slaughtering them. T and T^2 , proxy variables together representing productivity growth, were specified following the proposition by Nowland (1978) that productivity growth might have been occurring at a decreasing rate. Hence, T and T^2 were expected to have positive and negative coefficients, respectively, as in fact they have.

In the demand equations, prices of three principal substitute meats — beef and veal, sheep meat, and pork — were initially specified as separate explanatory variables, but this approach gave statistically poor results, possibly due to multicollinearity in the prices. An alternative, average price of the three substitute meats, weighted by per person consumption of each, gave acceptable results. Following the meat demand specifications adopted by Martin and Porter (1985), the income

effect was modelled by total consumption expenditure per person (*CE*). Although Martin and Porter found no evidence of change in consumers' tastes, a time trend proxy variable was initially specified to account for the taste and other trend related variables not specifically included in the model. The trend variable was later dropped because it was not statistically significant.

To evaluate the estimated models for their ability to predict endogenous variables within the estimation period, additional statistics (mean absolute percentage error, mean square error and its components, and Theil's U_2 coefficient) were examined. These statistics showed there was little bias in the predicted values and that the models clearly outperformed naive no-change forecasts.

Overall, both the poultry meat and chicken meat models are satisfactory but there may be some scope for improving them, especially if data inadequacies (for example, meat stocks and demographics) can be overcome in future. Thus, while the approach taken and the estimates obtained in this study seem reasonable, the estimates should be regarded as preliminary.

Elasticities

Short-run partial elasticities calculated at the mean levels from the models, are shown in Table 1. The own-price elasticity of supply is 0.90 for chicken meat and 1.19 for poultry meat. To date, there has been no study providing estimates of either chicken or poultry meat output supply responses in Australia with which these estimates could be compared. However, these supply elasticities seem quite plausible, given that the own-price supply elasticity for another Australian intensive livestock industry, the pig industry, is in the range 0.7 to 1.1 (Richardson and O'Connor 1978).

The supply elasticity for the price of feed mix is of particular interest. Since there is a lag of two quarters on the feed price, the elasticity is

TABLE 1
Elasticities of the Output Supply and Demand per Person

Elasticity with respect to	Estimated elasticity	
	Poultry meat	Chicken meat
		Supply
Own price (<i>PM</i>) ^a	1.19	0.90
Feed mix price (<i>PF</i>) ^b	-0.63	-0.51
		Demand
Own price (<i>PM</i>) ^a	-0.35	-0.36
Substitute meats' price (<i>PS</i>)	0.23	0.21
Consumption expenditure (<i>CE</i>)	0.71	0.69

^a *PM*, being an endogenous variable in the model, cannot change unless one or more of the predetermined variables change in the first place. Consequently, the essential condition for partial elasticity with respect to *PM* (that is, all other variables being held constant) cannot be fulfilled. These elasticities were estimated as if *PM* were not an endogenous variable; therefore, they should be regarded as indicative only.

^b Should be regarded as medium-run elasticity, since *PF* has a lag of two quarters in the model.

effectively zero or very small in the short run, and the elasticities of -0.51 for chicken meat and -0.63 for poultry meat are more appropriately medium-run elasticities.

The own-price demand elasticities for poultry and chicken meats are -0.35 and -0.36 , respectively. These estimates are consistent with those of previous studies, which have ranged from -0.23 (Fisher 1979) to -1.14 (Murray 1984) with intermediate estimates by Shaw, Dewbre and Reeves (1983) and Martin and Porter (1985).

The cross-price demand elasticity is 0.23 for poultry meat and 0.21 for chicken meat; these are with respect to substitute meats (beef and veal, sheep meat and pork) as a whole. They too are consistent with those given in previous studies: 0.3 for beef and mutton prices (Fisher 1979); 0.01 to 0.13 for mutton, pork, lamb and beef prices (Shaw et al. 1983); and 0.02 to 0.19 for mutton, lamb and beef prices (Martin and Porter 1985).

The elasticities of poultry meat and chicken meat demand with respect to consumption expenditure (CE) are 0.71 and 0.69 , respectively. They too are comparable to the range of elasticities reported in the studies cited.

Evidently, the price elasticities estimated in this study are plausible and generally well within the ranges of those obtained previously. This also suggests that the estimated models give reasonable results. They can therefore be used for further analysis, such as in quantifying the effects of the new feed wheat policy.

Effects of the New Feed Wheat Permit Policy

Using the estimated models, the aim in this part of the study was to measure the changes in the output supply, demand per person and prices of poultry and chicken meats attributable to the new feed wheat policy. A key data requirement for the assessment is a measure of the decrease in the price of feed mix due to the new policy. Because no published information could be found, views of sources close to the industry were canvassed. The sources reported that, because of the introduction of the new policy, in late December 1984, the price of feed wheat and consequently that of feed mix had been lower than would have been expected in the absence of the policy. Estimates of the reduction in feed mix price ranged from 4 per cent to 20 per cent, averaging around 10 per cent, in real terms. For the purpose of this analysis, it was therefore assumed that without the new policy the feed mix price would have been higher than its actual level by 10 per cent beginning from 1985. On this basis, effects of a 10 per cent lower feed prices were quantified for the output supply, demand per person and prices of poultry and chicken meats for the period 1985 (1) to 1986 (4). Briefly, the procedure involved raising the feed mix price values by 10 per cent, holding all other exogenous variables at their actual levels, and calculating the perturbed values of the quantity and price variables. The results are in Table 2 and are interpreted as follows: had the new policy not been introduced, then at the wholesale level, the output and demand of poultry and chicken meats during 1985 (3) to 1986 (4) would have been lower by between 0.8 per cent and 1 per cent, and the prices of poultry and chicken meats would have been higher by about 5 per cent. (The nil effects for the first two quarters of 1985 are due to the two-quarter lag in

TABLE 2

Change in the Output Supply, Demand per Person and Price of Poultry and Chicken Meats from a 10 per cent Increase in the Feed Mix Price^a

Year and quarter	Poultry meat		Chicken meat	
	Supply, demand	Price	Supply, demand	Price
	%	%	%	%
Short term				
1985 (1)	0	0	0	0
1985 (2)	0	0	0	0
1985 (3)	-0.90	+4.93	-0.91	+4.89
1985 (4)	-0.91	+4.89	-0.93	+4.82
1986 (1)	-0.93	+5.01	-0.94	+4.99
1986 (2)	-0.86	+4.99	-0.87	+4.97
1986 (3)	-0.83	+4.74	-0.86	+4.72
1986 (4)	-0.84	+4.83	-0.86	+4.80
Long term				
1989 (1) to (4)	-0.81	+4.65	-0.83	+4.57

^a The linearity of the models enables estimation of the effects for a lower or a higher percentage increase in the real price of feed mix. For instance, the effects of a 5 per cent and a 15 per cent increase in the real price of feed mix will be 0.5 and 1.5 times, respectively, those given for the 10 per cent increase.

the output responses to the feed mix price.)

The above changes are of short to medium-run nature only and may differ from those in the long term. Long-term changes were estimated by holding all exogenous variables constant at their 1986 (4) levels for the next five years (20 quarters) except for the feed mix price, which was increased, as before, by 10 per cent. By the third year, changes in the endogenous variables stabilised at approximately 0.8 per cent for both output and consumption, and -4.6 per cent for price. The long-run changes are apparently not very different from those for the short to medium term. Even so, for some purposes the long-run estimates may be preferable measures of the effects of the new feed wheat policy.

These results should be regarded as preliminary, in view of the method used for estimating the reduction in feed price on which they are based, and limitations of the estimated models themselves due to data inadequacies and abstraction from the real world in model formulation. Notwithstanding these caveats, the general picture emerging from this analysis of the effects of the new feed wheat policy is one of an increase in poultry meat output and demand, and lower poultry meat prices. (The lower prices of poultry meat do not necessarily imply reduction in profitability, since they arise from lowered feed costs.) Also, the lower poultry meat prices imply — other things remaining equal — increased competitiveness of poultry against substitute meats (except maybe against pig meat, the price of which would also be expected to be lower due to the lower feed wheat price).

Summary and Concluding Comments

Supply and demand models of poultry and chicken meats are presented in this paper. Results from the models, such as the elasticities,

especially the supply elasticities which were not available previously, are likely to be of interest to other economists.

The paper also contains measurements of effects on the poultry and chicken meat sectors of the new, substantially less regulatory policy, on domestic marketing of wheat for stockfeed. The policy was introduced in late 1984 to improve efficiency in the wheat marketing system. The policy change is expected to benefit wheat farmers, users of feed wheat such as poultry and chicken meat producers, and consumers through a reduction in price of poultry feed mix. Based on the estimated models of poultry and chicken meats, it was found that, other things being the same, the 10 per cent reduction in the feed price due to the new policy had the effect of increasing the output and consumption of poultry meats by nearly 1 per cent and lowering the price by about 5 per cent in real terms.

On a more general note, the findings of this study provide further evidence of significant gains possible from reforming regulations that no longer serve the best interests of farmers and society at large.

APPENDIX

Definitions, Means and Data Sources of Variables

SP (SC): Quantity of poultry (chicken) meat (dressed weight) as whole birds, pieces and giblets produced quarterly by commercial slaughtering establishments in Australia. Note that numbers in parentheses relate to chicken meat. Unit: kilotonnes. Mean: 64.7 (58.1) kt. *Source*: Australian Bureau of Statistics (ABS) Cat. No. 7221.0.

DP (DC): Estimated quantity of average per person consumption of poultry (chicken) meat per quarter in Australia; $DP = SP/POP$ and $DC = SC/POP$, where *POP* is the Australian population. Note that the definition of apparent consumption includes change in stocks and exports of the respective commodities. Unit: kilogram. Mean: 4.4 (4.0) kg. *Sources*: ABS Cat. Nos 1313.0, 7206.0 and 7221.0.

PM: Index (1980–81 = 100) of quarterly average prices received by farmers for poultry slaughterings, Australia; deflated by the Australian quarterly average consumer price index, all groups. Mean: 110.76. *Sources*: ABS Cat. No. 1313.0 and BAE (1986).

PF: Index (1980–81 = 100) of quarterly average price of broiler feed deflated by the consumer price index; estimated for Australia from the quarterly broiler feed prices data provided to the BAE by selected feed and farm input suppliers in various states; weighted by broiler meat output of respective states. Mean: 93.35. *Source*: BAE.

PS: Index (1980–81 = 100) of quarterly average consumer prices of substitute meats — beef and veal, sheep meat (lamb and mutton) and pork, deflated by the consumer price index; weighted by average consumption per person of each of the three substitute meats. Mean: 87.16. *Sources*: ABS Cat. Nos 6401.0 and 6403.0; Main, Reynolds and White (1976).

CE: Average total quarterly final consumption expenditure per person; derived by dividing the total private quarterly final consumption expenditure by *POP*, and deflating by the consumer price index. Unit: Australian dollar. Mean: \$1313.58. *Source*: ABS Cat. Nos. 1311.0 and 1313.0.

T : Time; 1971(1) = 1, 1971(2) = 2, . . . , 1986(4) = 64.

D_2, D_3, D_4 : Seasonal effects, measured by dummy (binary) variables for the second, third and fourth quarters of the calendar year, respectively.

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