Food Processor/ Retailer Market Power in Input Markets

The Australian Grains and Oilseeds Industries

A report for the Rural Industries Research and Development Corporation

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Foreword

The nature of competition in food processing and marketing industries has become an important area of policy interest and economics research in Australia. 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. These industries have been "on the radar" of the regulatory authorities for some time. The Prices Surveillance Authority and more recently the Australian Competition and Consumer Commission have brought actions against firms in this sector over the past decade for price fixing or other types of non-competitive behaviour.

The aim of this project was to re-examine earlier empirical results developed in RIRDC project UNE-67A by 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. Official statistics from the Australian Bureau of Statistics are used to define the structure of the relevant industries and to implement the model for thirteen grains and oilseeds products handled by seven groups of agents.

This publication considers some of the features of the grains and oilseeds sector in Australia and develops a new theoretical model of firm behaviour in this sector that accounts for these industry characteristics. The data used to implement the model are described and the results of the estimation are reported and discussed.

This project was funded from RIRDC Core Funds that are provided by the Australian Government.

This report, an addition to RIRDC’s diverse range of over 1200 research publications, forms part of our Global Competitiveness R&D program. This program aims to identify important impediments to the development of a globally competitive Australian agricultural sector and support research that will lead to options and strategies that will remove these impediments.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- purchases at www.rirdc.gov.au/eshop

Peter O’Brien
Managing Director
Rural Industries Research and Development Corporation
Acknowledgments

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The authors take full responsibility for any errors or omissions.

Abbreviations

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 Surveillance Authority
SCP  the Structure-Conduct-Performance paradigm of industrial organization
SUR  Seemingly Unrelated Regression
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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 Surveillance 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 surveillance 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 to 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. Further, there was no consistent evidence of market power in the purchase of canola by oil and fat manufacturers or in the sale of margarine to consumers. These results are contrary to those found by Griffith where there was significant evidence of departures from competition in the purchase of oilseeds from farmers.

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).
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 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 Surveillance Authority (PSA 1994) determined that the markets for products contained in the "Breakfast Cereals" and "Cooking Oils and Fats" price indexes were “not effectively competitive” (p.14). The PSA consequently maintained price surveillance 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 (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

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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 consequently, firm performance (eg. profits, margins). SCP models have a much looser foundation in economic theory than NEIO models.
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).
2. Objectives and Outline

Following on from these background considerations, in this study our objective is to 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. 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.
3. 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 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 of the companion technical report (O'Donnell et al. 2004). 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, rusk 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).
Figure 1. Basic Structure of Grains and Oilseeds Product Supply Chain
Table 1. Product Supplies and Exports by IOPC Item: 1996-97 ($million)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Australian Production (1)</th>
<th>Competing Imports cif (2)</th>
<th>Total (1)+(2)</th>
<th>Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>0102</td>
<td>Grains</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Wheat and meslin, unmilled</td>
<td>4362.2</td>
<td>0.6</td>
<td>4362.8</td>
<td>2,999.5</td>
</tr>
<tr>
<td></td>
<td>*Barley, unmilled</td>
<td>1070.7</td>
<td>-1070.7</td>
<td>-</td>
<td>0.1257.4</td>
</tr>
<tr>
<td></td>
<td>Oats, unmilled</td>
<td>193.8</td>
<td>-</td>
<td>193.8</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>*Rice, in the husk</td>
<td>257.3</td>
<td>0.4</td>
<td>207.7</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Grain sorghum</td>
<td>200.3</td>
<td>-</td>
<td>200.3</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>*Oilseeds</td>
<td>289.3</td>
<td>40.2</td>
<td>329.5</td>
<td>112.8</td>
</tr>
<tr>
<td></td>
<td>Legumes for grain nec</td>
<td>420.5</td>
<td>0.3</td>
<td>420.7</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Cereal grains nec</td>
<td>207.3</td>
<td>0.4</td>
<td>207.7</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>7,001.5</td>
<td>41.7</td>
<td>7043.2</td>
<td>3,907.6</td>
</tr>
<tr>
<td>2104</td>
<td>Oils and Fats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crude vegetable oils</td>
<td>158.8</td>
<td>114.3</td>
<td>273.0</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Oil cake and other solid residues</td>
<td>n.a.</td>
<td>83.0</td>
<td>n.a.</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>*Refined/processed animal/vegetable oils</td>
<td>356.4</td>
<td>184.8</td>
<td>541.3</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>Acid oils from refining animal/vegetable oils</td>
<td>n.a.</td>
<td>13.0</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>*Margarine</td>
<td>260.8</td>
<td>2.9</td>
<td>263.7</td>
<td>69.6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>848.3</td>
<td>398.0</td>
<td>1246.3</td>
<td>119.1</td>
</tr>
<tr>
<td>2105</td>
<td>Flour Mill Products and Cereal Foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Wheat and other cereal flours (exc l self raising)</td>
<td>755.0</td>
<td>4.0</td>
<td>759.0</td>
<td>54.8</td>
</tr>
<tr>
<td></td>
<td>Cereal (exc rice) groats etc. for human consumption</td>
<td>12.4</td>
<td>1.2</td>
<td>13.6</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>Wheat bran for humans (exc for breakfast foods)</td>
<td>13.7</td>
<td>1.2</td>
<td>14.9</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Flour mill products nec, for human consumption</td>
<td>77.5</td>
<td>1.7</td>
<td>79.2</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Starch of wheat and corn</td>
<td>153.5</td>
<td>13.8</td>
<td>167.4</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Glucose, glucose syrup &amp; modified starches</td>
<td>129.7</td>
<td>19.4</td>
<td>149.1</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>Wheat gluten</td>
<td>98.5</td>
<td>2.3</td>
<td>100.8</td>
<td>46.3</td>
</tr>
<tr>
<td></td>
<td>*Cereal foods (incl breakfast foods)</td>
<td>817.5</td>
<td>51.7</td>
<td>869.2</td>
<td>57.3</td>
</tr>
<tr>
<td></td>
<td>Flour (self raising)</td>
<td>20.3</td>
<td>0.2</td>
<td>20.4</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Prepared baking powders, jelly crystals etc.</td>
<td>n.a.</td>
<td>79.9</td>
<td>n.a.</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Rice, semi-milled or wholly milled</td>
<td>n.a.</td>
<td>39.0</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Rice, husked but not further prepared</td>
<td>n.a.</td>
<td>0.1</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Rice groats; other worked cereal grains etc.</td>
<td>n.a.</td>
<td>27.8</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Rice bran, sharps and other residues</td>
<td>38.1</td>
<td>-</td>
<td>38.1</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Pasta</td>
<td>175.8</td>
<td>54.6</td>
<td>230.5</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>12.1</td>
<td>-</td>
<td>12.1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Increase in stocks</td>
<td>0.9</td>
<td>-</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>3172.9</td>
<td>269.9</td>
<td>3462.7</td>
<td>542.1</td>
</tr>
<tr>
<td>2106</td>
<td>Bakery Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Bread and bread rolls</td>
<td>1393.0</td>
<td>49.5</td>
<td>1442.4</td>
<td>42.0</td>
</tr>
<tr>
<td></td>
<td>Meat pies</td>
<td>242.5</td>
<td>10.3</td>
<td>252.8</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>*Cakes, pastries and crumpets</td>
<td>725.5</td>
<td>93.6</td>
<td>819.1</td>
<td>37.8</td>
</tr>
<tr>
<td></td>
<td>*Biscuits, biscuit crumbs, rusks etc, unleavened bread</td>
<td>702.5</td>
<td>124.6</td>
<td>827.1</td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>Increase in stocks</td>
<td>1.7</td>
<td>-</td>
<td>1.7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>3065.2</td>
<td>278.0</td>
<td>3343.2</td>
<td>187.8</td>
</tr>
<tr>
<td>2108</td>
<td>Other Food Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Raw Sugar</td>
<td>1876.6</td>
<td>0.7</td>
<td>1877.3</td>
<td>1226.1</td>
</tr>
<tr>
<td></td>
<td>*Prepared animal and bird feeds nec</td>
<td>1332.0</td>
<td>15.8</td>
<td>1347.9</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td>Dog and cat food, canned</td>
<td>535.6</td>
<td>31.9</td>
<td>567.5</td>
<td>121.0</td>
</tr>
<tr>
<td></td>
<td>Potato crisps and flakes</td>
<td>603.4</td>
<td>0.1</td>
<td>603.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>4774.9</td>
<td>1212.9</td>
<td>5987.8</td>
<td>1175.3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>9122.5</td>
<td>1261.4</td>
<td>10383.9</td>
<td>2424.7</td>
</tr>
<tr>
<td>2110</td>
<td>Beer and Malt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Beer, ale and stout, bottled</td>
<td>1157.6</td>
<td>76.0</td>
<td>1233.6</td>
<td>125.8</td>
</tr>
<tr>
<td></td>
<td>*Beer, ale and stout, canned</td>
<td>547.4</td>
<td>46.5</td>
<td>593.9</td>
<td>90.7</td>
</tr>
<tr>
<td></td>
<td>*Beer, ale and stout, bulk</td>
<td>392.4</td>
<td>21.5</td>
<td>413.9</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Malt (exc malt extract)</td>
<td>250.8</td>
<td>0.6</td>
<td>251.4</td>
<td>108.3</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>19.0</td>
<td>-</td>
<td>19.0</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>2387.5</td>
<td>144.6</td>
<td>2532.1</td>
<td>338.8</td>
</tr>
</tbody>
</table>

Source: ABS 5215.0  nec not elsewhere classified  n.a. not applicable
4. 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 notation used in describing the model is as follows. The vector of outputs of firm \( n \) is denoted as \( y_n = (y_{n1}, ..., y_{nM})' \); the vector of inputs is \( x_n = (x_{n1}, ..., x_{nK})' \); aggregate outputs and inputs are \( Y = \Sigma y_n \equiv (Y_1, ..., Y_M)' \) and \( X = \Sigma x_n \equiv (X_1, ..., X_K)' \); the output price vector is \( p = (p_1, ..., p_M)' \); and the input price vector is \( w = (w_1, ..., w_K)' \). We assume each firm may exercise some market power in the sale of outputs and/or the purchase of inputs.

First, we define demand functions for outputs and supply functions for inputs respectively in the usual way:

\[
(1) \quad Y_i = D_i(p, v), \quad i = 1, ..., M,
\]
and

\[
(2) \quad X_j = S_j(w, z) \quad j = 1, ..., K,
\]

where \( v \) and \( z \) are vectors of exogenous variables.

Then we set up the profit maximisation problem for firm \( n \) in two alternative but equivalent ways (see Chambers 1988, p.268):

\[
(3) \quad \max_{y_n} \sum_{i=1}^{M} p_i y_{ni} - c_n(w, y_n) - \kappa_n
\]
and

\[
(4) \quad \max_{x_n} r_n(p, x_n) - \sum_{j=1}^{K} w_j x_{nj} - \kappa_n
\]

where \( \kappa_n \) represents fixed costs, \( c_n(w, y_n) \) is the minimum cost of producing output vector \( y_n \) given input prices \( w \), and \( r_n(p, x_n) \) is the maximum revenue that can be obtained from input vector \( x_n \) given output prices \( p \). The first-order optimisation conditions associated with (3) and (4) can be derived and then re-written in terms of conjectural and price elasticities:

\[
(5) \quad p_i + (1/y_{ni}) \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j y_{nj} \theta_{nki}/\varepsilon_{kj}) = \frac{\partial c_n(w, y_n)}{\partial y_{ni}}
\]
and

\[
(6) \quad w_i + (1/x_{ni}) \sum_{j=1}^{K} (w_j x_{nj} \phi_{nji}/\eta_j) = \frac{\partial r_n(p, x_n)}{\partial x_{ni}}
\]

where the term \( \theta_{nki} \) is the conjectural elasticity indicating the belief of firm \( n \) about how aggregate output of product \( k \) responds to its own output of product \( i \), the term \( \phi_{nji} \) is the conjectural elasticity indicating the belief of firm \( n \) about how aggregate demand for input \( j \) responds to its own demand for input \( i \), the term \( \varepsilon_{ki} \) is the \( j \)-th price elasticity of demand for product \( k \), and the term \( \eta_j \) is the own-price elasticity of supply of input \( j \).

\[\text{2 The technical details of these manipulations are reported in the companion technical report (O’Donnell et al. 2004).}\]
Heuristically, equation (5) can be interpreted as:

\[(5') \text{Output price} = \text{marginal cost} - \left[ (\text{output price}) \times (\text{output market power parameters}) \right. \left/ \text{(elasticities of demand)} \right] \]

and equation (6) can be interpreted as:

\[(6') \text{Input price} = \text{marginal revenue} - \left[ (\text{input price}) \times (\text{input market power parameters}) \right. \left/ \text{(elasticities of supply)} \right] \]

The values of the conjectural elasticities can be used to identify the two polar cases of market power.

If the market power parameters are zero, that is \(\theta_{nki} = \phi_{nji} = 0\), then equations (5) and (6) collapse to the well-known set of first-order conditions for a perfectly competitive market, i.e., to maximise profit, set quantity of output such that output price equals the marginal cost of producing another unit of output, and set input quantity such that input price equals the marginal revenue achieved from using another unit of input.

If the market power parameters are unity, that is \(\theta_{nii} = \phi_{nii} = 1\) and \(\theta_{nki} = \phi_{nki} = 0\), then equations (5) and (6) collapse to the well-known set of first-order conditions for a monopoly and monopsony respectively. The aim of our empirical work is to test whether the equilibrium conjectural elasticities, \(\theta_{nki}\) and \(\phi_{nji}\), are zero, or not, thus implying perfectly competitive markets, or not.

Finally, (5) and/or (6) collapse to the perfectly competitive first-order conditions if the elasticities of supply and/or demand are very large, that is if \(|\epsilon_{kj}| \to \infty\) and/or \(|\eta_{j}| \to \infty\). 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.

O’Donnell et al. (2004) show how these characterisations of the behaviour of individual firms can be transformed into equations that may be estimated using industry-level data. We end up with industry-level price equations of the form:

\[(7) \quad p_i = h(w) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j \theta_{ki} / \epsilon_{kj})(Y_j / Y_i) \]

and

\[(8) \quad w_i = f(p) - \sum_{j=1}^{K} (w_j \phi_{ji} / \eta_j)(X_j / X_i). \]

Equations (7) and (8) are the backbone of the empirical model used in this project, and again, we are wishing to test whether the equilibrium conjectural elasticities, \(\theta_{ki}\) and \(\phi_{ji}\), are zero or not. Further, given that our data are likely to be annual and that we are interested in equilibrium behaviour, it is likely that prices and quantities are simultaneously determined. Thus, unless we decide otherwise (see section below), we estimate the price equations (7) and (8) jointly with their respective quantity equations (1) and (2), for each output and input of interest.
5. 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. 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 (e.g., 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. In this section we describe the inputs and outputs of each of these groups.

We will outline the empirical model for the first couple of groups of agents in some detail. 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 \((K+M, \text{for both price and quantity})\). However, as noted above, grains and oilseeds producers are assumed to be price-takers in all input markets (i.e., \( \phi_{nji} = 0 \)), implying no need to estimate any input equations of the form given by (2) and (8). Thus, the behaviour of grains and oilseeds producers is modelled using the 12 output equations given by equations (1) and (7) for each of \( i = 1, ..., 6 \).

The full model for grains and oilseeds producers is therefore:

\[
(1) \ Y_i = D_i(p_n, v), \quad i = 1, ..., 6 \\
\text{and} \\
(7) \ p_i = h_i(w) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j \theta_{ki}/\epsilon_{kj})(Y_j/Y_i), \quad i,j,k = 1, ..., 6.
\]

As another example, 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 (8) 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 (7) for \( i = 1 \) and 2, input equations (2) and (8) for \( j = 1, 2, 4 \) and 5, and input equation (8) for \( j = 3 \).

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

\[
(1) \ Y_i = D_i(p_n, v), \quad i = 1, 2 \\
(2) \ X_j = S_j(w_j, z), \quad j = 1, 2, 4, 5 \\
(7) \ p_i = h_i(w) - \sum_{j=1}^{M} \sum_{k=1}^{M} (p_j \theta_{ki}/\epsilon_{kj})(Y_j/Y_i), \quad i,j,k = 1, 2 \\
\text{and} \\
(8) \ w_i = f_i(p) - \sum_{j=1}^{K} (w_j \phi_{ji}/\eta)(X_j/X_i), \quad i,j,k = 1, ..., 5.
\]

Advice from the industry steering committee was particularly helpful in making these choices.

Thus, it is a major extension of the earlier model proposed in Griffith and O’Donnell (2002).
1. Grains and Oilseeds
   Agents: producers
   Inputs: labour; capital; materials; land
   Outputs: wheat; barley; canola; oats; grain sorghum; triticale

2. Flour and Cereal Foods
   Agents: traders; processors; retailers & distributive trades
   Inputs: wheat; barley; canola; oats; triticale; labour; plant and machinery; other inputs
   Outputs: wheat and other cereal flours; cereal foods including breakfast foods

3. Beer and Malt
   Agents: traders; processors; retailers & distributive trades
   Inputs: wheat; barley; labour; plant and machinery; other inputs
   Outputs: beer

4. Oils and Fats
   Agents: traders; processors; retailers & distributive trades
   Inputs: canola; labour; other inputs
   Outputs: margarine

5. Bakery Products
   Agents: traders; processors; retailers & distributive trades
   Inputs: flour; labour; plant and machinery; other inputs
   Outputs: bread; cakes and biscuits

6. Other Food Products
   Agents: traders; processors; retailers & distributive trades
   Inputs: wheat; barley; canola; oats; grain sorghum; triticale; labour; other inputs
   Outputs: other foods

7. Final Consumers
   Agents: households, export markets
   Inputs: wheat; barley; canola; oats; grain sorghum; triticale; wheat and other cereal flours; cereal foods including breakfast foods; beer; margarine; bread; cakes and biscuits; other foods
   Outputs: nil

Figure 2. Overview of Grains and Oilseeds Model
The estimating models for the other groups of agents can be set up in a similar manner (see O’Donnell et al. (2004) for details). Thus, 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 (7) for $i = 1$, and input equations (2) and (8) for $j = 1$ and 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 (7) for $i = 1$, and the input equation (8) for $j = 1$.

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 (7) for $i = 1$ and 2 and the input equation (8) for $j = 1$.

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 (7) for $i = 1$, input equations (2) and (8) for $j = 1, 2, 4,$ and $6$, and input equation (8) 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.

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 (8) for $j = 1,\ldots,13$.

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

For estimation purposes we assume that the demand and supply functions (1) and (2) and the price functions (7) and (8) are linear. This gives us equations of the form:

\[ Y_k = \gamma_k + \sum_{j=1}^{M} \gamma_{kj}p_j + \mu_k \sqrt{V} \quad k = 1, ..., M, \]

\[ X_j = \alpha_j + \alpha_jw_j \quad j = 1, ..., K, \]

\[ p_i = h_i(w) + \sum_{j=1}^{M} \sum_{k=1}^{M} \beta_{kji}Y_{kji} \quad i = 1, ..., M \]

and

\[ w_i = f_i(p) + \sum_{j=1}^{K} \psi_{ji}X_{ji} \quad i = 1, ..., K \]

where \( Y_{kji} = -Y_kY_j/Y_i \equiv Y_{jki}, \ X_{ji} = -X_jX_j/X_i \), \( \beta_{kji} = \theta_{ki}/\gamma_{kji} \) and \( \psi_{ji} = \phi_{ji}/\alpha_{ji} \). Estimates of \( \beta_{kji}, \gamma_{kji}, \psi_{ji} \) and \( \alpha_{ji} \) can be obtained by estimating equations (9) to (12) individually or as part of a seemingly unrelated regression (SUR) system of equations. Then estimates of the conjectural elasticities, \( \theta_{ki} \) and \( \phi_{ji} \), are obtained residually as \( \theta_{ki} = \beta_{kji}\gamma_{kji} \) and \( \phi_{ji} = \psi_{ji}\alpha_{ji} \).

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 estimating this constrained model are usually unsatisfactory (see O'Donnell et al. (2004) for details). However a Bayesian framework can be used satisfactorily. Empirical implementation of the Bayesian approach involves the use of Markov Chain Monte Carlo (MCMC) simulation methods. Details of how this procedure is applied can be found in Griffiths, O'Donnell and Tan Cruz (2000).

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, \( \kappa_n \), does not appear in the first-order conditions for profit maximisation given by equations (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.
7. Results

50,000 MCMC observations were drawn from the posterior probability density functions (pdfs) of the parameters using the statistics software package **GAUSS**. The means and standard deviations of these samples for the parameters of interest are reported in Tables 2 to 8 for the seven groups of agents in this sector<sup>5</sup>. Our primary interest is in the $\beta_{i\i}$ and $\psi_{j\j}$ parameters from equations (11) and (12) respectively – if these parameters are equal to zero then industry behaviour is consistent with perfect competition. Importantly, $\beta_{i\i} \to 0$ as $\theta_{i\i} \to 0$ and/or $|\varepsilon_{i\i}| \to \infty$ (that is, as the i-th output conjectural elasticity approaches zero and/or as the demand for the i-th output becomes perfectly own-price elastic). Likewise, $\psi_{j\j} \to 0$ as $\phi_{j\j} \to 0$ and/or $|\eta_{j\j}| \to \infty$ (that is, as the j-th input conjectural elasticity approaches zero and/or as the supply of the j-th input becomes perfectly own-price elastic). Thus, we are also interested in these "component" parameters, which are reported in the tables along with the (negative) Lerner index, a common measure of market power. This index is defined as $\theta_{i\i}/\varepsilon_{i\i}$ 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 $\phi_{j\j}/\eta_{j\j}$ 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 $\theta_{i\i}$ 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. Also, we need to remember that marketing boards for barley were in operation in several states over the period of the study, and so 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 $\theta_{i\i}$ 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 $\phi_{j\j}$ 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 $\phi_{j\j}$ coefficients in Table 3 for $j=1,2,4$ and 5),
- wheat and barley by beer and malt manufacturers (the $\phi_{j\j}$ coefficients in Table 4 for $j=1$ and 2), and
- wheat, barley, oats and triticale by other food product manufacturers (the $\phi_{j\j}$ coefficients in Table 7 for $j=1,2,4$ and 6).

<sup>5</sup> The full estimation results are reported in O'Donnell et al. (2004) for interested readers.
### Table 2. Parameter Estimates: Grains and Oilseeds Producers

<table>
<thead>
<tr>
<th></th>
<th>Wheat (i = 1)</th>
<th>Barley (i = 2)</th>
<th>Grain Canola (i = 3)</th>
<th>Oats (i = 4)</th>
<th>Sorghum (i = 5)</th>
<th>Triticale (i = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>0.136</td>
<td>0.028</td>
<td>0.003</td>
<td>0.111</td>
<td>0.004</td>
<td>0.028</td>
</tr>
<tr>
<td>(0.137)</td>
<td>(0.032)</td>
<td>(0.004)</td>
<td>(0.099)</td>
<td>(0.006)</td>
<td>(0.031)</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon_{ii}$</td>
<td>-2.966</td>
<td>-0.124</td>
<td>-0.220</td>
<td>-2.166</td>
<td>-0.228</td>
<td>-1.127</td>
</tr>
<tr>
<td>(0.427)</td>
<td>(0.124)</td>
<td>(0.351)</td>
<td>(0.312)</td>
<td>(0.207)</td>
<td>(0.835)</td>
<td></td>
</tr>
<tr>
<td>$\theta_{ii}/\varepsilon_{ii}$</td>
<td>0.046</td>
<td>0.233</td>
<td>0.014</td>
<td>0.051</td>
<td>0.021</td>
<td>0.031</td>
</tr>
<tr>
<td>(0.045)</td>
<td>(0.094)</td>
<td>(0.012)</td>
<td>(0.045)</td>
<td>(0.022)</td>
<td>(0.029)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Wheat &amp; Other Flours (i = 1)</th>
<th>Cereal Foods (i = 2)</th>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>0.010</td>
<td>φ_{ii} 0.180</td>
<td>0.121</td>
</tr>
<tr>
<td>0.015 (0.001)</td>
<td>(0.186)</td>
<td>(0.020)</td>
<td>(0.147)</td>
</tr>
<tr>
<td>$\varepsilon_{ii}$</td>
<td>-0.891</td>
<td>η_{ii} 1.092</td>
<td>1.092</td>
</tr>
<tr>
<td>(0.936)</td>
<td>(0.972)</td>
<td>(a) (0.972)</td>
<td></td>
</tr>
<tr>
<td>$\theta_{ii}/\varepsilon_{ii}$</td>
<td>0.015</td>
<td>φ_{ii}/η_{ii} 0.314</td>
<td>0.314</td>
</tr>
<tr>
<td>(0.015)</td>
<td>(0.393)</td>
<td>(0.433)</td>
<td>(0.393)</td>
</tr>
</tbody>
</table>

(a) Assumed value.

### Table 4. Parameter Estimates: Beer and Malt Manufacturers

<table>
<thead>
<tr>
<th></th>
<th>Beer Output</th>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>φ_{ii} 0.274</td>
<td>0.247</td>
</tr>
<tr>
<td>0.007 (0.007)</td>
<td>(0.243)</td>
<td>(0.241)</td>
</tr>
<tr>
<td>$\varepsilon_{ii}$</td>
<td>-1.951</td>
<td>η_{ii} 1.081</td>
</tr>
<tr>
<td>(0.455)</td>
<td>(0.802)</td>
<td>(0.509)</td>
</tr>
<tr>
<td>$\theta_{ii}/\varepsilon_{ii}$</td>
<td>0.004</td>
<td>φ_{ii}/η_{ii} 0.478</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.612)</td>
<td>(0.778)</td>
</tr>
</tbody>
</table>

15
Table 5. Parameter Estimates: Oil and Fat Manufacturers

<table>
<thead>
<tr>
<th>Margarine Output</th>
<th>Canola Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>$\phi_{ij}$</td>
</tr>
<tr>
<td>0.008</td>
<td>0.017</td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>$\bar{e}_i$</td>
<td>$\bar{\eta}_i$</td>
</tr>
<tr>
<td>-2.804</td>
<td>0.050</td>
</tr>
<tr>
<td>(0.684)</td>
<td>(a)</td>
</tr>
<tr>
<td>$\theta_{i}/\bar{e}_i$</td>
<td>$\phi_{ij}/\bar{\eta}_i$</td>
</tr>
<tr>
<td>0.003</td>
<td>0.341</td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.240)</td>
</tr>
</tbody>
</table>

(a) Assumed value.

Table 6. Parameter Estimates: Bakery Product Manufacturers

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Bread (i = 1)</th>
<th>Cakes and Biscuits (i = 2)</th>
<th>Flour Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>0.027</td>
<td>0.010</td>
<td>$\phi_{ij}$</td>
</tr>
<tr>
<td>(0.028)</td>
<td>(0.010)</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>$\bar{e}_i$</td>
<td>-0.576</td>
<td>-1.896</td>
<td>$\bar{\eta}_i$</td>
</tr>
<tr>
<td>(0.333)</td>
<td>(0.573)</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>$\theta_{i}/\bar{e}_i$</td>
<td>0.047</td>
<td>0.005</td>
<td>$\phi_{ij}/\bar{\eta}_i$</td>
</tr>
<tr>
<td>0.047</td>
<td>(0.037)</td>
<td>0.062</td>
<td></td>
</tr>
<tr>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.060)</td>
<td></td>
</tr>
</tbody>
</table>

(a) Assumed value.

Table 7. Parameter Estimates: Other Food Product Manufacturers

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Wheat (j = 1)</th>
<th>Barley (j = 2)</th>
<th>Canola (j = 3)</th>
<th>Oats (j = 4)</th>
<th>Grain Sorghum (j = 5)</th>
<th>Triticale (j = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ii}$</td>
<td>0.004</td>
<td>$\phi_{ij}$</td>
<td>0.164</td>
<td>0.195</td>
<td>0.035</td>
<td>0.142</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.177)</td>
<td>(0.205)</td>
<td>(0.010)</td>
<td>(0.163)</td>
<td>(0.013)</td>
<td>(0.209)</td>
</tr>
<tr>
<td>$\bar{e}_i$</td>
<td>-4.038</td>
<td>$\bar{\eta}_i$</td>
<td>0.448</td>
<td>0.516</td>
<td>0.050</td>
<td>0.275</td>
</tr>
<tr>
<td>(1.266)</td>
<td>(0.445)</td>
<td>(0.452)</td>
<td>(a)</td>
<td>(0.343)</td>
<td>(a)</td>
<td>(1.007)</td>
</tr>
<tr>
<td>$\theta_{i}/\bar{e}_i$</td>
<td>0.001</td>
<td>$\phi_{ij}/\bar{\eta}_i$</td>
<td>0.588</td>
<td>0.533</td>
<td>0.705</td>
<td>0.804</td>
</tr>
<tr>
<td>(0.001)</td>
<td>(0.571)</td>
<td>(0.554)</td>
<td>(0.193)</td>
<td>(0.707)</td>
<td>(0.252)</td>
<td>(0.604)</td>
</tr>
</tbody>
</table>

(a) Assumed value.
<table>
<thead>
<tr>
<th></th>
<th>Wheat (j = 1)</th>
<th>Barley (j = 2)</th>
<th>Canola (j = 3)</th>
<th>Oats (j = 4)</th>
<th>Grain Sorghum (j = 5)</th>
<th>Triticale (j = 6)</th>
<th>Cereal Foods (j = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi_{jj} )</td>
<td>0.054 (0.036)</td>
<td>0.051 (0.036)</td>
<td>0.004 (0.001)</td>
<td>0.071 (0.030)</td>
<td>0.002 (0.001)</td>
<td>0.062 (0.030)</td>
<td>0.002 (0.001)</td>
</tr>
<tr>
<td>( \eta_{-jj} )</td>
<td>0.500 (a)</td>
<td>0.600 (a)</td>
<td>0.050 (a)</td>
<td>0.260 (a)</td>
<td>0.050 (a)</td>
<td>0.500 (a)</td>
<td>0.050 (a)</td>
</tr>
<tr>
<td>( \phi_{jj}/\eta_{-jj} )</td>
<td>0.108 (0.072)</td>
<td>0.085 (0.060)</td>
<td>0.072 (0.025)</td>
<td>0.273 (0.116)</td>
<td>0.036 (0.026)</td>
<td>0.124 (0.059)</td>
<td>0.033 (0.028)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Wheat &amp; Other Flours (j = 8)</th>
<th>Beer (j = 9)</th>
<th>Margarine (j = 10)</th>
<th>Bread (j = 11)</th>
<th>Cakes &amp; Biscuits (j = 12)</th>
<th>Other Foods (j = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi_{jj} )</td>
<td>0.025 (0.012)</td>
<td>0.034 (0.018)</td>
<td>0.019 (0.014)</td>
<td>0.078 (0.022)</td>
<td>0.016 (0.011)</td>
<td>0.010 (0.008)</td>
</tr>
<tr>
<td>( \eta_{-jj} )</td>
<td>0.500 (a)</td>
<td>0.500 (a)</td>
<td>0.500 (a)</td>
<td>0.500 (a)</td>
<td>0.500 (a)</td>
<td>0.500 (a)</td>
</tr>
<tr>
<td>( \phi_{jj}/\eta_{-jj} )</td>
<td>0.050 (0.025)</td>
<td>0.068 (0.036)</td>
<td>0.039 (0.028)</td>
<td>0.156 (0.043)</td>
<td>0.033 (0.022)</td>
<td>0.020 (0.017)</td>
</tr>
</tbody>
</table>

(a) Assumed value.
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. 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,
- 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, and
- 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).

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6 The full set of probability density functions may be obtained from the authors if required.
Figure 3. Flour and Cereal Food Product Manufacturers – Cereal Foods Output
Figure 4. Flour and Cereal Food Product Manufacturers – Wheat Input
Figure 5. Beer and Malt Manufacturers – Beer Output
Figure 6. Flour and Cereal Food Product Manufacturers – Oats Input
Figure 7. Oil and Fat Manufacturers – Canola Input
Figure 8. Bakery Product Manufacturers – Flour Input
8. Discussion

In this study our formal objective was to develop and implement a methodology for estimating the degree of competition in complex, multiple-input, multiple-output food markets such as those in the Australian grains and oilseeds sector. A secondary objective was to provide an assessment of the causes and responses to market power.

The theoretical model developed in this project can be regarded as a novel generalisation of several models appearing in the agricultural economics literature. The model allows for both variable-proportions technologies and imperfect competition at different stages of the marketing chain. Thus, the modelling approach outlined in this report is a major improvement on previous approaches and when applied should provide more realistic assessments of the presence or absence of market power. Further, the empirical version of the model 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. Also, the data required are in most cases available from official published sources. 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). Thus, the modelling approach outlined in this report should be readily transferable across to other industries where market power considerations are important.

Aggregate Australian data taken from official sources were used to implement the model for thirteen grains and oilseeds products handled by seven groups of agents. Although the model could have been estimated using, say, ordinary least squares, we were motivated to use a Bayesian estimation framework by a desire to incorporate into the estimation process theoretical information about the signs of the parameters. The results reported above confirm the preliminary conclusions reached by Griffith (2000) and Piggott et al. (2000) about this sector of the agricultural economy, using a completely different model and a completely different data set. 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 grain buyers. The wheat and barley industries seem to be especially disadvantaged by this type of market conduct.

However, there was no consistent evidence of market power in the purchase of canola by oil and fat manufacturers or in the sale of margarine to consumers. These results are contrary to those found by Griffith where there was significant evidence of departures from competition in the purchase of oilseeds from farmers.

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.

Overall, any evidence we have of persistent market power occurs in input markets rather than in output markets.

Another conclusion is that the MCMC estimation framework used in this study appears to be especially useful in studies where there is some uncertainty concerning parameter values. In particular, the estimated posterior pdfs of the samples of observations on the parameters of interest (as shown in Figures 3-8) are thought to be considerably more informative than the means and standard deviations of those samples (as shown in Tables 2-8). For example, when we consider just the mean values for the $\theta_{ii}$ 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.

Overall, we are confident that we have achieved the primary objective of the project.

Unfortunately, personnel changes within the project research team have meant that the secondary objective of the project could not be met. We were unable to investigate formally whether there are institutional or market constraints in the present grains and oilseeds trading system that, if relaxed, would allow a more competitive market environment.
9. Implications

New empirical information has been provided on the competitive structure of the Australian grains and oilseeds processing and marketing sectors, and of the conduct of grain purchasers in their dealings with farmers. Our conclusion is that there is oligopsonistic behaviour by grains buyers and the major implication is that grains and oilseeds producers are disadvantaged relative to the outcomes from a marketing system for grains and oilseeds that is closer to being competitive. 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 grain producers achieving countervailing power in these markets.

The research findings have been and will be delivered directly to the potential end-users (ACCC and other State and Federal government institutions involved in competition policy) through members of end-user institutions sitting on the project steering committee and via RIRDC publications in the future. The results of the project have also been presented at NSW Farmers Association workshops on market power around NSW. The focus of these meetings is on constructive actions by governments and producer groups to achieve some countervailing power in these imperfectly competitive markets.

Development of the technical aspects of the modelling approach have been presented and peer reviewed at the 2002 and 2003 annual conferences of the Australian Agricultural and Resource Economics Society (Griffith and O'Donnell 2002, O'Donnell et al. 2003). The hope is that other researchers will take up this approach and apply it to other agricultural industries of interest.

Overall, the ultimate value of the information generated is that it will reduce the risk that competition policy decisions impacting on firms in the domestic food marketing chain will lower overall community welfare.
10. Recommendations

We have stated our results in quite cautious language, as there is much uncertainty surrounding our estimates. Much of this uncertainty probably stems from the lack of good quality data. One strand of future research should be directed improving the collection and integrity of relevant data (including for the retail and distributive nodes of the various markets).

Another strand of future research should be directed at improving the technical aspects of model estimation. For example, improvements in the reliability of the results could be achieved by estimating the models in larger SUR frameworks, not least so that we can obtain consistent estimates of input elasticities across sectors, and by incorporating more equality and inequality information into the estimation process (eg. symmetry and homogeneity constraints; inequality constraints on income elasticities).
11. References


Australian Competition and Consumer Commission (1999), Submission to the Joint Select Committee on the Retailing Sector, Canberra.


