Testing for Market Power in Multiple-Input, Multiple-Output Industries: The Australian Grains and Oilseeds Industries

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The authors take full responsibility for any errors or omissions.

Acronyms and Abbreviations Used in the Report

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ANZSIC	Australian and New Zealand Standard Industrial Classification
CPI	Consumer Price Index
GAUSS	A statistical software package
GDP	Gross Domestic Product
FOCs	first-order optimisation conditions
IOPC	Input-Output Product Classification codes
MCMC	Markov Chain Monte Carlo
NEIO	new empirical industrial organisation
Pdfs	probability density functions
PSA	Prices Surveillence Authority
SCP	the Structure-Conduct-Performance paradigm of industrial organization
SUR	Seemingly Unrelated Regression

Testing for Market Power in Multiple-Input, Multiple-Output Industries: The Australian Grains and Oilseeds Industries

Executive Summary

Recent empirical studies have found significant evidence of departures from competition in the input side of the Australian bread, breakfast cereal and margarine end-product markets. For example, Griffith (2000) found that firms in some parts of the processing and marketing sector exerted market power when purchasing grains and oilseeds from farmers. As noted at the time, this result accorded well with the views of previous regulatory authorities (p.358). In the mid-1990s, the Prices Surveillence Authority (PSA 1994) determined that the markets for products contained in the Breakfast Cereals and Cooking Oils and Fats indexes were "not effectively competitive" (p.14). The PSA consequently maintained price surveillence on the major firms in this product group. The Griffith result is also consistent with the large number of legal judgements against firms in this sector over the past decade for price fixing or other types of non-competitive behaviour. For example, bread manufacturer George Weston was fined twice during 2000 for non-competitive conduct and the ACCC has also recently pursued and won cases against retailer Safeway in grains and oilseeds product lines.

Griffith obtained his results using highly aggregated data and a relatively simple empirical model. In this study we focus on confirming the earlier results by formally testing for competitive behaviour in the Australian grains and oilseeds industries using a more sophisticated empirical model and a less aggregated grains and oilseeds data set. We specify a general duality model of profit maximisation that allows for imperfect competition in both the input and output markets of the grains and oilseeds industries. The model also allows for variable-proportions technologies and can be regarded as a generalisation of several models appearing in the agricultural economics and industrial organisation literatures. Aggregate Australian data taken from the 1996-97 input-output tables are used to define the structure of the relevant industries, and time series data are used implement the model for thirteen grains and oilseeds products handled by seven groups of agents. The model is estimated in a Bayesian econometrics framework. Results are reported in terms of the characteristics of estimated probability distributions for demand and supply elasticities and indexes of market power.

Our results suggest that there is a positive probability that: (a) flour and cereal food product manufacturers exert market power when purchasing wheat, barley, oats and triticale; (b) beer and malt manufacturers exert market power when purchasing wheat and barley; and (c) other food product manufacturers exert market power when purchasing wheat, barley, oats and triticale. What is interesting is that each of the transaction nodes where market power is indicated is one where a farm commodity is sold to a processing sector – that is, the evidence suggests oligopsonistic behaviour by grains buyers. The wheat and barley industries seem to be especially disadvantaged by this type of market conduct.

A related and equally interesting result is that there was no consistent evidence of market power in the downstream nodes of the data set relating to the sales of flour and other cereal foods, or the sale of bread and other bakery products. These transaction points are where legal judgements against suppliers have been made in the recent past.

We have stated our results in quite cautious language, as there is much uncertainty surrounding our estimates. This stems partly from the lack of good quality data, so we suggest that one avenue for future research should be improving the collection and integrity of relevant data (especially including the retail and distributive nodes of the various markets).

Testing for Market Power in Multiple-Input, Multiple-Output Industries: The Australian Grains and Oilseeds Industries

1. Introduction

The study of competition in food processing and marketing has had a long history in the North American and European economics and agricultural economics literatures (see, for example, Collins and Preston 1966, Marion *et al*. 1979, McDonald *et al*. 1989 and Holloway 1991). However, it has only recently become evident as an important area of research in Australia. There are two related reasons why a focus on the nature of competition in the Australian food chain has emerged. Firstly, there has been substantial deregulation of agricultural product marketing structures. Many marketing boards, corporations and/or commissions that previously regulated prices and sometimes quantities in the food products market, have been abolished. Secondly, and perhaps relatedly, there has emerged a growing level of concentration in the food processing and retailing sectors (Australian Parliament 1999). Regarding the latter, the business media regularly reports on both formal proposals and informal conjectures relating to merger or takeover activity in the food production, processing and retailing sectors. The Australian Competition and Consumer Commission (ACCC) is required to assess the competitive implications of such proposals. However, since it is primarily an investigation and enforcement institution, not a research institution, it can only do this well if it has access to independent research (ACCC 1999, p.5).

In a recent empirical study which examined competition across the entire Australian food marketing chain, Griffith (2000) found evidence of statistically significant departures from a competitive market on the input side of the bread, breakfast cereal and margarine end-product markets. That is, he found that firms in some parts of the processing and marketing sector exerted market power when purchasing grains and oilseeds from farmers. As noted at the time, this result accorded well with the views of previous regulatory authorities (Griffith 2000, p.358). For example, in the mid-1990s, the Prices Surveillence Authority (PSA 1994) determined that the markets for products contained in the Breakfast Cereals and Cooking Oils and Fats indexes were "not effectively competitive" (p.14). The PSA consequently maintained price surveillence on the major firms in this product group (at the time Arnotts, Kelloggs, Uncle Tobys and Sanitarium). The Griffith result is also consistent with the large number of legal judgements against firms in this sector over the past decade for price fixing or other types of non-competitive behaviour. For example, bread manufacturer George Weston was fined twice during 2000 for non-competitive conduct and the ACCC has also recently pursued and won cases against retailer Safeway in grains and oilseeds product lines.

In this study we focus on formally testing for competitive behaviour in the Australian grains and oilseeds industries. Our investigation of competitive behaviour in the overall food market is motivated in part by the need by organisations such as the ACCC for independent research, while our particular interest in the grains and oilseeds industries stems from the Griffith findings as well as the cases coming before the courts.

Griffith obtained his results using highly aggregated data and a relatively simple empirical model. This paper reports progress towards the estimation of a more sophisticated empirical model using a less aggregated grains and oilseeds data set. The empirical model we consider is a member of the class of new empirical industrial organisation (NEIO) models. NEIO models have a firm foundation in economic theory and have dominated the analysis of industrial organisation for the last fifteen years[1] (see the recent reviews by Digal and Ahmadi-Esfahani 2002, Griffith 2000 and Piggott *et al*. 2000). However a problem with most NEIO models is that they assume imperfectly competitive behaviour by firms on only *one* side of a transaction, while firms on the other side of the transaction are assumed to be perfectly competitive. McCorriston and Sheldon (1996) show that price transmission depends crucially on the nature of firm behaviour at *every* stage in the food marketing chain. In this paper we develop a model which allows both parties to a transaction to exert market power.

The other key factor that determines the extent to which a change in the price of an agricultural product will be transmitted to the retail sector is the nature of the food processing technology. This matters because input substitutability has an impact on changes in processing costs. Although economists have long been capable of estimating important characteristics of production technologies (see for example Chambers 1988), they have little experience in estimating the degree of competition in multi-product markets where the production technology is at all complex. This is despite the fact that, certainly in the case of multi-market models, the assumption of fixed proportions in many industries is highly questionable (see Alston and Scobie 1983, Mullen *et al*. 1988, Lemieux and Wohlgenant 1989, Wohlgenant 1989).

Following on from these background considerations, in this study we report the development and implementation of a methodology for estimating the degree of competition in complex, multiple-input, multiple-output markets such as those in the Australian grains and oilseeds sector. The model allows for both variable-proportions technologies and imperfect competition at different stages of the marketing chain. The theoretical model can be regarded as a generalisation of several models appearing in the agricultural economics literature. We use an empirical version of the model that has the convenient property that it is linear in the parameters, so that it can be estimated using simple techniques such as ordinary least squares. Moreover, estimates from the empirical model can be combined with demand and supply elasticity estimates to obtain unambiguous estimates of indexes of market power (known as conjectural elasticities).

The rest of the Report is organised as follows. Next, we describe the supply and use of grains and oilseeds in Australia. Then we develop a theoretical model which extends existing work, and which includes a discussion of aggregation issues and closely related models. Following this, we use our knowledge of industry practice to change the theoretical model into a model that can be estimated, select suitable estimation methods and describe the data employed. Finally, we report the results of our estimation and draw some conclusions about the presence or absence of market power in this sector of the Australian economy.

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[1] Previously, most agricultural economists had analysed firm behaviour in a structure-conduct-performance (SCP) framework. The SCP paradigm asserts that the structural characteristics of an industry (eg. the degree of buyer-seller concentration) determine the conduct of firms in the industry (eg. pricing behaviour) and ultimately firm performance (eg. profits, margins). SCP models have a much looser foundation in economic theory than NEIO models.

2. Supply and Usage of Grains and Oilseeds Products

Australian Bureau of Statistics (ABS) input-output tables for 1996-97 (the most recent available) were used to form a picture of the supply and usage of grains and oilseeds products (see Figure 1). The percentages in Figure 1 are the shares of grains and oilseeds output (by value) directed to various intermediate and final uses. Output shares less than one per cent by value are excluded from the figure, thus shares may not sum to 100 per cent for any one interface. For example, 55 per cent of grains and oilseeds output (by value) was exported; 10 per cent was re-used by producers; 10 per cent was used in the flour and cereal food manufacturing industry; eight per cent was used in the other food products manufacturing industry; five per cent was used in the beer and malt manufacturing industry; one per cent was used in the oil and fat manufacturing industry; and only two per cent went directly to households. Thus the remaining nine per cent of grains and oilseeds output by value was used by a large number of other industries, but each of which accounted for less than one per cent.

For this study, the key transactions/interfaces in Figure 1 are those labelled A to N. The agents involved in these transactions are households; overseas consumers (exports); grain producers; oil and fat manufacturers; flour and cereal food manufacturers; bakery product manufacturers; other food product manufacturers; and beer and malt manufacturers. All other interfaces account for less than one per cent of grain/oilseed output by value.

An obvious omission from Figure 1 is the retail sector. Much of the recent interest in the agribusiness literature in the food markets area is related to the relationships between food manufacturers and food retailers (see for example Gohin and Guyomard 2000). Similarly, much of the policy interest in Australia relates to the growing concentration levels in food retailing (Australian Parliament 1999). However, data for the retail food sector of the form shown in Figure 1 for other sectors is just not available due to small numbers of firms and confidentiality restrictions. This is especially the case on a state level basis.

The products/industries in Figure 1 have been identified/labelled using both Input-Output Product Classification (IOPC) codes (eg. "0102 Grains") and Australian and New Zealand Standard Industrial Classification (ANZSIC) codes (eg. "ANZSIC 2161"). Details of selected ANZSIC classifications are provided in Appendix A. A measure of the relative importance of particular products within the IOPC/ANZSIC groupings is provided in Table 1. The four largest grain and oilseed crops (by value) and the twelve largest product items derived from grains and oilseeds are marked with an asterisk. The largest single farm products by value are wheat; barley; rice; and oilseeds. The largest final products by value are bread and bread rolls; prepared animal and bird feeds; beer, ale and stout; cereal foods (including breakfast foods); wheat and other cereal flours; cakes, pastries and crumpets, biscuits, biscuit crumbs, rusks etc.; unleavened bread; refined and processed animal and vegetable oils; and margarine.

In our empirical work we attempt to identify whether there is any non-competitive behaviour at points where these farm and final products are exchanged (ie, interfaces A to N in Figure 1).

3. The Theoretical Model

We begin by considering a potentially non-competitive industry in which N firms produce M homogenous outputs using K inputs that are employed in variable proportions. The vector of outputs of firm n is denoted as $\mathbf{y}_n = (y_{n1}, ..., y_{nM})'$; the vector of inputs is $\mathbf{x}_n = (x_{n1}, ..., x_{nK})'$; aggregate outputs and inputs are $\mathbf{Y} \equiv \Sigma\mathbf{y}_n \equiv (Y_1, ..., Y_M)'$ and $\mathbf{X} \equiv \Sigma\mathbf{x}_n \equiv (X_1, ..., X_K)'$; the output price vector is $\mathbf{p} = (p_1, ..., p_M)'$; and the input price vector is $\mathbf{w} = (w_1, ..., w_K)'$. We assume each firm may exercise some market power in the sale of outputs *and/or* the purchase of inputs. The demand functions for outputs and the supply functions for inputs are respectively:

$$(1)\quad Y_m = D_m(\mathbf{p}, \mathbf{v}), \qquad m = 1, ..., M,$$

and

$$(2)\quad X_j = S_j(\mathbf{w}, \mathbf{z}) \qquad j = 1, ..., K,$$

where $\mathbf{v}$ and $\mathbf{z}$ are vectors of exogenous variables.

The profit maximisation problem for firm n can be written in two alternative but equivalent ways (see Chambers 1988, p.268):

$$(3)\quad \max_{\mathbf{y}_n} \sum_{i=1}^{M} p_i y_{ni} - c_n(\mathbf{w}, \mathbf{y}_n) - \kappa_n$$

and

$$(4)\quad \max_{\mathbf{x}_n} r_n(\mathbf{p}, \mathbf{x}_n) - \sum_{i=1}^{K} w_i x_{ni} - \kappa_n$$

where κ_n represents fixed costs, $c_n(\mathbf{w}, \mathbf{y}_n)$ is the minimum cost of producing output vector $\mathbf{y}_n$ given input prices $\mathbf{w}$, and $r_n(\mathbf{p}, \mathbf{x}_n)$ is the maximum revenue that can be obtained from input vector $\mathbf{x}_n$ given output prices $\mathbf{p}$. Assuming an interior solution for all quantities, the first-order optimisation conditions (FOCs) associated with (3) and (4) can be written:

$$(5)\quad p_i + \sum_{j=1}^{M} \sum_{k=1}^{M} \frac{\partial p_j}{\partial Y_k} \frac{\partial Y_k}{\partial y_{ni}} y_{nj} - \frac{\partial c_n(\mathbf{w}, \mathbf{y}_n)}{\partial y_{ni}} = 0$$

and

$$(6)\quad w_i + \sum_{j=1}^{K} \frac{\partial w_j}{\partial X_j} \frac{\partial X_j}{\partial x_{ni}} x_{nj} - \frac{\partial r_n(\mathbf{p}, \mathbf{x}_n)}{\partial x_{ni}} = 0.$$

To motivate our empirical work, it is convenient to rewrite both equations in terms of conjectural and price elasticities:

$$(7)\quad p_i + (1/y_{ni}) \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j y_{nj} \theta_{nki}/\varepsilon_{kj}) = \frac{\partial c_n(\mathbf{w}, \mathbf{y}_n)}{\partial y_{ni}}$$

and

$$(8)\quad w_i + (1/x_{ni}) \sum_{j=1}^{K} (w_j x_{nj} \phi_{nji}/\eta_j) = \frac{\partial r_n(\mathbf{p}, \mathbf{x}_n)}{\partial x_{ni}}$$

where $\theta_{nki} \equiv (\partial Y_k/\partial y_{ni})(y_{ni}/Y_k) \geq 0$ is the conjectural elasticity indicating the belief of firm n about how aggregate output of product k responds to its own output of product i, $\phi_{nji} \equiv (\partial X_j/\partial x_{ni})(x_{ni}/X_j) \geq 0$ is the conjectural elasticity indicating the belief of firm n about how aggregate demand for input j responds to its own demand for input i, $\varepsilon_{kj} \equiv (\partial Y_k/\partial p_j)(p_j/Y_k) \leq 0$ is the j-th price elasticity of demand for product k, and $\eta_j \equiv (\partial X_j/\partial w_j)(w_j/X_j) \geq 0$ is the own-price elasticity of supply of input j.

Heuristically, equation (7) can be interpreted as:

(7') Output price = marginal cost - [(output price)
* (output market power parameters) / (elasticities of demand)]

and equation (8) can be interpreted as:

(8') Input price = marginal revenue - [(input price)
* (input market power parameters) / (elasticities of supply)].

Closer examination of equations (7) and (8) reveals that the conjectural elasticities can be used to identify the two polar cases of market power. If the market power parameters are zero, that is $\theta_{nki} = \phi_{nji} = 0\ \forall$ k, j and i, then (7) and (8) collapse to the well-known set of perfectly competitive FOCs. If the market power parameters are unity, that is $\theta_{nii} = \phi_{nii} = 1\ \forall$ i and $\theta_{nki} = \phi_{nki} = 0\ \forall\ k \neq i$, then (7) and (8) collapse to the set of monopoly-monopsony FOCs. Further examination of equations (7) and (8) reveals that the intermediate values $\theta_{nki} = y_{nk}/Y_k$ and $\phi_{nji} = x_{ni}/X_j$ cause (7) and (8) to collapse to the Cournot FOCs (k , i = 1, ..., M; n = 1, ..., N). The aim of our empirical work is to test whether the equilibrium conjectural elasticities, θ_{nki} and ϕ_{nji}, are zero or not.

Finally, (7) and/or (8) collapse to the perfectly competitive FOCs if the elasticities of supply and/or demand are very large, that is if $|\varepsilon_{kj}| \to \infty$ and/or $|\eta_j| \to \infty\ \forall$ k and j. This result suggests that, in these cases of perfectly elastic output demands and/or input supplies, the conjectural elasticities cannot be, and probably do not need to be, empirically identified. Very elastic demand or supply curves mean that prices have very little opportunity to vary and consequently that there is very little opportunity for the exertion of market power. More will be said about this below.

4. Aggregation Issues

Equations (7) and (8) characterise the behaviour of potentially non-competitive individual firms. However, in our empirical work we only have access to industry-level data. For cost and revenue functions to be well-defined at the industry level, the individual firm functions must be of the Gorman polar form:

(9) $c_n(\mathbf{w}, \mathbf{y}_n) = g_n(\mathbf{w}) + \sum_{i=1}^{M} h_i(\mathbf{w})y_{ni}$

and

(10) $r_n(\mathbf{p}, \mathbf{x}_n) = b_n(\mathbf{p}) + \sum_{i=1}^{K} f_i(\mathbf{p})x_{ni}.$

The Gorman polar form is typically assumed for utility functions to ensure identical preferences across individuals so that individual demand curves can be aggregated into a market demand curve. Here, equations (9) and (10) are applied to firms and imply that marginal costs and marginal revenues are constant across firms:

$$(11)\ \frac{\partial c_n(\mathbf{w}, \mathbf{y}_n)}{\partial y_{ni}} = h_i(\mathbf{w})$$

and

$$(12)\ \frac{\partial r_n(\mathbf{p}, \mathbf{x}_n)}{\partial x_{ni}} = f_i(\mathbf{p}).$$

We follow Appelbaum (1979, 1982) and Wann and Sexton (1992) and further assume that equilibrium conjectural elasticities are the same for all firms, ie., $\theta_{nki} = \theta_{mki}$ and $\phi_{nji} = \phi_{mji}$ $\forall$ m and n (see Wann and Sexton 1992, and Gohin and Guyomard 2000 for a rationale). Then multiplying both sides of (7) by y_{ni}, summing over all firms, dividing by Y_i, and rearranging yields the industry-level function:

$$(14)\ p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i).$$

A similar treatment of equation (8) yields:

$$(15)\ w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K} (w_j\phi_{ji}/\eta_j)(X_j/X_i).$$

Equations (14) and (15) are the backbone of the empirical model used in this project, and again, we are wishing to test whether the equilibrium conjectural elasticities, θ_{nki} and ϕ_{nji}, are zero or not. Further, given our data are likely to be annual and we are interested in equilibrium behaviour, simultaneity considerations are important. Thus, unless we decide otherwise (see section 6 below), we estimate the price equations (14) and (15) jointly with their respective quantity equations (1) and (2), for each output and input of interest.

5. Related Models

- If M = 1 (ie. only one output) the model collapses to that proposed by Holloway (1991). That paper also gives some useful insights into our own theoretical model.
- Raper *et al*. (2000) develop an empirical model by obtaining explicit expressions for the derivatives $\partial Y_k/\partial p_j$ in (5) and $\partial X_j/\partial w_j$ in (6). These expressions require additional assumptions about the nature of competition in upstream and downstream markets, and are developed in that paper for the case of a single output. A generalisation of the Raper *et al.* model to the case of multiple outputs is presented in Appendix B.

6. The Empirical Model

The theoretical model developed above is formally specified in terms of inputs and outputs, so in Figure 2 the statistical information given in Figure 1 and Table 1 is transformed into a more useful format. Further, account is taken of industry data and experience where some inputs and outputs are constrained to be zero[2]. This is because some inputs or outputs are not relevant in the particular production process being modelled, or because we assume that all firms are price-takers when sourcing inputs from outside the sector (eg. labour, capital, materials), implying $\phi_{nji} = 0$ for these inputs. As well, we totally exclude rice from this model because it is only produced in quantity in one state and therefore has too few observations to be capable of producing reliable empirical estimates of the relevant parameters. Consequently, the empirical model comprises a total of 64 equations relating to the behaviour of seven groups of agents in the Australian grains and oilseeds sector[3]. In this section we describe the inputs and outputs of each of these groups.

We assume **grains and oilseeds producers** use K = 3 variable inputs (labour, capital and materials) and one fixed input (land) to produce M = 6 outputs (wheat, barley, canola, oats, grain sorghum and triticale). Thus we have a possible 18 equations to estimate (K+M, for both price and quantity). However, as noted above, grains and oilseeds producers are assumed to be price-takers in all input markets (ie., $\phi_{nji} = 0 \ \forall$ j and i), implying no need to estimate any input equations of the form given by (2) and (15). Thus, the behaviour of grains and oilseeds producers is modelled using the 12 output equations given by equations (1) and (14) for each of i = 1, ...,6.

The full model for grains and oilseeds producers is therefore:

(1) $Y_i = D_i(p_i, \mathbf{v})$, $\quad$ i = 1, ..., 6

and

(14) $p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i)$, $\quad$ i,j,k = 1,...,6.

We assume **flour and cereal food product manufacturers** use K = 7 variable inputs (wheat, barley, canola, oats, triticale, labour and a category of "other inputs") and fixed inputs including plant and machinery to produce M = 2 outputs (wheat and other cereal flours, and cereal foods including breakfast foods). Again, we have a possible 18 equations to estimate. However, equation (2) could not be estimated for j = 3 because canola was not produced in most states in most time periods, so there are insufficient observations to obtain reliable estimates of the parameters. Further, equations (2) and (15) are not estimated for j = 6 and 7 because the conjectural elasticities associated with labour and other inputs are already assumed to be zero. Therefore, the behaviour of flour and cereal food product manufacturers is modelled using the 13 equations given by output equations (1) and (14) for i = 1 and 2, input equations (2) and (15) for j = 1, 2, 4 and 5, and input equation (15) for j = 3.

The full model for flour and cereal food product manufacturers is therefore:

(1) $Y_i = D_i(p_i, \mathbf{v})$, $\quad$ i = 1,2

(2) $X_j = S_j(w_j, \mathbf{z})$, $\quad$ j = 1, 2, 4, 5

[2] The inputs of the industry steering committee were particularly helpful in making these choices.
[3] Thus, it is a major extension of the earlier model proposed in Griffith and O'Donnell (2002).

$$(14)\ p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M}\sum_{k=1}^{M}(p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i), \quad i,j,k = 1,2$$

and

$$(15)\ w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K}(w_j\phi_{ji}/\eta_j)(X_j/X_i), \qquad i,j,k = 1, ...,5.$$

We assume **beer and malt manufacturers** use K = 4 variable inputs (wheat, barley, labour and other inputs) and fixed inputs including plant and machinery to produce M = 1 output (beer). Given that the conjectural elasticities associated with labour and other inputs are already assumed to be zero, the behaviour of beer and malt manufacturers is modelled using the 6 equations given by output equations (1) and (14) for i = 1, and input equations (2) and (15) for j = 1 and 2.

The full model for beer and malt manufacturers is therefore:

$$(1)\ Y_i = D_i(p_i, \mathbf{v}), \qquad i = 1$$

$$(2)\ X_j = S_j(w_j, \mathbf{z}), \qquad j = 1,2$$

$$(14)\ p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M}\sum_{k=1}^{M}(p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i), \quad i,j,k = 1$$

and

$$(15)\ w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K}(w_j\phi_{ji}/\eta_j)(X_j/X_i), \qquad i,j,k = 1,2.$$

We assume **oil and fat manufacturers** use K = 3 variable inputs (canola, labour and other inputs) and fixed inputs including plant and machinery to produce M = 1 output (margarine). Given that the conjectural elasticities associated with labour and other inputs are already assumed to be zero, and that equation (2) could not be estimated for j = 1 because of the large number of zero observations, the behaviour of oil and fat manufacturers is modelled using the 3 equations given by output equations (1) and (14) for i = 1, and the input equation (15) for j = 1.

The full model for oil and fat manufacturers is therefore:

$$(1)\ Y_i = D_i(p_i, \mathbf{v}), \qquad i = 1$$

$$(14)\ p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M}\sum_{k=1}^{M}(p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i), \quad i,j,k = 1$$

and

$$(15)\ w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K}(w_j\phi_{ji}/\eta_j)(X_j/X_i), \qquad i,j,k = 1.$$

We assume **bakery product manufacturers** use K = 3 variable inputs (flour, labour and other inputs) and fixed inputs including plant and machinery to produce M = 2 outputs (bread, and cakes and biscuits). Given that the conjectural elasticities associated with labour and other inputs are already assumed to be zero, and that equation (2) could not be estimated for j = 1 because of the large number of zero observations, the empirical model for bakery product manufacturers is made up of the 5 equations given by output equations (1) and (14) for i = 1 and 2 and the input equation (15) for j = 1.

The full model for bakery product manufacturers is therefore:

(1) $Y_i = D_i(p_i, \mathbf{v})$, $i = 1,2$

(14) $p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i)$, $i,j,k = 1,2$

and

(15) $w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K} (w_j\phi_{ji}/\eta_j)(X_j/X_i)$, $i,j,k = 1$.

We assume **other food product manufacturers** use K = 8 variable inputs (wheat, barley, canola, oats, grain sorghum, triticale, labour and other inputs) and fixed inputs including plant and machinery to produce M = 1 output (other foods). The empirical model is made up of the 12 equations given by output equations (1) and (14) for i = 1, input equations (2) and (15) for j = 1, 2, 4, and 6, and input equation (15) for j = 3 and 5. Again, equation (2) was not estimated for j = 3 and 5 (canola and grain sorghum) because of the large number of zero observations, and we have already assumed that the conjectural elasticities associated with labour and other inputs are zero.

The full model for other food product manufacturers is therefore:

(1) $Y_i = D_i(p_i, \mathbf{v})$, $i = 1$

(2) $X_j = S_j(w_j, \mathbf{z})$, $j = 1, 2, 4, 6$

(14) $p_i = h_i(\mathbf{w}) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j\theta_{ki}/\varepsilon_{kj})(Y_j/Y_i)$, $i,j,k = 1$

and

(15) $w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K} (w_j\phi_{ji}/\eta_j)(X_j/X_i)$, $i,j,k = 1,...,6$.

Finally, we assume the category of final **consumers** (including both domestic consumers and exporters) consumes K = 13 products (wheat, barley, canola, oats, grain sorghum, triticale, cereal foods including breakfast foods, wheat and other cereal flours, beer, margarine, bread, cakes and biscuits, and other foods). The empirical model is made up of the 13 input equations given by (15) for j = 1,...,13.

The full model for final consumers is therefore:

(15) $w_i = f_i(\mathbf{p}) - \sum_{j=1}^{K} (w_j\phi_{ji}/\eta_j)(X_j/X_i)$, $i,j,k = 1, ...,13$.

As noted above, it would have been preferable to also model retail sector purchases and sales, but data restrictions precluded such an addition.

7. Estimation

For estimation purposes we assume $h_i(\mathbf{w})$, $f_i(\mathbf{p})$ and the demand and supply functions (1) and (2) are linear[4] for all i. Specifically, if the demand and supply functions (1) and (2) are linear, they can be written:

$$(16)\quad Y_k = \gamma_{k0} + \sum_{j=1}^{M} \gamma_{kj} p_j + \mu_k v \qquad k = 1, ..., M,$$

and

$$(17)\quad X_j = \alpha_{j0} + \alpha_j w_j \qquad j = 1, ..., K,$$

Moreover, since $\varepsilon_{kj} \equiv (\partial Y_k/\partial p_j)(p_j/Y_k) = \gamma_{kj} p_j/Y_k$, and $\eta_j \equiv (\partial X_j/\partial w_j)(w_j/X_j) = \alpha_j w_j/X_j$, (14) and (15) can be written as linear functions:

$$(18)\quad p_i = h_i(\mathbf{w}) + \sum_{j=1}^{M} \sum_{k=1}^{M} \beta_{kji} Y_{kji}$$

and

$$(19)\quad w_i = f_i(\mathbf{p}) + \sum_{j=1}^{K} \psi_{ji} X_{ji}$$

where $Y_{kji} \equiv -Y_k Y_j/Y_i \equiv Y_{jki}$, $X_{ji} \equiv -X_j X_j/X_i$, $\beta_{kji} = \theta_{ki}/\gamma_{kj}$ and $\psi_{ji} = \phi_{ji}/\alpha_j$. Estimates of β_{kji}, γ_{kj}, ψ_{ji} and α_j can be obtained by estimating equations (16) to (19) individually or as part of a seemingly unrelated regression (SUR) system. Then estimates of the conjectural elasticities, θ_{ki} and ϕ_{ji}, are obtained residually as $\theta_{ki} = \beta_{kji}\gamma_{kj}$ and $\phi_{ji} = \psi_{ji}\alpha_j$.

All prices and quantities were treated as endogenous, and following Gohin and Guyomard (2000), lagged values were used as instruments (lagged values for undefined observations were set to the variable means). Own-price elasticities of output demand and own-price elasticities of input supply were constrained to be non-positive and non-negative respectively, in line with economic theory. Conjectural elasticities were constrained to lie in the unit interval. No other theoretical restrictions were imposed.

Sampling theory methods for imposing inequality constraints are usually unsatisfactory. For example, the global imposition of regularity conditions forces many flexible functional forms to exhibit properties not implied by economic theory (Griffiths, O'Donnell and Tan Cruz 2000). However a Bayesian framework can be used to impose regularity conditions locally without destroying these flexibility properties. Empirical implementation of the Bayesian approach involves the use of Markov Chain Monte Carlo (MCMC) simulation methods based on algorithms such as the Gibbs sampler and the Metropolis-Hastings algorithm that allow samples to be draw directly from marginal probability density functions (pdfs). Details of how this procedure is applied can be found in Griffiths, O'Donnell and Tan Cruz (2000).

[4] This functional form assumption is arbitrary, although it is not possible to assume the demand and supply functions are log-linear if the model is to remain identified.

8. Data Requirements

Estimation of the model requires data on prices and quantities of variable inputs and outputs. Prices and quantities of fixed inputs are not required because the cost of fixed inputs, κ_n, does not appear in the first-order conditions for profit maximisation given by (5) and (6).

The data set covers the six states of New South Wales, Victoria, Queensland, South Australia, Western Australia and Tasmania over the ten financial years 1989-1990 to 1999-2000. Thus, in the pooled data set 66 observations were available for estimation, although six of these observations were lost through lagging.

Data on the following variables were collected from various ABS and Australian Bureau of Agricultural and Resource Economics (ABARE) sources:

- production and prices of wheat, barley, canola, oats, grain sorghum and triticale;
- prices paid by farmers for variable inputs (labour, materials and capital);
- quantities of fixed inputs used by farmers (land);
- production and prices of the outputs of the major grains and oilseeds manufacturing industries (eg. flour mill products, cereal food and baking mixes, oil and fat);
- prices and quantities of labour used in the grains and oilseed manufacturing industries;
- the price of materials used in food product manufacturing industries (as an index);
- retail prices of bread, biscuits, breakfast cereal, flour, margarine and beer;
- average consumer prices; and
- national income.

Various interpolation methods were used to impute values for some data that were missing in some states in some time periods. For example, data on production and the gross value of production was used to calculate the prices of all grains and oilseeds. Missing values were obtained using predictions from a regression of each grain/oilseed price on wheat, barley and oats prices, and the CPI. Data on employment and wages and salaries in manufacturing industries was used to calculate a labour price. Missing values were obtained using predictions from a regression of the labour price on all other price indexes, GDP and consumption expenditure.

9. Results

50,000 MCMC samples were drawn from the posterior pdfs of the parameters using the statistics software package **GAUSS**. The means and standard deviations of these samples are reported in Tables 2 to 8 for the seven groups of agents in this sector. Our primary interest is in the β_{iii} and ψ_{jj} parameters from equations (18) and (19) respectively – if these parameters are equal to zero then industry behaviour is consistent with perfect competition. Importantly, $\beta_{iii} \rightarrow 0$ as $\theta_{ii} \rightarrow 0$ and/or $|\varepsilon_{ii}| \rightarrow \infty$ (that is, as the i-th output conjectural elasticity approaches zero and/or demand for the i-th output becomes perfectly own-price elastic). Likewise, $\psi_{jj} \rightarrow 0$ as $\phi_{jj} \rightarrow 0$ and/or $|\eta_j| \rightarrow \infty$ (that is, as the j-th input conjectural elasticity approaches zero and/or supply of the j-th input becomes perfectly own-price elastic). Thus, we are also interested in these "component" parameters. These parameters are reported in the last three rows of each table, along with the (negative) Lerner index, a common measure of market power. This index is defined as $\theta_{ii}/\varepsilon_{ii}$ for output markets, that is, the ratio of the i-th output conjectural elasticity to the absolute value of the i-th output own-price demand elasticity. Similarly, it is defined as ϕ_{jj}/η_j for input markets, that is, the ratio of the j-th input conjectural elasticity to the j-th input own-price supply elasticity.

In Table 2 for example, relating to grains and oilseeds producers, none of the mean values for the θ_{ii} parameter are large either in absolute value or in relation to their standard deviations. The temptation is to conclude that grains and oilseeds producers sell to processors in competitive markets. However, when the value of the estimated aggregate supply elasticity is considered, the calculated Lerner index may suggest some market power in the sale of barley to processors. We need to remember though that marketing boards for barley were in operation in several states over the period of the study, and that the estimated Lerner index here is simply the result of monopoly selling of barley by these boards.

In other tables, there is no evidence of seller market power in any of the output markets. All θ_{ii} parameters are small either in absolute value or in relation to their standard deviations. We can conclude that manufacturers sell to further processors or to consumers in competitive markets.

Further, there is no evidence of market power in consumer purchases of any of the 13 products studied. All ϕ_{jj} parameters are small either in absolute value or in relation to their standard deviations. We can conclude that consumers purchase from manufacturers or further processors in competitive markets.

However, even though the estimated means are not large relative to their standard deviations, there does seem to be some evidence of market power in the purchase of:

- wheat, barley, oats and triticale by flour and cereal food product manufacturers (the ϕ_{jj} coefficients in Table 3 for j=1,2,4 and 5);
- wheat and barley by beer and malt manufacturers (the ϕ_{jj} coefficients in Table 4 for j=1 and 2); and
- wheat, barley, oats and triticale by other food product manufacturers (the ϕ_{jj} coefficients in Table 7 for j=1,2,4 and 6).

The estimated posterior pdfs are more informative than the means and standard deviations of the samples of observations on the parameters of interest. There are 41 estimated pdfs, however only a small selection is presented here, in Figures 3 to 8[5]. Like the tabulated results, the first panel in each figure presents the output or input conjectural elasticities, the second the elasticities of demand or supply, and the last the (negative) Lerner index.

Across all of the figures, there are some common patterns:

- the pdfs of most conjectural elasticities have modes at zero, implying the absence of market power. This is true for all of the output markets, such as the sale of cereal foods from flour and cereal food product manufacturers as shown in Figure 3.

[5] The full set of probability density functions may be obtained from the authors if required.

- some estimated own-price elasticities of demand or supply are large in absolute value, and this sometimes makes it difficult to statistically identify the associated conjectural elasticities. This identification problem manifests itself in pdfs which span the [0, 1] interval. The example shown in Figure 4 is for the purchase of wheat by flour and cereal food product manufacturers.
- it is not always the case that large estimated own-price elasticities of demand/supply make it difficult to identify associated conjectural elasticities. See, for example, Figure 5 for the sale of beer by beer and malt manufacturers.
- even when estimated own-price elasticities of demand or supply are relatively small, there may be considerable uncertainty concerning the values of conjectural elasticities. In these cases we conclude there is positive probability that the industry exercises market power. The example shown in Figure 6 is for the purchase of oats by flour and cereal food product manufacturers.
- in some cases we have no knowledge of elasticities of demand and supply. We can obtain estimates of associated conjectural elasticities by simply assuming values for price elasticities at mean prices and quantities. Two examples are given in Figures 7 and 8. Figure 7 reports the estimates for the purchase of canola by oil and fat manufacturers, while Figure 8 reports the estimates for the purchase of flour by bakery product manufacturers. Note that these estimated pdfs can be "scaled" up (down) proportionately by increasing (decreasing) the assumed value of the elasticity of demand or supply.

Based on these general patterns in the estimated pdfs, we suggest that there is positive probability that the following industries exert market power:

- flour and cereal food product manufacturers (when purchasing wheat, barley, oats and triticale),
- beer and malt manufacturers (when purchasing wheat and barley), and
- other food product manufacturers (when purchasing wheat, barley, oats and triticale).

10. Conclusions

In this study we set out to develop and implement a methodology for estimating the degree of competition in complex, multiple-input, multiple-output markets such as those in the Australian grains and oilseeds sector. Stated another way, we explored the degree of farm-retail price transmission in this sector. We specified a general duality model of profit maximisation that allows for imperfect competition in both input and output markets, and for variable-proportions technologies. Aggregate Australian data taken from the official input-output tables were used to implement the model for thirteen grains and oilseeds products handled by seven groups of agents. The model was estimated in a Bayesian framework. Results are reported in terms of the characteristics of the estimated probability distributions for output and input conjectural elasticities, demand and supply elasticities and indexes of market power. Our results suggest that there is a positive probability that flour and cereal food product manufacturers exert market power when purchasing wheat, barley, oats and triticale; that beer and malt manufacturers exert market power when purchasing wheat and barley; and that other food product manufacturers exert market power when purchasing wheat, barley, oats and triticale.

These results confirm the preliminary conclusions reached by Griffith (2000) and Piggott *et al*. (2000). What is interesting is that each of the transaction nodes where market power is indicated is one where a farm commodity is sold to a processing sector – that is, the evidence suggests oligopsonistic behaviour by grains buyers. The wheat and barley industries seem to be especially disadvantaged by this type of market conduct. While these results are the subject of a good deal of uncertainty, there are implications to be considered relating to marketing board deregulation and ways of grains producers achieving countervailing power in these markets.

A related and equally interesting result is that there was no consistent evidence of market power in the downstream nodes of the data set relating to the sales of flour and other cereal foods, or the sale of bread and other bakery products. These sectors are those highlighted by the Prices Surveillance Authority (1994) as being "not effectively competitive" or those subject to numerous actions by the ACCC. Perhaps the growing power of the retail chains has limited potential abuse of market power in these sectors, but unfortunately the data were not available to enable this hypothesis to be tested.

Another conclusion is that the MCMC estimation framework used in this study appears to be useful. In particular, the estimated posterior pdfs of the samples of observations on the parameters of interest are shown to be considerably more informative than the means and standard deviations of those samples. For example, when we consider just the mean values for the θ_{ii} parameters, none are large in relation to their standard deviations and we may conclude that grains and oilseeds producers sell to processors in competitive markets. However, while there remains much uncertainty in the results, when we consider the pdfs of these parameters, we do conclude that there is oligopsonistic behaviour by grains buyers and that grains and oilseeds producers are disadvantaged.

Much of the uncertainty surrounding our estimates probably stems from the lack of good quality data. Future research efforts should be directed at the following issues:

- improving the collection and integrity of relevant data (including for the retail and distributive nodes of the various markets),
- estimating the models in larger SUR frameworks, not least so that we can obtain consistent estimates of input elasticities across sectors, and
- incorporating more equality and inequality information into the estimation process (eg. symmetry and homogeneity constraints; inequality constraints on income elasticities).

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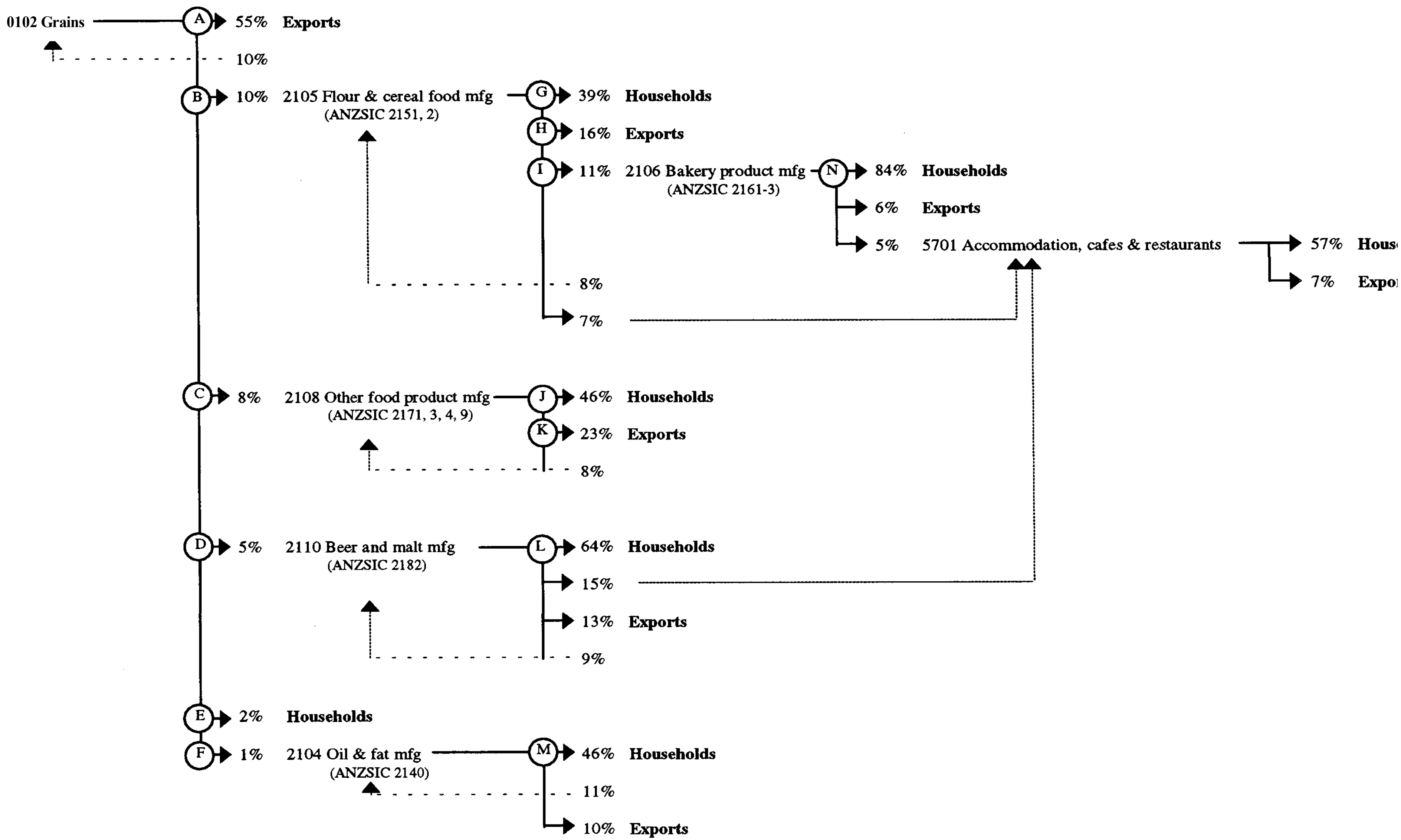


Figure 1. Basic Structure of Grains and Oilseeds Product Supply Chain

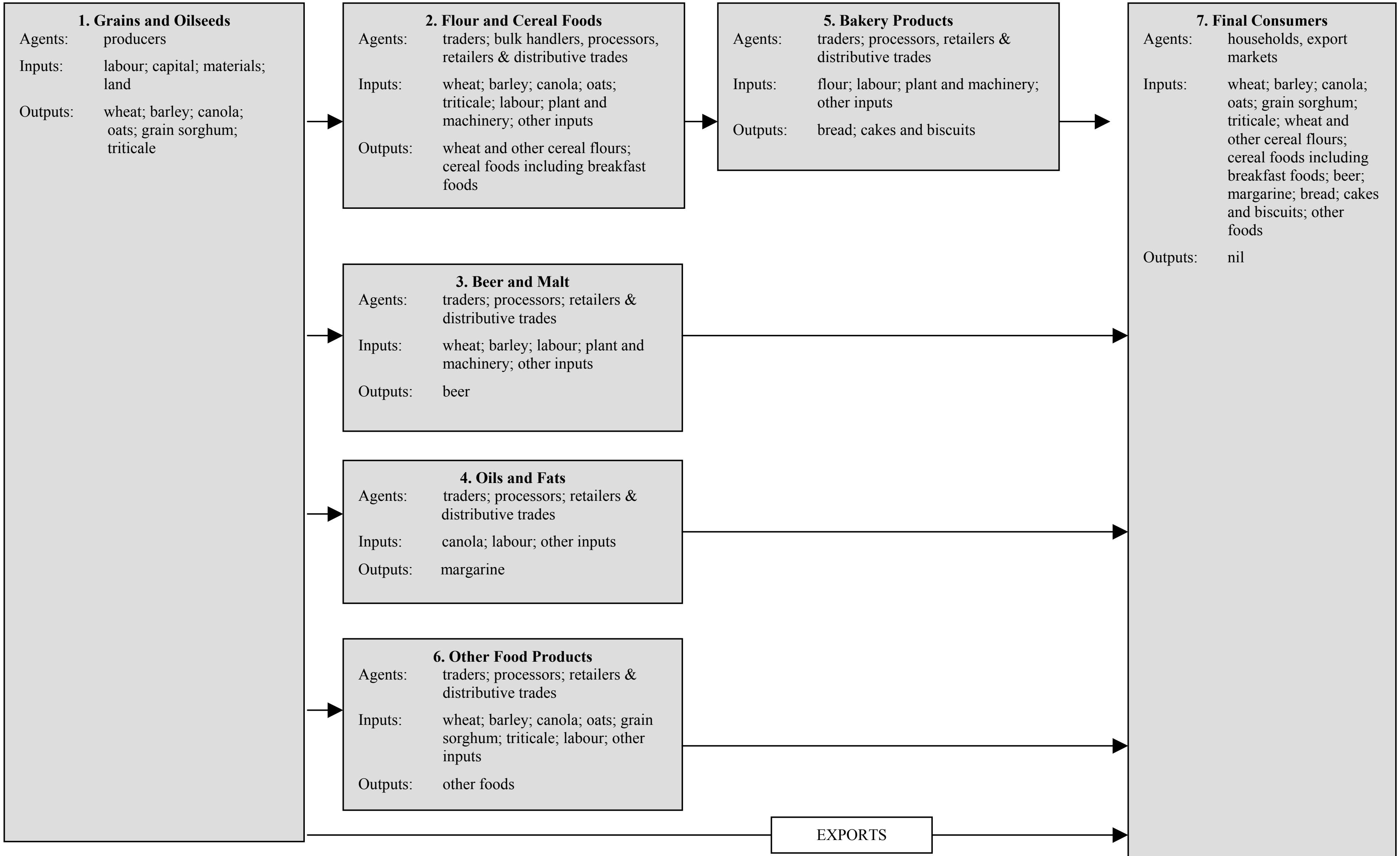
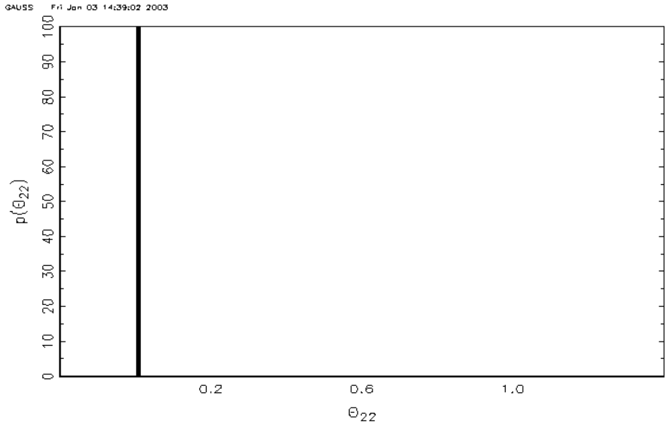


Figure 2. Overview of Grains and Oilseeds Model



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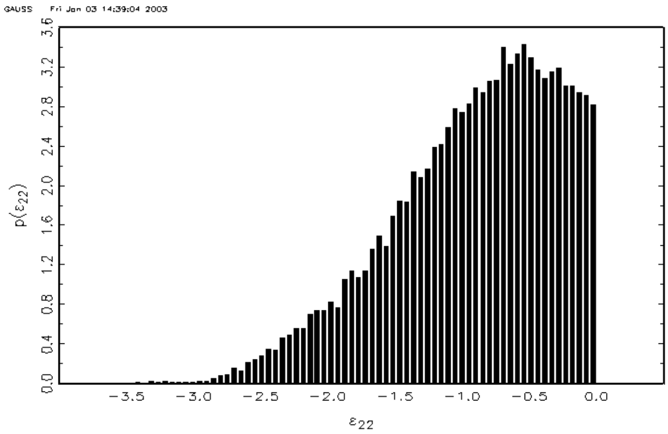

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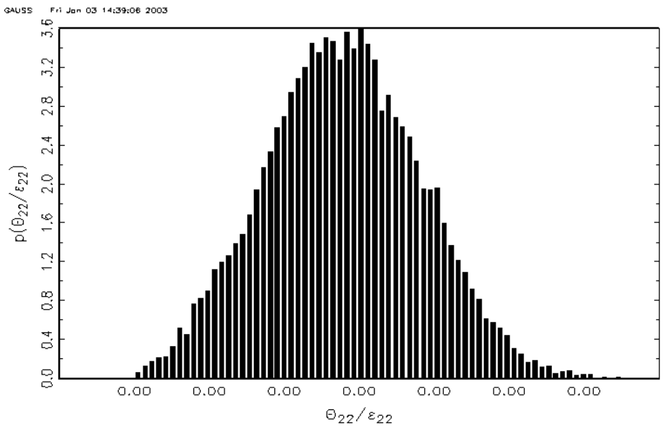

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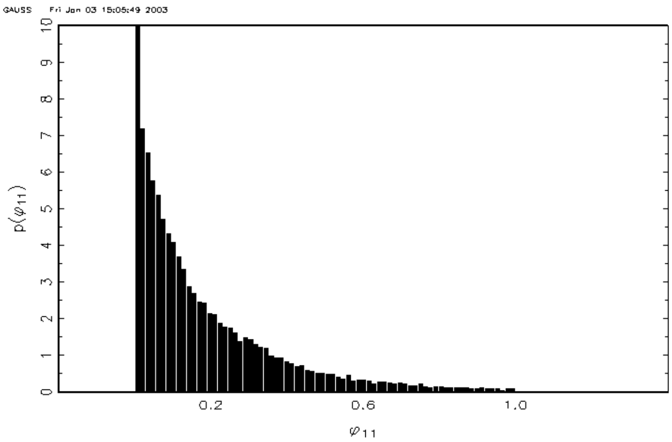
Figure 3. Flour and Cereal Food Product Manufacturers – Cereal Foods Output



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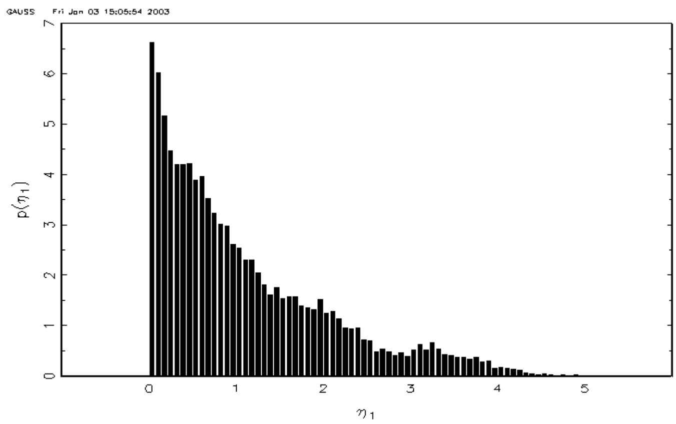

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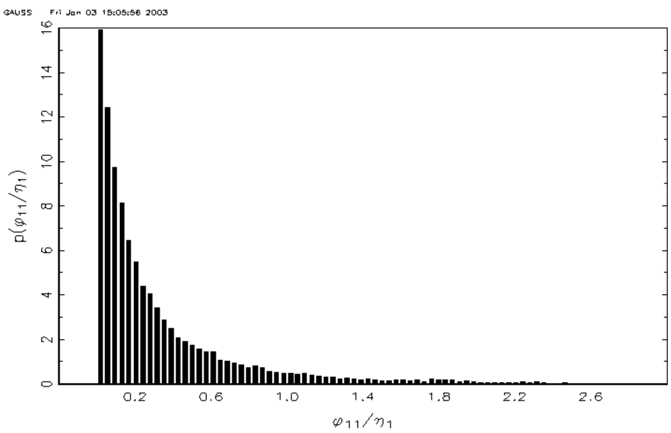

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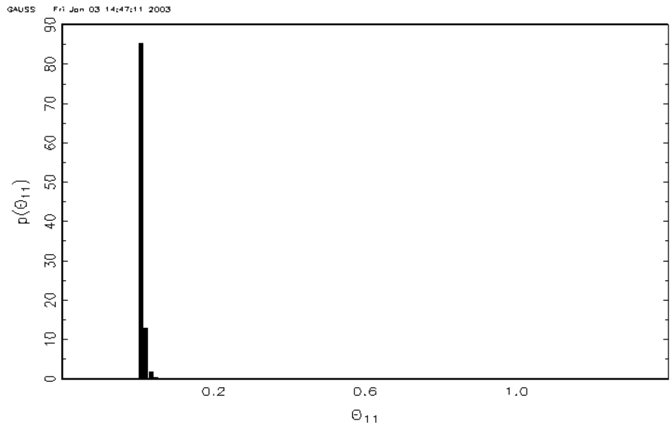
Figure 4. Flour and Cereal Food Product Manufacturers – Wheat Input



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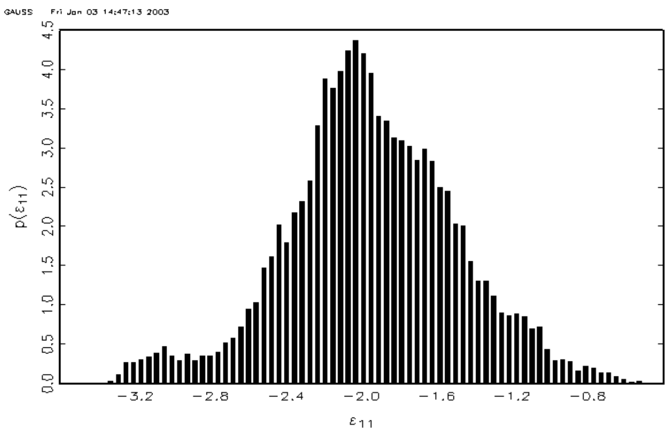

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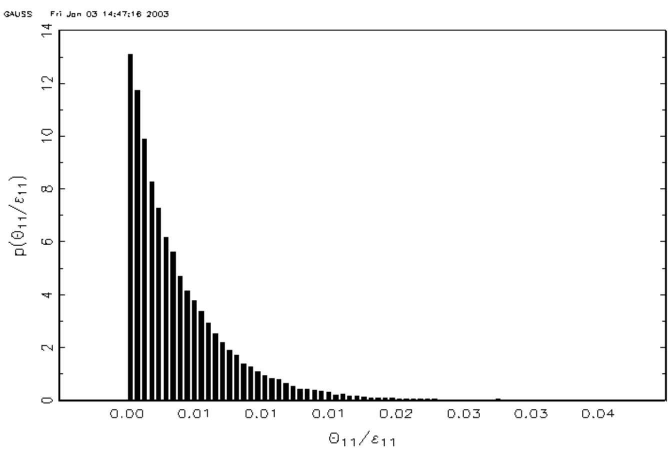

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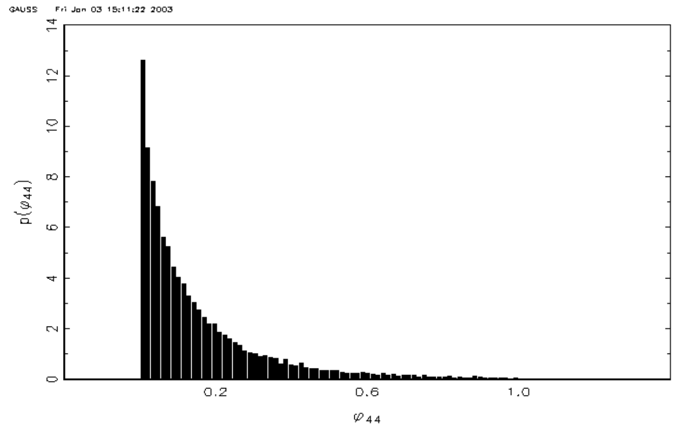
Figure 5. Beer and Malt Manufacturers – Beer Output



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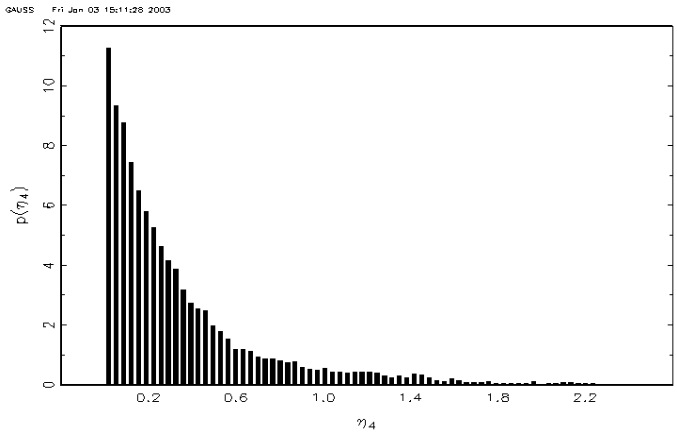

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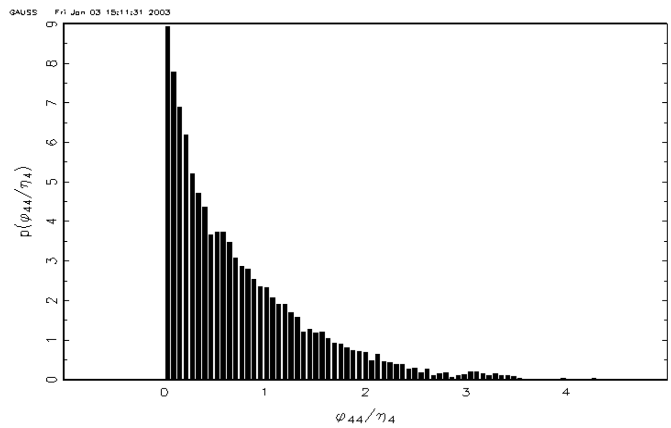

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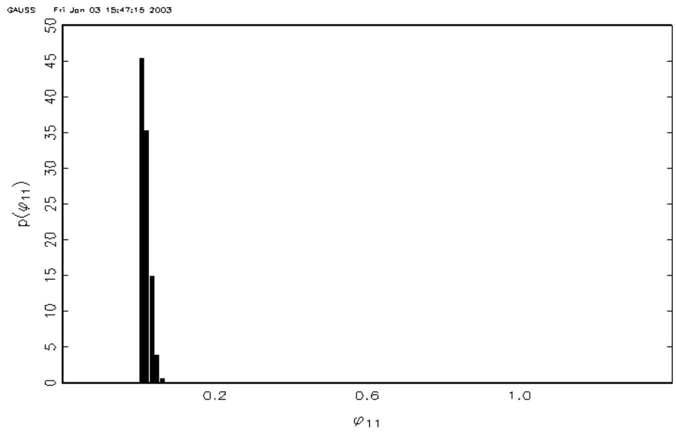
Figure 6. Flour and Cereal Food Product Manufacturers – Oats Input



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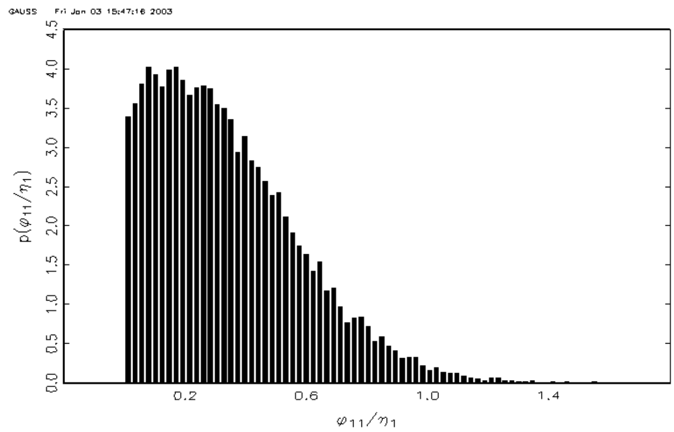

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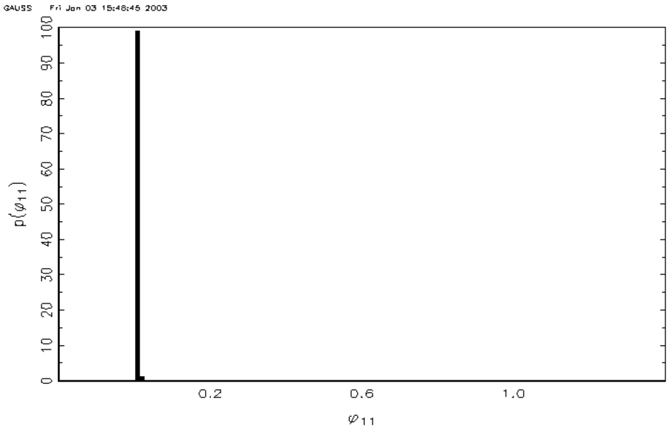
Figure 7. Oil and Fat Manufacturers – Canola Input



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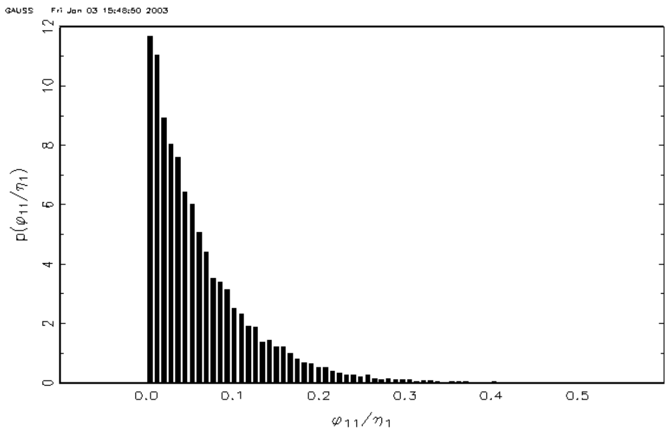

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Figure 8. Bakery Product Manufacturers – Flour Input

Table 1. Product Supplies and Exports by IOPC Item: 1996-97 ($million)

Code	Description	Australian Production (1)	Competing Imports cif (2)	Total (1) + (2)	Exports
0102	**Grains**				
	*Wheat and meslin, unmilled	4362.2	0.6	4362.8	2,999.5
	*Barley, unmilled	1070.7	-	1070.7	551.9
	Oats, unmilled	193.8	-	193.8	15.3
	*Rice, in the husk	257.3	0.1	257.4	3.5
	Grain sorghum	200.3	-	200.3	34.5
	*Oilseeds	289.3	40.2	329.5	112.8
	Legumes for grain nec	420.5	0.3	420.7	n.a.
	Cereal grains nec	207.3	0.4	207.7	n.a.
	Total	*7,001.5*	*41.7*	*7043.1*	*3,907.6*
2104	**Oils and Fats**				
	Crude vegetable oils	158.8	114.3	273.0	n.a.
	Oil cake and other solid residues	n.a.	83.0	n.a.	6.5
	*Refined/processed animal/vegetable oils	356.4	184.8	541.3	18.6
	Acid oils from refining animal/vegetable oils	n.a.	13.0	n.a.	n.a.
	*Margarine	260.8	2.9	263.7	69.6
	Total	*848.3*	*398.0*	*1246.3*	*119.1*
2105	**Flour Mill Products and Cereal Foods**				
	*Wheat and other cereal flours (excl self raising)	755.0	4.0	759.0	54.8
	Cereal (excl rice) groats etc. for human consumption	12.4	1.2	13.6	5.8
	Wheat bran for humans (excl for breakfast foods)	13.7	1.2	14.9	0.4
	Flour mill products nec, for human consumption	77.5	1.7	79.2	-
	Starch of wheat and corn	153.5	13.8	167.4	20.5
	Glucose, glucose syrup & modified starches	129.7	19.4	149.1	14.8
	Wheat gluten	98.5	2.3	100.8	46.3
	*Cereal foods (incl breakfast foods)	817.5	51.7	869.2	57.3
	Flour (self raising)	20.3	0.2	20.4	0.6
	Prepared baking powders, jelly crystals etc.	n.a.	79.9	n.a.	3.6
	Rice, semi-milled or wholly milled	n.a.	39.0	n.a.	n.a.
	Rice, husked but not further prepared	n.a.	0.1	n.a.	-
	Rice groats; other worked cereal grains etc.	n.a.	27.8	n.a.	n.a.
	Rice bran, sharps and other residues	38.1	-	38.1	0.8
	Pasta	175.8	54.6	230.5	14.8
	Other	12.1	-	12.1	-
	Increase in stocks	0.9	-	0.9	-
	Total	*3172.9*	*269.9*	*3469.7*	*542.1*
2106	**Bakery Products**				
	*Bread and bread rolls	1393.0	49.5	1442.4	42.0
	Meat pies	242.5	10.3	252.8	9.3
	*Cakes, pastries and crumpets	725.5	93.6	819.1	37.8
	*Biscuits, biscuit crumbs, rusks etc, unleavened bread	702.5	124.6	827.1	98.6
	Increase in stocks	1.7	-	1.7	-
	Total	*3065.2*	*278.0*	*3343.2*	*187.8*
2108	**Other Food Products**				
	Raw Sugar	1876.6	0.7	1877.3	1226.1
	*Prepared animal and bird feeds nec	1332.0	15.8	1347.9	11.9
	Dog and cat food, canned	535.6	31.9	567.5	121.0
	Potato crisps and flakes	603.4	0.1	603.5	0.4
	Other	4774.9	1212.9	5987.8	1175.3
	Total	*9122.5*	*1261.4*	*10383.9*	*2424.7*
2110	**Beer and Malt**				
	*Beer, ale and stout, bottled	1157.6	76.0	1233.6	125.8
	*Beer, ale and stout, canned	547.4	46.5	593.9	90.7
	*Beer, ale and stout, bulk	392.4	21.5	413.9	1.8
	Malt (excl malt extract)	250.8	0.6	251.4	108.3
	Other	19.0	-	19.0	12.1
	Total	*2367.3*	*144.6*	*2511.8*	*338.8*

Source: ABS 5215.0 nec not elsewhere classified n.a. not applicable

Table 2. Parameter Estimates: Grains and Oilseeds Producers

	Wheat (i = 1)	Barley (i = 2)	Canola (i = 3)	Oats (i = 4)	Grain Sorghum (i = 5)	Triticale (i = 6)
γ_{i0}	10718.388 (1706.214)	1426.044 (308.325)	214.064 (144.260)	490.391 (107.765)	-118.944 (144.762)	-89.088 (43.911)
γ_{i1}	-43.408 (6.243)	7.709 (1.330)	1.196 (0.472)	0.735 (0.568)	1.069 (0.844)	-0.050 (0.158)
γ_{i2}	10.806 (7.308)	-0.659 (0.658)	-2.121 (1.174)	0.054 (0.834)	-7.312 (1.091)	1.021 (0.242)
γ_{i3}	1.319 (2.514)	-2.667 (0.709)	-0.071 (0.113)	-0.061 (0.250)	0.750 (0.323)	0.092 (0.080)
γ_{i4}	-12.623 (6.138)	-5.040 (1.618)	0.248 (0.451)	-4.169 (0.600)	5.698 (1.041)	-0.742 (0.229)
γ_{i5}	-2.840 (5.477)	0.773 (1.393)	-0.896 (0.552)	-0.806 (0.426)	-0.313 (0.285)	0.410 (0.126)
γ_{i6}	-0.132 (6.381)	-3.475 (2.020)	0.295 (0.587)	1.145 (0.649)	0.590 (0.984)	-0.516 (0.382)
μ_i	8.592 (4.040)	1.682 (0.849)	1.372 (0.283)	2.091 (0.272)	3.404 (0.412)	0.898 (0.087)
δ_{i0}	185.115 (70.627)	-106.551 (57.751)	66.320 (128.308)	-20.218 (62.046)	-233.282 (65.997)	-125.111 (53.708)
δ_{i1}	-1.155 (0.786)	-1.628 (0.678)	-2.951 (0.586)	-1.244 (0.404)	-2.019 (0.514)	-0.985 (0.560)
δ_{i2}	1.151 (1.289)	-2.850 (1.462)	5.800 (2.007)	-3.788 (1.443)	-2.327 (1.246)	-6.938 (1.510)
δ_{i3}	0.573 (1.451)	6.725 (1.460)	0.038 (2.707)	6.670 (1.427)	7.671 (1.668)	10.477 (1.396)
β_{11i}	-0.003 (0.003)	-0.003 (0.002)	0.000 (0.000)	-0.002 (0.001)	0.001 (0.001)	0.000 (0.000)
β_{12i}	0.047 (0.026)	0.024 (0.009)	0.001 (0.001)	0.008 (0.002)	-0.006 (0.003)	0.000 (0.001)
β_{13i}	0.180 (0.116)	0.056 (0.028)	-0.021 (0.010)	0.026 (0.012)	-0.019 (0.019)	-0.002 (0.005)
β_{14i}	0.208 (0.069)	0.002 (0.027)	-0.001 (0.005)	0.022 (0.009)	-0.001 (0.005)	-0.004 (0.004)
β_{15i}	0.068 (0.023)	0.010 (0.005)	0.002 (0.003)	0.005 (0.002)	0.016 (0.011)	0.002 (0.001)
β_{16i}	-0.354 (0.196)	-0.210 (0.066)	0.006 (0.015)	-0.058 (0.020)	-0.002 (0.030)	-0.002 (0.008)
β_{22i}	-0.035 (0.031)	-0.044 (0.018)	0.000 (0.001)	-0.007 (0.002)	0.003 (0.003)	0.000 (0.001)
β_{23i}	0.055 (0.301)	0.179 (0.095)	0.035 (0.037)	-0.063 (0.025)	0.076 (0.046)	0.006 (0.008)

Table 2 (cont).

	Wheat (i = 1)	Barley (i = 2)	Canola (i = 3)	Oats (i = 4)	Grain Sorghum (i = 5)	Triticale (i = 6)
β_{24i}	0.007 (0.121)	0.050 (0.064)	-0.005 (0.006)	0.015 (0.020)	-0.002 (0.012)	-0.003 (0.004)
β_{25i}	-0.036 (0.081)	0.055 (0.039)	-0.003 (0.004)	-0.009 (0.006)	0.012 (0.034)	0.001 (0.003)
β_{26i}	-0.415 (0.619)	-0.516 (0.300)	-0.016 (0.049)	0.010 (0.051)	0.098 (0.049)	0.004 (0.017)
β_{33i}	-0.156 (0.785)	0.013 (0.177)	-0.044 (0.038)	-0.009 (0.061)	0.024 (0.095)	0.001 (0.019)
β_{34i}	-2.572 (0.917)	-1.702 (0.346)	0.131 (0.079)	-0.319 (0.104)	0.143 (0.080)	-0.001 (0.040)
β_{35i}	-0.398 (0.441)	-0.327 (0.112)	-0.017 (0.095)	-0.157 (0.050)	0.072 (0.171)	0.015 (0.011)
β_{36i}	1.815 (3.301)	1.969 (0.770)	0.453 (0.389)	0.721 (0.254)	-1.137 (0.543)	0.007 (0.072)
β_{44i}	-0.796 (0.373)	-0.048 (0.162)	0.021 (0.021)	-0.027 (0.023)	0.057 (0.022)	0.020 (0.019)
β_{45i}	-0.326 (0.303)	0.038 (0.121)	0.040 (0.027)	-0.087 (0.045)	-0.342 (0.085)	-0.020 (0.009)
β_{46i}	2.649 (2.430)	1.748 (0.811)	0.019 (0.112)	0.317 (0.246)	-0.166 (0.165)	0.024 (0.061)
β_{55i}	-0.021 (0.026)	-0.012 (0.010)	-0.001 (0.005)	0.000 (0.002)	-0.015 (0.016)	0.000 (0.001)
β_{56i}	0.384 (0.765)	0.134 (0.256)	-0.146 (0.068)	0.065 (0.147)	0.980 (0.363)	-0.049 (0.039)
β_{66i}	2.347 (5.323)	1.340 (1.713)	-0.210 (0.426)	0.128 (0.494)	-0.381 (0.516)	-0.068 (0.062)
θ_{ii}	0.136 (0.137)	0.028 (0.032)	0.003 (0.004)	0.111 (0.099)	0.004 (0.006)	0.028 (0.031)
$\bar{\varepsilon}_{ii}$	-2.966 (0.427)	-0.124 (0.124)	-0.220 (0.351)	-2.166 (0.312)	-0.228 (0.207)	-1.127 (0.835)
$\theta_{ii}/\bar{\varepsilon}_{ii}$	0.046 (0.045)	0.233 (0.094)	0.014 (0.012)	0.051 (0.045)	0.021 (0.022)	0.031 (0.029)

Table 3. Parameter Estimates: Flour and Cereal Food Product Manufacturers

	Outputs			Inputs				
	Wheat & Other Flours (i = 1)	Cereal Foods (i = 2)		Wheat (j = 1)	Barley (j = 2)	Canola (j = 3)	Oats (j = 4)	Triticale (j = 5)
γ_{i0}	1.395	1.007	α_{j0}	42.643	577.687	-	188.351	26.596
	(0.495)	(0.628)		(2958.514)	(335.931)		(108.150)	(40.209)
γ_{i1}	-0.003	-0.002	α_j	15.982	1.934	-	0.639	0.290
	(0.003)	(0.002)		(14.219)	(2.095)		(0.697)	(0.267)
γ_{i2}	-0.002	-0.003						
	(0.002)	(0.002)						
μ_i	0.011	0.019						
	(0.002)	(0.001)						
δ_{i0}	76.080	2.092	κ_{j0}	-57.376	17.841	100.033	21.607	-59.874
	(50.995)	(57.588)		(69.176)	(58.205)	(122.842)	(63.782)	(63.671)
δ_{i1}	-0.069	0.226	κ_{j1}	0.004	0.203	-0.071	0.291	0.294
	(0.081)	(0.096)		(0.161)	(0.147)	(0.286)	(0.166)	(0.152)
δ_{i2}	0.141	-0.006	κ_{j2}	0.772	0.337	1.046	0.138	0.457
	(0.114)	(0.138)		(0.187)	(0.178)	(0.336)	(0.177)	(0.192)
δ_{i3}	0.114	0.176	ψ_{1j}	0.021	0.000	0.001	-0.002	0.000
	(0.034)	(0.037)		(0.027)	(0.005)	(0.001)	(0.002)	(0.000)
δ_{i4}	-0.168	-0.293	ψ_{2j}	-0.203	0.085	-0.001	-0.002	0.000
	(0.097)	(0.090)		(0.116)	(0.082)	(0.001)	(0.005)	(0.002)
δ_{i5}	0.215	0.123	ψ_{3j}	-2.915	0.372	1.267	0.328	-0.009
	(0.087)	(0.087)		(3.816)	(0.522)	(0.519)	(0.199)	(0.016)
δ_{i6}	3.148	0.201	ψ_{4j}	-0.738	-0.074	0.018	0.377	-0.034
	(0.395)	(0.399)		(1.956)	(0.451)	(0.046)	(0.353)	(0.021)
δ_{i7}	-0.076	2.030	ψ_{5j}	1.031	-1.222	0.612	0.341	1.271
	(0.569)	(0.666)		(13.988)	(3.461)	(1.210)	(1.264)	(1.280)
β_{11i}	-4.797	-0.013						
	(4.592)	(0.006)						
β_{12i}	-17.263	0.140						
	(9.334)	(0.055)						
β_{22i}	2.420	-0.417						
	(4.385)	(0.155)						
θ_{ii}	0.010	0.001	ϕ_{jj}	0.180	0.121	0.020	0.147	0.199
	(0.015)	(0.001)		(0.186)	(0.147)	(0.008)	(0.165)	(0.192)
$\bar{\varepsilon}_{ii}$	-0.891	-0.917	$\bar{\eta}_j$	1.092	0.365	0.050	0.332	0.633
	(0.936)	(0.617)		(0.972)	(0.396)	(a)	(0.362)	(0.583)
$\theta_{ii}/\bar{\varepsilon}_{ii}$	0.015	0.001	$\phi_{jj}/\bar{\eta}_j$	0.314	0.448	0.409	0.726	0.581
	(0.015)	(0.001)		(0.393)	(0.433)	(0.168)	(0.680)	(0.585)

(a) Assumed value.

Table 4. Parameter Estimates: Beer and Malt Manufacturers

	Beer Output		Inputs: Wheat (j = 1)	Inputs: Barley (j = 2)
γ_{10}	5.497 (0.964)	α_{j0}	-206.394 (2332.631)	465.264 (450.800)
γ_{11}	-0.024 (0.006)	α_j	15.824 (11.735)	2.698 (2.419)
μ_1	0.011 (0.002)			
δ_{10}	-110.215 (56.730)	κ_{j0}	93.772 (35.026)	123.740 (33.631)
δ_{11}	-0.008 (0.071)	κ_{j1}	0.615 (0.199)	0.296 (0.186)
δ_{12}	-0.067 (0.086)	ψ_{1j}	0.033 (0.042)	0.001 (0.005)
δ_{13}	0.636 (0.289)	ψ_{2j}	0.027 (0.230)	0.147 (0.150)
δ_{14}	2.538 (0.647)			
β_{111}	-0.311 (0.313)			
θ_{ii}	0.007 (0.007)	ϕ_{jj}	0.274 (0.243)	0.247 (0.241)
$\bar{\varepsilon}_{ii}$	-1.951 (0.455)	$\bar{\eta}_j$	1.081 (0.802)	0.509 (0.457)
$\theta_{ii}/\bar{\varepsilon}_{ii}$	0.004 (0.004)	$\phi_{jj}/\bar{\eta}_j$	0.478 (0.612)	0.778 (0.794)

Table 5. Parameter Estimates: Oil and Fat Manufacturers

	Margarine Output		Canola Input
γ_{10}	2.170 (0.576)	α_{10}	-
γ_{11}	-0.015 (0.004)	α_j	-
μ_1	0.014 (0.001)		
δ_{10}	-25.774 (27.263)	κ_{10}	421.724 (111.103)
δ_{11}	-0.020 (0.014)	κ_{11}	-0.297 (0.707)
δ_{12}	0.124 (0.084)	ψ_{11}	1.054 (0.743)
δ_{13}	1.727 (0.264)		
β_{111}	-0.557 (0.548)		
θ_{ii}	0.008 (0.008)	ϕ_{11}	0.017 (0.012)
$\bar{\varepsilon}_{ii}$	-2.804 (0.684)	$\bar{\eta}_1$	0.050 (a)
$\theta_{ii}/\bar{\varepsilon}_{ii}$	0.003 (0.003)	$\phi_{11}/\bar{\eta}_1$	0.341 (0.240)

(a) Assumed value.

Table 6. Parameter Estimates: Bakery Product Manufacturers

	Outputs			
	Bread (i = 1)	Cakes and Biscuits (i = 2)		Flour Input
γ_{i0}	3.618 (0.332)	3.322 (0.697)	α_{10}	-
γ_{i1}	-0.004 (0.003)	0.005 (0.004)	α_{1}	-
γ_{i2}	-0.017 (0.004)	-0.026 (0.008)		
μ_{i}	0.011 (0.001)	0.021 (0.002)		
δ_{i0}	-42.661 (35.656)	29.296 (15.023)	κ_{10}	184.185 (38.978)
δ_{i1}	0.345 (0.054)	0.180 (0.022)	κ_{11}	1.319 (0.187)
δ_{i2}	2.583 (0.276)	0.762 (0.126)	κ_{12}	-0.960 (0.372)
δ_{i3}	0.533 (0.368)	0.646 (0.158)	ψ_{11}	19.378 (18.690)
β_{11i}	-6.106 (4.756)	-3.924 (0.999)		
β_{12i}	14.953 (5.035)	17.215 (1.112)		
β_{22i}	-3.903 (1.434)	-0.391 (0.364)		
θ_{ii}	0.027 (0.028)	0.010 (0.010)	ϕ_{11}	0.003 (0.003)
$\bar{\varepsilon}_{ii}$	-0.576 (0.333)	-1.896 (0.573)	$\bar{\eta}_{1}$	0.050 (a)
$\theta_{ii}/\bar{\varepsilon}_{ii}$	0.047 (0.037)	0.005 (0.005)	$\phi_{11}/\bar{\eta}_{1}$	0.062 (0.060)

(a) Assumed value.

Table 7. Parameter Estimates: Other Food Product Manufacturers

	Other Food Output		Inputs					
			Wheat (j = 1)	Barley (j = 2)	Canola (j = 3)	Oats (j = 4)	Grain Sorghum (j = 5)	Triticale (j = 6)
γ_{10}	55.918	α_{10}	1585.622	449.144	-	184.494	-	-7.169
	(16.676)		(1356.258)	(425.103)		(93.806)		(74.934)
γ_{11}	-0.476	α_{1}	6.550	2.732	-	0.529	-	0.518
	(0.149)		(6.508)	(2.394)		(0.661)		(0.461)
μ_{1}	0.156							
	(0.011)							
δ_{10}	20.186	κ_{j0}	-159.802	-96.607	116.315	135.485	-147.696	-7.423
	(13.993)		(105.087)	(93.179)	(190.393)	(95.331)	(108.737)	(102.123)
δ_{11}	-0.014	κ_{j1}	3.185	2.337	2.688	0.075	2.790	1.494
	(0.013)		(0.912)	(0.808)	(1.660)	(0.835)	(0.957)	(0.870)
δ_{12}	0.072	ψ_{1j}	0.040	-0.001	0.000	-0.001	0.001	0.000
	(0.016)		(0.039)	(0.005)	(0.001)	(0.002)	(0.000)	(0.000)
δ_{13}	-0.015	ψ_{2j}	0.013	0.101	0.002	0.006	0.000	0.006
	(0.005)		(0.147)	(0.105)	(0.001)	(0.006)	(0.001)	(0.003)
δ_{14}	-0.054	ψ_{3j}	2.221	0.623	2.181	0.199	0.035	0.009
	(0.015)		(4.488)	(0.596)	(0.597)	(0.222)	(0.034)	(0.010)
δ_{15}	-0.019	ψ_{4j}	-2.522	-0.626	0.082	0.418	-0.057	-0.019
	(0.010)		(2.427)	(0.594)	(0.059)	(0.367)	(0.034)	(0.018)
δ_{16}	-0.014	ψ_{5j}	-0.071	0.014	0.012	-0.007	0.295	0.002
	(0.016)		(0.142)	(0.017)	(0.003)	(0.006)	(0.183)	(0.002)
δ_{17}	0.252	ψ_{6j}	21.875	-0.580	2.135	-1.300	0.336	0.964
	(0.072)		(17.328)	(3.653)	(1.257)	(1.336)	(0.880)	(1.320)
δ_{18}	0.895							
	(0.135)							
β_{111}	-0.008							
	(0.008)							
θ_{11}	0.004	ϕ_{jj}	0.164	0.195	0.035	0.142	0.020	0.219
	(0.004)		(0.177)	(0.205)	(0.010)	(0.163)	(0.013)	(0.209)
$\bar{\varepsilon}_{11}$	-4.038	$\bar{\eta}_{j}$	0.448	0.516	0.050	0.275	0.050	1.133
	(1.266)		(0.445)	(0.452)	(a)	(0.343)	(a)	(1.007)
$\theta_{11}/\bar{\varepsilon}_{11}$	0.001	$\phi_{jj}/\bar{\eta}_{j}$	0.588	0.533	0.705	0.804	0.405	0.441
	(0.001)		(0.571)	(0.554)	(0.193)	(0.707)	(0.252)	(0.604)

(a) Assumed value.

Table 8. Parameter Estimates: Consumers

	Wheat (j = 1)	Barley (j = 2)	Canola (j = 3)	Oats (j = 4)	Grain Sorghum (j = 5)	Triticale (j = 6)	Cereal Foods (j = 7)
κ_{j0}	202.574	176.090	412.725	154.595	163.615	173.506	232.780
	(13.041)	(10.222)	(12.987)	(9.928)	(8.125)	(10.201)	(9.078)
ψ_{1j}	0.007	0.000	0.000	0.000	0.000	0.000	0.000
	(0.005)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{2j}	-0.014	0.016	0.000	-0.001	0.000	0.001	0.000
	(0.026)	(0.011)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
ψ_{3j}	-0.416	0.076	0.224	0.007	0.017	-0.003	0.000
	(0.705)	(0.106)	(0.078)	(0.040)	(0.011)	(0.004)	(0.000)
ψ_{4j}	-0.418	0.062	0.028	0.142	0.016	-0.010	0.000
	(0.578)	(0.116)	(0.022)	(0.060)	(0.028)	(0.006)	(0.000)
ψ_{5j}	0.013	0.021	0.007	0.012	0.026	-0.004	0.000
	(0.066)	(0.013)	(0.002)	(0.005)	(0.019)	(0.002)	(0.000)
ψ_{6j}	-1.433	-0.212	0.286	0.149	0.239	0.272	-0.001
	(3.102)	(0.724)	(0.178)	(0.286)	(0.176)	(0.130)	(0.001)
ψ_{7j}	-17466.485	591.551	1227.792	3658.776	-1960.231	325.119	10.291
	(39158.216)	(4969.109)	(1253.596)	(4516.374)	(3488.414)	(888.037)	(8.760)
ψ_{8j}	8292.706	-3288.719	-343.369	-3722.739	-4257.080	-955.265	-12.624
	(24426.159)	(4987.487)	(1089.926)	(2565.389)	(1967.394)	(645.444)	(6.691)
ψ_{9j}	3066.385	-70.099	0.020	145.019	-271.324	-44.930	-0.518
	(2384.999)	(275.403)	(70.047)	(103.476)	(100.569)	(56.906)	(0.576)
$\psi_{10,j}$	35716.459	1967.568	-493.583	-1882.323	7661.659	110.023	-27.057
	(45685.865)	(6500.959)	(2296.494)	(5381.444)	(4303.024)	(1456.217)	(10.990)
$\psi_{11,j}$	-1839.449	1245.668	171.149	-515.618	4408.011	226.629	-0.748
	(5405.111)	(999.119)	(242.323)	(357.303)	(1158.255)	(115.620)	(1.982)
$\psi_{12,j}$	362.670	-115.373	279.562	1161.909	-1778.593	52.393	1.733
	(4007.665)	(862.816)	(244.766)	(612.517)	(609.687)	(112.130)	(1.132)
$\psi_{13,j}$	-141.711	-45.123	-31.511	-69.586	6.695	3.088	-0.136
	(189.788)	(36.644)	(14.050)	(26.563)	(26.143)	(5.189)	(0.076)
ϕ_{jj}	0.054	0.051	0.004	0.071	0.002	0.062	0.002
	(0.036)	(0.036)	(0.001)	(0.030)	(0.001)	(0.030)	(0.001)
$\bar{\eta}_j$	0.500	0.600	0.050	0.260	0.050	0.500	0.050
	(a)	(a)	(a)	(a)	(a)	(a)	(a)
$\phi_{jj}/\bar{\eta}_j$	0.108	0.085	0.072	0.273	0.036	0.124	0.033
	(0.072)	(0.060)	(0.025)	(0.116)	(0.026)	(0.059)	(0.028)

(a) Assumed value.

Table 8 (cont).

	Wheat & Other Flours (j = 8)	Beer (j = 9)	Margarine (j = 10)	Bread (j = 11)	Cakes & Biscuits (j = 12)	Other Foods (j = 13)
κ_{j0}	330.583	172.686	167.213	169.701	161.140	119.560
	(6.914)	(6.323)	(3.559)	(10.989)	(5.222)	(1.583)
ψ_{1j}	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{2j}	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{3j}	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{4j}	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{5j}	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_{6j}	-0.001	0.001	0.000	-0.001	-0.002	-0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
ψ_{7j}	-7.845	19.353	5.188	7.731	-10.442	30.771
	(9.641)	(19.830)	(4.872)	(17.790)	(8.902)	(19.485)
ψ_{8j}	15.124	-0.926	-8.702	-17.660	-4.209	-19.370
	(7.425)	(9.341)	(3.108)	(12.264)	(9.310)	(11.794)
ψ_{9j}	0.042	5.633	0.279	2.410	-0.033	4.924
	(0.201)	(2.986)	(0.439)	(1.368)	(0.483)	(1.743)
$\psi_{10,j}$	-6.056	-16.938	7.042	3.178	20.000	7.421
	(8.799)	(16.994)	(5.110)	(20.382)	(10.563)	(23.005)
$\psi_{11,j}$	5.238	15.819	2.720	20.124	19.958	26.402
	(1.504)	(5.990)	(1.252)	(5.571)	(4.184)	(6.381)
$\psi_{12,j}$	3.232	-1.077	-0.012	-2.166	2.407	-8.276
	(0.966)	(2.173)	(0.832)	(2.395)	(1.620)	(2.898)
$\psi_{13,j}$	-0.213	-0.441	0.010	-0.357	-0.250	0.168
	(0.045)	(0.110)	(0.050)	(0.168)	(0.126)	(0.142)
ϕ_{jj}	0.025	0.034	0.019	0.078	0.016	0.010
	(0.012)	(0.018)	(0.014)	(0.022)	(0.011)	(0.008)
$\bar{\eta}_j$	0.500	0.500	0.500	0.500	0.500	0.500
	(a)	(a)	(a)	(a)	(a)	(a)
$\phi_{jj}/\bar{\eta}_j$	0.050	0.068	0.039	0.156	0.033	0.020
	(0.025)	(0.036)	(0.028)	(0.043)	(0.022)	(0.017)

(a) Assumed value.

APPENDIX A. SELECTED ANZSIC CLASSIFICATIONS

2140 Oil and Fat Manufacturing

This class consists of units mainly engaged in manufacturing crude vegetable or marine oils, fats, cake or meal, margarine, compound cooking oils or fats, blended table or salad oils, or refined or hydrogenated oils or fats not elsewhere classified (n.e.c.).

Exclusions / References
Units mainly engaged in:
(a) manufacturing unrefined animal oils or fats (except neatsfoot oil) or in rendering tallow or lard are included in Class 2111 Meat Processing; and
(b) distilling or refining essential oils are included in Class 2549 Chemical Product Mfg n.e.c.

Primary Activities
Manufacturing of: Animal oils, refined; Cotton linters; Deodorised vegetable oils; Edible oils or fats, blended; Fish or other marine animal oils or meal; Lard, refined; Margarine; Tallow, refined; Vegetable oil, meal or cake.

2151 Flour Mill Product Manufacturing

This class consists of units mainly engaged in milling flour, (except rice flour) or in manufacturing cereal starch, gluten, starch sugars or arrowroot.

Exclusions / References
Units mainly engaged in:
(a) manufacturing milled rice, rice flour, meal or offal, hulled or shelled oats, oatmeal for human consumption, prepared cereal breakfast foods or self-raising flour are included in Class 2152 Cereal Food and Baking Mix Manufacturing;
(b) manufacturing prepared animal or bird foods from cereals, or in manufacturing cereal meal, grain offal or crushed grain for use as fodder (from whole grain, except from rice or rye) are included in Class 2174 Prepared Animal and Bird Feed Manufacturing; and
(c) repacking flour or cereal foods are included in Class 4719 Grocery Wholesaling n.e.c.

Primary Activities
Manufacturing of: Arrowroot; Atta flour; Barley meal or flour (for human consumption; except prepared breakfast food); Bran, wheaten (except prepared breakfast food); Cornflour; Dextrin; Dextrose; Flour, wheat (except self-raising flour); Glucose; Gluten; Pollard (from wheat, barley or rye); Rye flour, meal or offal (except prepared breakfast food); Sausage binder or similar meal (from wheat); Semolina; Starch; Starch sugars; Wheat germ; Wheat meal (for human consumption; except prepared breakfast food).

2152 Cereal Food and Baking Mix Manufacturing

This class consists of units mainly engaged in manufacturing prepared cereal breakfast foods, pasta, milled rice, rice flour, meal or offal, hulled or shelled oats, oatmeal for human consumption, self-raising flour, prepared baking mixes, jelly crystals or custard powder.

Exclusions / References
Units mainly engaged in:
(a) manufacturing prepared animal or bird foods from cereals, or in manufacturing cereal meal, grain offal or crushed grain for use as fodder (from whole grain, except from rice or rye) are included in Class 2174 Prepared Animal and Bird Feed Manufacturing; and

(b) repacking cereal food products are included in Class 4719 Grocery Wholesaling n.e.c.

Primary Activities
Manufacturing of: Baking mixes, prepared; Baking powder; Batter mixes; Bread dough, frozen; Bread mixes, dry; Cake mixes; Cereal breakfast foods, prepared; Cereal foods n.e.c.; Crumbs (made from cereal food; except biscuit or bread-crumbs); Custard powder; Desserts, prepared (in dry form) n.e.c.; Farina; Jelly crystals; Milled rice; Oatmeal (for human consumption); Oats, hulled or shelled; Oats, kilned or unkilned; Pasta; Pastry dough, frozen; Pastry mixes; Pizza mix; Rice flour, meal or offal; Rice (except fried); Sago; Scone mixes; Self-raising flour; Tapioca.

2161 Bread Manufacturing

This class consists of units mainly engaged in manufacturing bread.

Exclusions / References
Units mainly engaged in selling to the public bread baked on the same premises are included in Class 5124 Bread and Cake Retailing. Units mainly engaged in manufacturing unleavened bread are included in Class 2163 Biscuit Manufacturing.

Primary Activities
Bread bakery operation; Manufacturing of: Breadcrumbs; Bread rolls; Fruit loaf; Leavened bread.

2162 Cake and Pastry Manufacturing

This class consists of units mainly engaged in manufacturing cakes, pastries, pies or similar bakery products (including canned or frozen bakery products).

Exclusions / References
Units mainly engaged in selling cakes or pastries, produced on their premises, directly to the general public are included in Class 5124 Bread and Cake Retailing.

Primary Activities
Cake icing or decorating; Manufacturing of: Cakes or pastries; Crumpets; Doughnuts; Fruit or yoghurt slices; Meat pies; Pastry (except frozen pastry dough); Pies; Plum pudding.

2163 Biscuit Manufacturing

This class consists of units mainly engaged in manufacturing biscuits (including unleavened bread).

Exclusions / References
Units mainly engaged in:
(a) manufacturing dog biscuits are included in Class 2174 Prepared Animal and Bird Feed Manufacturing; and
(b) manufacturing hot bake biscuits or cookies for sale on the same premises to the public are included in Class 5124 Bread and Cake Retailing.

Primary Activities
Manufacturing of: Biscuit crumbs; Biscuits (except dog biscuits); Ice cream cones or wafers; Rusks; Unleavened bread.

2171 Sugar Manufacturing

2173 Seafood Processing

2174 Prepared Animal and Bird Feed Manufacturing

This class consists of units mainly engaged in manufacturing prepared animal or bird feed, including cereal meal, grain offal or crushed grain for use as fodder (from whole grain, except from rice or rye).

Exclusions / References
Units mainly engaged in:
(a) slaughtering animals for pet food are included in Class 2111 Meat Processing;
(b) manufacturing animal feeds prepared from dried skim milk powder are included in Class 2129 Dairy Product Manufacturing n.e.c.;
(c) manufacturing crushed rye, or rye flour, meal or offal for use as fodder are included in Class 2151 Flour Mill Product Manufacturing; and
(d) manufacturing crushed rice, or rice flour, meal or offal for use as fodder are included in Class 2152 Cereal Food and Baking Mix Manufacturing.

Primary Activities
Manufacturing of: Animal feed, prepared (except uncanned meat or bone meal or protein enriched skim milk powder); Animal food, canned; Bird feed; Cattle lick; Cereal meal (for fodder; except from rice or rye); Chaff; Crushed grain (including mixed; for fodder); Dehydrated lucerne; Dog biscuits; Fodder, prepared; Grain offal (for fodder; except from rice or rye); Lucerne cubes; Lucerne meal; Pet food, canned; Poultry feed, prepared; Sheep lick.

2179 Food Manufacturing n.e.c.

This class consists of units mainly engaged in manufacturing food products n.e.c. (including snack foods and prepared meals).

Exclusions / References
Units mainly engaged in:
(a) manufacturing sugar are included in Class 2171 Sugar Manufacturing;
(b) refining salt for industrial purposes are included in Class 2535 Inorganic Industrial Chemical Manufacturing n.e.c.;
(c) egg pulping or drying are included in Class 4719 Grocery Wholesaling n.e.c.; and
(d) blending or packing tea are included in Class 4719 Grocery Wholesaling n.e.c.

Primary Activities
Manufacturing of: Coffee; Corn chips; Dessert mixes, liquid; Flavoured water packs (for freezing into flavoured ice); Flavourings, food; Food colourings; Food dressings; Food n.e.c.; Ginger product (except confectionery); Herbs, processed; Honey, blended; Hop extract, concentrated; Ice (except dry ice); Meat or ham pastes; Nut foods (except candied); Pearl barley; Potato crisps; Pre-prepared meals n.e.c.; Pretzels; Rice preparations n.e.c.; Salt, cooking or table; Savoury specialities; Seasonings, food; Soya bean concentrates, isolates or textured protein; Spices; Taco, tortilla and tostada shells; Tea; Yeast or yeast extract.

2182 Beer and Malt Manufacturing

This class consists of units mainly engaged in manufacturing, bottling or canning beer, ale, stout or porter, or manufacturing malt.

Exclusions / References
Units mainly engaged in manufacturing malt extract or malted milk powder are included in Class 2129 Dairy Product Manufacturing n.e.c.

Primary Activities
Manufacturing of: Barley malt; Beer (except non-alcoholic beer); Malt (except malt extract); Oaten malt; Porter; Wheaten malt.

5110 Supermarket and Grocery Stores

This class consists of units mainly engaged in retailing groceries or non-specialised food lines, whether or not the selling is organised on a self-service basis.

Primary Activities
Groceries retailing; Grocery supermarket operation.

5124 Bread and Cake Retailing

This class consists of units mainly engaged in retailing bread, cakes, pastries or biscuits. This class includes units that bake bread, cake, pastries or biscuits on the premises for sale to the final consumer.

Exclusions / References
Units mainly engaged in baking bread, cakes, pastries or biscuits are included in Group 216 Bakery Product Manufacturing.

Primary Activities
Biscuits retailing; Bread retailing; Bread vendors; Cakes retailing; Pastries retailing.

5125 Takeaway Food Retailing

This class consists of units mainly engaged in retailing food ready to be taken away for immediate consumption.

Exclusions / References
Units mainly engaged in selling prepared meals for consumption on the premises are included in Group 573 Cafes and Restaurants.

Primary Activities
Retailing of: Chicken, take away (cooked, ready to eat); Cut lunches; Fish and chips, take away (cooked, ready to eat); Hamburgers (cooked, ready to eat); Ice cream (for immediate consumption); Milk drinks (for immediate consumption); Pizza, take away (cooked, ready to eat); Soft drinks (for immediate consumption); Take away foods (cooked ready to eat).

5720 Pubs, Taverns and Bars

This class consists of hotels, bars or similar units (except licensed clubs) mainly engaged in selling alcoholic beverages for consumption on the premises, or in selling alcoholic beverages both for consumption on and off the premises (e.g. from bottle shops located at such premises).

Exclusions / References
Units mainly engaged in:

(a) retailing alcoholic beverages for consumption off the premises are included in Class 5123 Liquor Retailing; and
(b) operating licensed clubs are included in Class 5740 Clubs (Hospitality).

Primary Activities
Operation of: Bar (mainly drinking place); Hotel (mainly drinking place); Night club (mainly drinking place); Pub (mainly drinking place); Tavern (mainly drinking place); Wine bar (mainly drinking place).

5730 Cafes and Restaurants

This class consists of units mainly engaged in providing meals for consumption on the premises.

Exclusions / References
Units which are mainly engaged in:
(a) retailing ready to eat food in take away containers are included in Class 5125 Takeaway Food Retailing;
(b) selling alcoholic beverages for consumption on the premises (except clubs) are included in Class 5720 Pubs, Taverns and Bars; and
(c) operating hospitality clubs are included in Group 574 Clubs (Hospitality).

Primary Activities
Operation of: Cafe; Catering service; Restaurant.

5740 Clubs (Hospitality)

This class consists of associations mainly engaged in providing hospitality services to members. These units also may provide gambling, sporting or other social or entertainment facilities.

Primary Activities
Club operation (hospitality); Licensed club operation.

APPENDIX B. EXTENSION OF THE RAPER ET AL. MODEL

Consider an *upstream firm* (or group of firms) that uses an M × 1 vector of inputs, **z**, to produce a J × 1 vector of outputs, $\mathbf{y}_u$, for sale to a downstream firm. The profit maximisation problem of this upstream firm is:

$$(1)\quad \max_{\mathbf{y}_u}\ \mathbf{p}_u'\mathbf{y}_u - C_u(\mathbf{y}_u, \mathbf{w})$$

where $\mathbf{p}_u$ is a vector of output prices, **w** is a vector of input prices and $C_u(\mathbf{y}_u, \mathbf{w})$ is the cost function of the upstream firm (specifying the minimum cost of producing output $\mathbf{y}_u$ at prices **w**). Following Raper *et al*, assume

$$(2)\quad \frac{\partial p_{uj}}{\partial y_{ui}} = 0 \qquad \text{for all } j \neq i.$$

so that the first-order conditions for profit maximisation become

$$(3)\quad \frac{\partial p_{uj}}{\partial y_{uj}} y_{uj} + p_{uj} - \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}} = 0 \qquad \text{for } j = 1, ..., J.$$

If the upstream firm is competitive in all markets then (3) collapses to:

$$(4)\quad p_{uj} - \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}} = 0 \qquad \text{for } j = 1, ..., J$$

which, in the case of J = 1 (and if the derivative is taken to the right-hand-side) is the firms inverse output supply equation (see Raper *et al*). A model which includes (3) and (4) as special cases would take the form:

$$(5)\quad \lambda_{mj}\left[\frac{\partial p_{uj}}{\partial y_{uj}} y_{uj}\right] + p_{uj} - \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}} = 0 \qquad \text{for } j = 1, ..., J$$

where $0 \leq \lambda_{mj} \leq 1$ is a parameter which measures monopolistic market power.

Now consider a *downstream firm* (or group of firms) that produces a K × 1 vector of outputs, $\mathbf{y}_d$, using the intermediate goods produced by the upstream firm as its primary inputs, as well as an N × 1 vector of other inputs **x**. The profit maximisation problem of this downstream firm is:

$$(6)\quad \max_{\mathbf{y}_u, \mathbf{y}_d}\ \mathbf{p}_d'\mathbf{y}_d - C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u) - \mathbf{p}_u'\mathbf{y}_u$$

where $\mathbf{p}_d$ is a vector of output prices, **v** is a vector of input prices and $C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)$ is the cost function of the downstream firm (specifying the minimum cost of producing output $\mathbf{y}_d$ given prices **v** and "upstream" inputs $\mathbf{y}_u$). Once again, follow Raper *et al* and assume

$$(7)\quad \frac{\partial p_{dk}}{\partial y_{di}} = 0 \qquad \text{for all } k, i.$$

Then the first-order conditions for profit maximisation include the following:

$$(8)\ \frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}} + \frac{\partial p_{uj}}{\partial y_{uj}} y_{uj} + p_{uj} = 0 \qquad \text{f} \qquad \text{or } j = 1, ..., J$$

If the downstream firm is competitive in all markets then (8) collapses to:

$$(9)\ \frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}} + p_{uj} = 0 \qquad \text{for } j = 1, ..., J$$

Again, a model which includes (8) and (9) as special cases is:

$$(10)\ \frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}} + \lambda_{sj}[\frac{\partial p_{uj}}{\partial y_{uj}} y_{uj}] + p_{uj} = 0 \qquad \text{for } j = 1, ..., J$$

where $0 \leq \lambda_{sj} \leq 1$ is a parameter measuring monopsonistic market power.

In practice, it is not possible to estimate (5) because an expression for the deriviative $\frac{\partial p_{uj}}{\partial y_{uj}}$ is unavailable. However, if the downstram firm is competitive in all markets, equation (9) implies

$$P_{uj}(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u) = -\frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}},$$

so (5) can be written as:

$$(11) \lambda_{mj}[\frac{\partial P_{uj}(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}} y_{uj}] + p_{uj} - \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}} = 0 \qquad \text{for } j = 1, ..., J$$

Equation (11) can be estimated as a single equation model. Then tests of hypotheses concerning λ_{mj} are tests for the existence of monopolistic market power under the assumption that the downstream firm is competitive.

Continuing this line of reasoning, define $P_{uj}(\mathbf{y}_u, \mathbf{w}) = \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}}$. Then (10) can be written as

$$(12)\ \frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial y_{uj}} + \lambda_{sj}[\frac{\partial P_{uj}(\mathbf{y}_u, \mathbf{w})}{\partial y_{uj}} y_{uj}] + p_{uj} = 0 \qquad \text{for } j = 1, ..., J$$

If equation (12) is estimated as a single equation, tests of hypotheses concerning λ_{sj} become tests for the existence of monopsonistic market power under the assumption that the upstream firm is competitive.

Econometrically, estimation of (11) and (12) as single equations is inefficient. It is more efficient to estimate both equations jointly with the conditional input demand functions implied by Shephard's lemma. If the normalised cost functions are normalised quadratic, ie.,

$$(13)\ C_u^*(\mathbf{y}_u, \mathbf{w}) = \beta_0 + \sum_{j=1}^{J} \beta_{uj} y_{uj} + 0.5 \sum_{j=1}^{J}\sum_{k=1}^{J} \beta_{ujk} y_{uj} y_{uk} + \sum_{m=1}^{M-1} \beta_m w_m^* + 0.5 \sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \beta_{mn} w_m^* w_n^* + \sum_{j=1}^{J}\sum_{m=1}^{M-1} \gamma_{ujm} y_{uj} w_m^*$$

and

$$(14)\ C_d^*(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u) = \alpha_0 + \sum_{j=1}^{K} \alpha_{dj} y_{dj} + 0.5 \sum_{j=1}^{K}\sum_{k=1}^{K} \alpha_{djk} y_{dj} y_{dk} + \sum_{m=1}^{N-1} \alpha_m v_m^* + 0.5 \sum_{m=1}^{N-1}\sum_{n=1}^{N-1} \alpha_{mn} v_m^* v_n^* + \sum_{j=1}^{J} \alpha_{uj} y_{uj}$$

$$+ 0.5 \sum_{j=1}^{J}\sum_{k=1}^{J} \alpha_{ujk} y_{uj} y_{uk} + \sum_{j=1}^{K}\sum_{m=1}^{N-1} \phi_{djm} y_{dj} v_m^* + \sum_{j=1}^{K}\sum_{m=1}^{N-1} \phi_{ujm} y_{uj} v_m^* + \sum_{j=1}^{K}\sum_{k=1}^{K} \phi_{jk} y_{uj} y_{dk}$$

then the conditional input demands are

$$(15)\ z_m(\mathbf{y}_u, \mathbf{w}) = \frac{\partial C_u(\mathbf{y}_u, \mathbf{w})}{\partial w_m} = \beta_m + \sum_{n=1}^{M-1} \beta_{mn} w_n^* + \sum_{j=1}^{J} \gamma_{ujm} y_{uj} \qquad \text{for } m < M$$

and

$$(16)\ x_m = \frac{\partial C_d(\mathbf{y}_d, \mathbf{v}; \mathbf{y}_u)}{\partial v_m} = \alpha_m + \sum_{n=1}^{N-1} \alpha_{mn} v_n^* + \sum_{j=1}^{K} \phi_{djm} y_{dj} + \sum_{j=1}^{K} \phi_{ujm} y_{uj} \qquad \text{for } m < M$$

where $w_m^* = w_m/w_M$ and $v_n^* = v_n/v_N$. Moreover, (11) and (12) can be written:

$$(17)\ p_{uj}^* = \lambda_{mj} \alpha_{ujj} (v_N/w_M) y_{uj} + \beta_{uj} + \sum_{k=1}^{J} \beta_{ujk} y_{uk} + \sum_{m=1}^{M-1} \gamma_{ujm} w_m^*$$

and

$$(18)\ p_{tj}^* = - \lambda_{sj} \beta_{ujj} (w_M/v_N) y_{uj} - \alpha_{uj} - \sum_{k=1}^{J} \alpha_{ujk} y_{uk} - \sum_{m=1}^{N-1} \phi_{ujm} v_m^* - \sum_{k=1}^{K} \phi_{jk} y_{dk}$$

where $p_{uj}^* = p_{uj}/w_M$ and $p_{tj}^* = p_{uj}/v_N$. The form of these equations is (almost) identical to a set of equilibrium tobacco producer and manufacturer equations reported in Raper *et al.* (p. 242).

Finally, if any inputs are fixed rather than variable, normalised input prices should be replaced with fixed input quantities on the right-hand-sides of equations (17) and (18).

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