DEPARTMENT OF PRIMARY INDUSTRIES SUBMISSION TO THE PRODUCTIVITY COMMISSION

INQUIRY INTO PIG AND PIGMEAT INDUSTRIES: POSSIBLE SAFEGUARD ACTION AGAINST IMPORTS

INTRODUCTION

This submission provides the Productivity Commission with information relevant to its project charter; that is, to answer the question of whether action in accordance with the World Trade Organisation (WTO) Safeguards Agreement is warranted against the import of certain pigmeat and to report to the Commonwealth Government on:

- Whether safeguard measures (such as import quotas or tariffs) would be justified under the WTO;
- If so, what measures would be necessary to prevent or remedy serious injury and to facilitate adjustment; and
- Whether, having regard to the government's requirement for assessing the impact of regulation which affects business, those measures should be implemented

This Queensland submission includes:

- Tabling of the University of Queensland Economic Report – 'the impact of trade liberalisation and increasing imports on the Australian pig industry' by Tim Purcell and Steve Harrison of the Economics Dept, UQ. This is an updated version of the 28 May 1998 Report that now looks at the effect of imports on production, in addition to prices and includes a chapter specifically dealing with the 'safeguards' issue relevant to the Productivity Commission Inquiry. The report identifies the link between the importation of pork and the fall in domestic pig prices and other relationships.
- Evidence of material damage to the production sector of the Queensland pork industry as represented by:
  - an increase in pig producer indebtedness to stockfeed manufacturers which are used as the first source of credit during severe financial downturns.
  - reduced financial performance of piggery enterprises indicated by a sample of DPI's herd recording scheme, SOWTEL.

PORK INDUSTRY SITUATION

The Queensland pork industry continues to be in a state of crisis brought about by low pig prices. While pig prices have improved in the past few weeks, prices are still well below the cost of production. Over the past eight months many producers have been unable to find markets for their animals and the average farm lost $1000 per week. There has been a significant increase in pig producer and agribusiness indebtedness.

There is substantial evidence that much of this crisis, which is the result of an acute over-supply in the Australian pig meat market, has been caused by the vastly increased imports of, in particular, Canadian pig meat during the past twelve months.

Few producers appear to have left the industry in Queensland over this crisis period. Many are postponing their decision until the traditionally high pre-Christmas pig price period has passed, in the meantime accumulating huge debt to associated agribusiness which is similarly affected. A Pork Council of Australia survey (August 1998 – Appendix 1) of pig producers indicates that more than 50 per cent will leave the industry if the current crisis (low farmgate prices) continues.

This situation follows the considerable industry restructuring that has already occurred over the last five years. Queensland producer numbers (based on Queensland Pork Producers' Organisation [QPPO] membership) have fallen 40per cent during this period from 650 in early 1993 to 390 in early 1998. The composition of this loss is primarily small piggeries (<30 sows) which fell by 63per cent whereas the number of piggeries above 220 sows increased by 90 per cent to 38. This pattern reflects the trend of the national industry over this period. Nationally, the industry has reduced from 40,000 producers in the mid-70s, to 19,000 in 1980 to the current number of 3337. Total sow numbers have remained static and productivity increased: from 220,000 tonnes in 1980 to 326,000 tonnes of pigmeat in 1997 (see Fig. 3).

The financial impact of prolonged pork industry difficulties on Queensland is considerable. Queensland is Australia's second largest pig producing State with 22 per cent (63,600 sows) of the national herd and 24 per cent of pigmeat produced and the product has a large value-added component. The annual gross farm gate value of production of the Queensland herd is approximately $150 million.

Factors causing the crisis include the following:

- historically low pig prices;
- the high level of pig meat imports (of which 80per cent is Canadian leg meat – ABS, APC see Fig. 1). This Canadian product is now equivalent to 27per cent of Australian leg production;
- lack of any mechanism to buffer the effect of oversupply resulting from unimpeded and sudden increases in imports;
- the increased bargaining power of pigmeat buyers;
- no practical reciprocal trade arrangements for the export of Australian pig meat to Canada;
- a surge in pork production resulting from the improved industry situation in 1996; and
- the extremely low price of beef in Queensland with the collapse of the Korean market.

There are several concepts of intensive pig production that require explanation in order to appreciate management of these enterprises and producer response.

There is poor comprehension by those not associated with the pork industry that small piggeries (eg. those with 100 sows or 1000 pigs on the property at any one time) or multi-enterprise farms cannot compete on efficiency grounds. This concept is incorrect. Smaller producers have access to the same technology, consultants, and information support that is available to operations of larger scale. They also have the benefit of committed labour, group buying and selling and local feed.

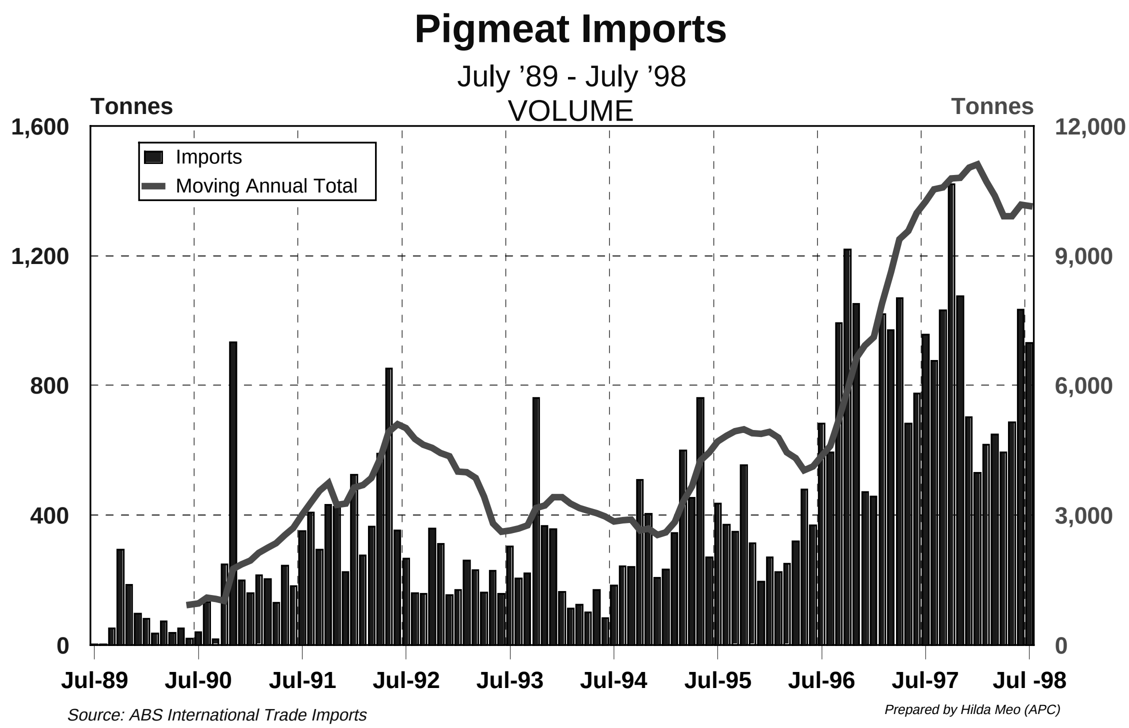
Modern pig production is different from most other forms of agriculture in that all pigs are fed entirely on specially prepared feedstuffs, the production system is continuous and cannot simply be 'turned off'. This differentiates intensive producers from the broadacre sheep and cattle producers where stock graze on pasture and there is more flexibility in holding stock back from sales during periods of low prices. If pork producers hold stock back from sale, production inefficiencies occur and weights and fat scores increase, resulting in severe price penalties or stock becoming unsaleable. The modern pig producer markets pigs every week of the year and, if shut down, a piggery requires at least 12 months to return to full production involving very high cost. A decision to 'shut down' generally means leaving the industry.

1. HAVE IMPORTS INCREASED?

Yes, pork imports have dramatically increased.

Since July 1990, imports from Canada entered Australia in frozen and uncooked form. Rising to levels of 3000-4000 tonnes per annum, they remained fairly steady, at what is regarded by industry as manageable levels, between July 1991 to July 1996. From this date imports increased rapidly, more than doubling to more than 11,000 tonnes per annum in 1997. Imports have increased in both absolute and proportional terms.

Fig. 1.



Current trends indicate that this level is increasing with the two most recent months of imports, May and June 1998, both being above the comparative 1997 levels. June 1998 imports, in particular, increased by 33 per cent to 1034 metric tonnes.

The composition of these imports is important.

On face value, annual imports of 11,000 tonnes appear to represent only 3.22 per cent of domestic production. However, when comparing like with like, imports in 1997 were equivalent to 30 per cent of Australia's leg production that is used for ham production. This is up from a base of 5 to 10 per cent during the period 1991 to 1996 (ABS, APC).

The leg primal in Australia is a premium product with high demand, particularly, in the second half of the year as processors prepare for the lucrative Christmas ham trade and summer cold meat season. This processor demand for legs was the primary driver of pig prices through June to November each year and is the main factor affecting average pig prices.

2. WHAT IS THE INDUSTRY?

The Agreement on Safeguards defines the domestic industry as comprising producers of 'like products' or products 'directly competitive' with imports.

For this submission, the 'industry' is regarded as the pig production (farming) sector of the Australian pork industry. Pig producers produce 'directly competitive' goods with imports of frozen boned-out pork. They are clearly affected by imports because they produce the basic input that is converted into the 'like product' and without which no 'like product' would exist. All pig producers, eventually, are affected by increased supply to the Australian market of either pigs or pig meat imports.

The Australian pig industry is highly vertically integrated at the producer-abattoir-processor level with producers contracted to particular abattoirs and processors and some producers being members of producer–abattoir–processor cooperatives, like Darling Downs Bacon (DDB). The decline in producer prices from November 1997 has seen DDB accept a reduction in its margins to provide some assistance to its producer members in the form of higher than market prices. The difficulty in separation of the processing chain into its component parts suggests that, in an economic sense, whole carcasses should be considered as "directly competitive" with the imported product.

The 1995 ABARE report to the Industry Commission into 'Pigs and Pigmeat' highlighted the issue of crowding out, and that imports of Canadian pigmeat would divert domestic supplies of legs to the fresh or "wet" meat sector, as well as to other processing end-uses. Due to this diversion there is the expectation that imports would have an effect on volumes and prices of other pigmeat products (not only pork legs). The structure of the pigmeat processing and marketing chain is such that there is approximately a 40:60 split between fresh or "wet" meat and processed or manufactured meat. The manufactured meat is further divided into legs, for ham, and middles for bacon and other smallgoods. There is a high substitutability between legs for ham and further processing of legs into other smallgoods."

The Australian pigmeat market which, traditionally has been domestically orientated and balanced, is very sensitive to sudden increases in supply, particularly of a high priced article such as pork legs that in the Australian market set the general pig price for the industry. Imports therefore compete at all levels; from frozen, boned-out carcase primals to processed product. The fact that all these farm businesses have been and are potentially harmed by increased imports of these products indicates that they can be regarded as producing 'like product'.

For further detail refer to the UQ Report, section 4.3 Appendix 2.

3. HAS THE INDUSTRY SUFFERED, OR IS IT LIKELY TO SUFFER, SERIOUS INJURY?

WTO defines serious injury as a significant overall impairment in the position of the domestic industry, while threat of a serious injury means serious injury that is imminent.

(a) Has the industry suffered serious injury?

DPI has evidence of the pig production sector and associated agribusiness suffering serious injury from the effects of low pig prices over the past year. DPI has detailed evidence of this damage during the June 1998 quarter.

Evidence of material damage to the production sector of the Queensland pork industry is:

- losses sustained during this low pig price period as indicated by a sample of DPI's herd recording scheme, Sowtel.
- an increase in pig producer indebtedness to stockfeed manufacturers which are used as the first source of credit during severe financial downturns.
- results from the PCA producer survey of 500 pig producers Australia-wide which indicate shedding of staff, greater devolvement of work to family farm members and an increase in emotional stress.

Reduced financial performance of DPI SOWTEL Recording Scheme members

Sowtel is a whole herd performance recording scheme involving 35 herds across Queensland, coordinated by DPI. In the limited time available, DPI has collected and processed detailed data, including variable and fixed costs, from 15 of these herds. This group of 15 is reasonably representative of the larger Sowtel group and provides a reasonable comparison with the nationally reported Pigstats data (see Appendix 3). Data are presented for the quarter year period ending June 1998 in Table 1.

Table 1.

FARM FINANCIAL PERFORMANCE JUNE 1998 QUARTER

Farm No	Total sales (kg meat sold)	Total Revenue	Av price $/kg	Total Costs	Profit	Profit $/kg sold
1	49805	$102,100	$2.05	$124,111	-$22,011	-$0.44
2	26355	$54,028	$2.05	$74,955	-$20,927	-$0.79
3	48460	$82,382	$1.70	$112,384	-$30,002	-$0.62
4	17949	$31,949	$1.78	$40,825	-$8,876	-$0.49
5	65446	$111,259	$1.70	$135,879	-$24,620	-$0.38
6	17008	$35,337	$2.08	$39,428	-$4,091	-$0.24
7	36627	$59,336	$1.62	$66,331	-$6,995	-$0.19
8	26196	$47,415	$1.81	$49,738	-$2,323	-$0.09
9	16439	$27,125	$1.65	$38,601	-$11,476	-$0.70
10	494733	$841,045	$1.70	$1,097,238	-$256,193	-$0.52
11	171717	$279,899	$1.63	$301,321	-$21,422	-$0.12
12	39906	$73,427	$1.84	$103,929	-$30,502	-$0.76
13	112972	$171,718	$1.52	$205,071	-$33,353	-$0.30
14	30780	$46,170	$1.50	$53,050	-$6,880	-$0.22
15	88161	$149,873	$1.70	$154,605	-$4,732	-$0.05
Average	**82837**	**$140,871**	**$1.70**	**$173,164**	**-$32,294**	**-$0.39**

Table 1. demonstrates that all 15 farms have suffered significant injury due to low pig price.

The average loss for these producers of 39.5 cents per kg of pigmeat sold represents a loss per farm of $32,294 over this three-month period. Economies of scale were not evident for the largest producer whose returns were 51.8 cents below their cost of production resulting in a total loss of $256,193.

Herds of the Sowtel scheme are regarded as performing slightly above the State average. It can therefore be deduced that the Queensland herd is sustaining significant losses, particularly when considering the duration of this low pig price period. Also, although pig prices have improved, prices received continue to be below the cost of production so the injury continues for these, and most, farms.

Pig farm employment has reduced

Staff have been made redundant on–farm and in agribusiness as a result of the very low pig prices over an extended period and the uncertainty of the future price and trade trends.

From members of the Sowtel Scheme and of discussion groups facilitated by DPI, there is considerable evidence of active and progressive producers, some due to unfortunately timed expansion based on misleading ABARE forecasts, having to sell their piggeries at values well below replacement cost.

Staff levels have been reduced and in many cases work is devolved to unpaid family labour of owner operator piggeries in an attempt to survive until prices improve. These producers are the majority (82per cent) of pig farms in Queensland (QPPO herds <100 sows). Emotional stress for staff and farm families has been severe with resulting increases in the use of counselling services and the reported suicide of one Queensland pig producer.

Stockfeed suppliers, in particular, are bearing much of the brunt of low pork prices and the need for farm credit (as evidenced by the examples below). They are in an invidious position where they need to continue to support (finance) producers, hoping that conditions eventually improve so that their clients can trade out of their debt and so repay the stockfeed companies. The tie of workers to capital (buildings) which occurs with small piggeries, and this capital being non-transferable because there is no market and no alternative use for a piggery, means pig producers continue to operate until greatly in debt. For these same reasons banks are reluctant to foreclose on piggeries, thereby postponing the exit of these producers from the industry. When economic conditions improve banks will be forced to take action to recover debts which in many cases are unserviceable at present prices.

The recent PCA producer survey of 500 pig producers throughout Australia indicated that 24per cent of farms decreased the number of people employed over last 12 months. Considering that the majority of farms are owner-operated, (82per cent of herds are less than 100 sows capacity) this loss is significant.

Statement from Better Blend Stockfeeds, Oakey

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Statement from Kewpie Stockfeeds, Kingaroy

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The Pig Price 'Crisis' Situation.

Fig 2

price decline
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(b) Is the industry likely to suffer serious injury?

In November 1997, import health protocols were extended to include cooked manufactured product from Canada and frozen product for manufacturing purposes from Denmark. This is causing concern for the production and processing sectors of the Australian pork industry due to the scale of these exporters and the possibility of their 'swamping' Australia with pork. Denmark is second top of the world exporting countries and Canada third top, exporting 470 and 410 kilotonnes of carcase weight, respectively in 1997 to world markets. Australia's total production for the same period was 324.3 kilotonnes (PRDC Pigstats 1997).

Pig producers now find it impossible to predict future price trends with any accuracy. This is due to the change in the trading mechanism of the Australian pork market as a result of significant pork imports. Based on current price, importers can place overseas orders eight weeks ahead of supply and there is no industry knowledge of these imports until more than 5 weeks after their arrival.

If returns continue at the current low level of $1.90-2.00 per kilogram, the following can be expected:

- a major loss of producers from the pork industry. This will include smaller producers and also medium scale units (400-800 sows) which have significant investment and, in operating at well below costs of production, will be under considerable pressure from financial institutions to foreclose.

- expansion and further investment may be postponed or abandoned by medium piggeries and corporate investors.

4. ARE IMPORTS CAUSING SERIOUS INJURY?

This question is dealt with in detail in the UQ Report, Appendix 2.

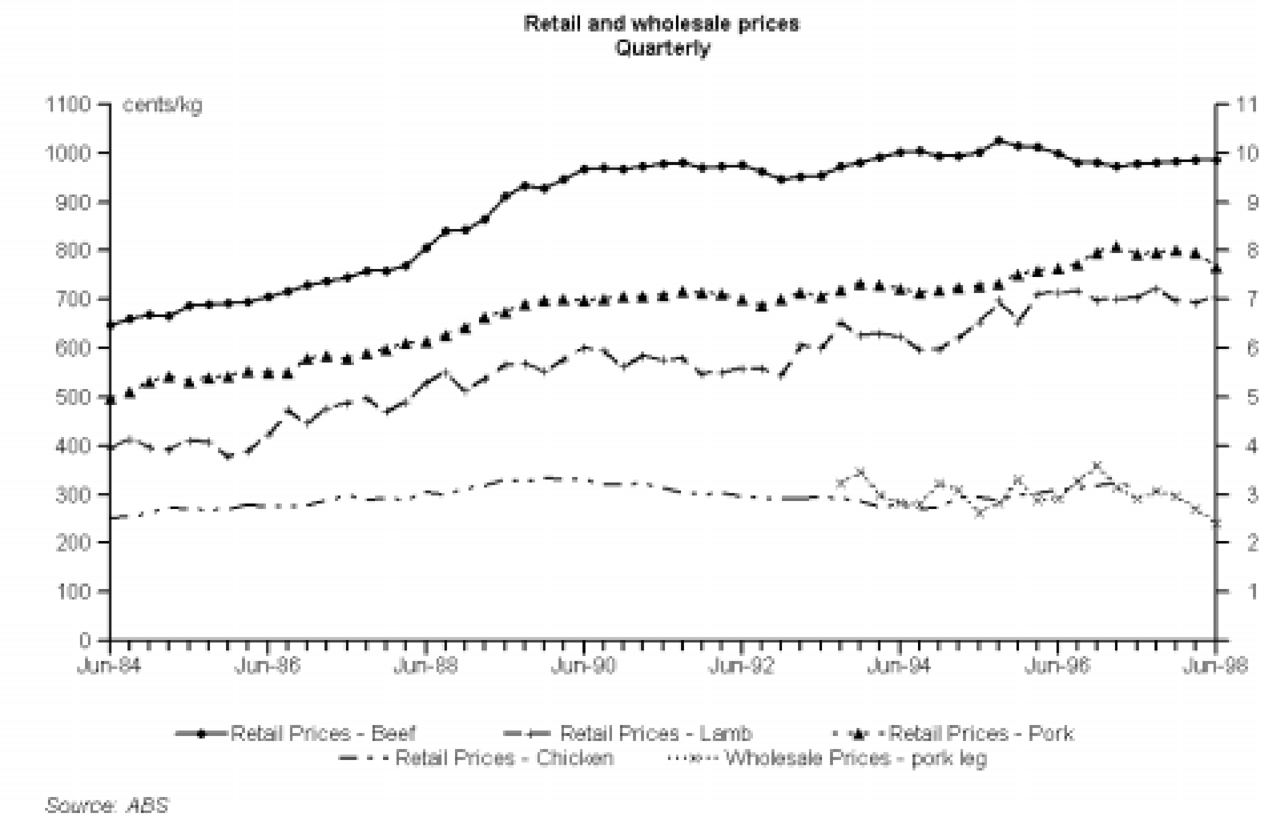
Yes, imports have affected producer prices, reducing them by around 10-13 cents per kg per 1000 tonnes of imports from their introduction, through to the latest data available in June 1998. Imports have also affected production due to buyers restricting domestic pig purchases and rigidly adhering to contracted supply numbers, and driving production down by around 7 kg for every kilogram imported. Imports have not affected retail prices because retail price has continued to increase, except in the 6 months to June ’98 following the announcement of expanded import protocols, as shown in Fig 4. Imports do not appear to have affected wholesale prices for bone-in pig meat. However, evidence on an individual processor level indicates that bone-out wholesale prices have been significantly affected.

The claim by ABARE, in its 1998 Briefing Note to the Rural Adjustment Scheme Advisory Council, that overproduction and increased production has been the cause of depressed producer prices is shown to be unsubstantiated. Fig 3 shows that during the period between 1995 and 1998 production was, in fact, below the long-term production trend.

Fig. 3

The contention by ABARE that declines in consumption have precipitated declines in producer prices is also shown to be unsubstantiated. Consumer patterns rely on retail price movements rather than producer price movements. The UQ Report shows that retail price movements of meats, however, are stable as shown in Fig 4. Further, observed declines in consumption have been matched by declines in production.

Fig. 4



The contention that consumers are purchasing beef in preference to pork due to the low cattle price is based on the premise that low cattle prices translate into low retail beef prices. Again, retail prices, as shown in Fig 4 above, have not changed significantly.

For further detail refer to the UQ Report, Appendix 2.

5. WHAT SAFEGUARD MEASURES WOULD REMEDY 'SERIOUS INJURY'?

Given that serious injury has been demonstrated, there is a strong argument for some safeguard measure or measures to be imposed. While economic theory suggests that quotas are a superior form of protection compared with tariffs, there would be substantial practical difficulties in imposing quotas.

The provision of such measures should recognise the need for market signals to continue to flow to the industry but should take into account the need for industry to adjust over a phase-in period which industry can absorb.

Further, any such measures should not put at risk international trading arrangements for any of our other primary products.

It is felt that even under WTO rules, short-term assistance for industries undergoing adjustment to changed market circumstances is possible and is highly desirable. To this end, it is recommended that the Commission give serious and urgent consideration to an appropriate form of industry assistance including the option of short-term tariff relief.

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APPENDIX 1.

PCA Telephone Survey of 500 producers taken as a stratified sample on 15/16 August 1998. Details in hardcopy attached.

APPENDIX 2.

University of Queensland Economic Report – 'the impact of trade liberalisation and increasing imports on the Australian pig industry' by Tim Purcell and Steve Harrison of the Economics Dept, UQ. This Report was commissioned by the Department of Primary Industries – Queensland to determine any linkage between pork imports and domestic pig prices and to understand other components and relationships of pork trading.

See hardcopy attached.

http://www.pc.gov.au/inquiry/pigs/subs/sub49b.pdf

APPENDIX 3.

Data from Sowtel provides Queensland pig farmers with basic pig and financial performance for their herd and allows comparison between herds of similar scale and across the group. Performance of Sowtel herds is regarded as slightly above the State average and the herds range in scale: 20% 0-50 sows, 35% 50-100, 36% 100-150 and 37% larger than 150 sows, which includes one herd of 1200 sows. The scheme provides comparable data to the PRDC Pigstats national industry benchmark of herd performance.

APPENDIX 4.
Better Blend
See attached hardcopy

APPENDIX 5.
Kewpie
See attached hard copy

Appendix 4 and 5 are confidential

The impact of trade liberalisation and increasing imports on the Australian pig industry

A submission to the Productivity Commission Inquiry on

Pig and Pigmeat Industries: Safeguard Action Against Imports

on behalf of the Department of Primary Industries, Queensland

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20 September 1998

Contents

0.1 Objectives of the study

In response to declining producer prices and their consequent effect on profitability, the Australian pig industry raised concerns with the Australian Government that the decline in producer price was due to lower priced imports from Canada and this was seriously injuring the industry. The pig industry requested that the Government institute safeguard measures under World Trade Organisation rules to provide short-term assistance to the industry. In response, the Government requested that the Productivity Commission, as its designated *Competent Authority*, investigate the legitimacy of imposing safeguard measures. This report forms part of the submission from the Department of Primary Industries, Queensland. The report examines the effect of imports on the Australian pig industry and highlights some of the options for industry assistance.

Earlier reports, and in particular the Industry Commission report of 1995 and submissions on which it was based, have argued that imports have had negligible impact on domestic pigmeat prices. In this investigation, the methodology adopted in previous studies has been examined, and various techniques of time series analysis have been applied to updated price and production volume series. Specifically, we sought to answer a number of questions including:

1. What has been the underlying pattern of change in prices and production in the Australian pigmeat industry?

2. Have pigmeat imports had an effect on the Australian pigmeat industry?

3. How adequate have the methodology and conclusions drawn in previous studies of the impact of imports on the Australian pig industry been?

4. Should the Government wish to provide assistance to the industry in the current state of extremely depressed prices, what considerations need to be taken into account?

We hope that the analysis and conclusions reached in this study will help to shed light on assistance and adjustment requirements for the Australian pig industry.

0.1.1 Acknowledgments

We would like to thank a number of people for providing information upon which this analysis has been based and for their helpful comments and criticisms. These include Robin Charters (Queensland Pork Producers Organisation); Hilda Meo (Australian Pork Corporation); Blair Bartholomew, Nick Delaney, Col Rosenberger, John Walthall, John Hargreaves, and Trevor Wilson (Department of Primary Industries, Queensland); and finally Rodney Beard and Jyothi Vijaya Gali (School of Natural and Rural Systems Management), Vince Matassa (School of Land and Food), and Neil Karunarantne (Department of Economics), all at the University of Queensland. Of course, we take responsibility for any remaining errors.

Chapter 1

Executive Summary

This report examines the effect of imports on the Australian pigmeat industry to determine whether safeguard actions under the Agreement on Safeguards of the GATT 1994 are justified. A previous investigation by the Industry Commission in 1995 into the effect of imports on the Australian pig industry concluded that imports have had a minimal impact, if any at all, on the saleyard price of pigmeat products and the production of pigmeat [53]. Using advanced econometric techniques we have been able to explore data generating processes and identify relationships between equilibrium prices and production quantities that are hidden when using standard economic analysis.

The analysis conducted in this report has found that prior to 1990 producer prices were relatively stable and producers could be confident of being able to predict market movements. After 1990 there is a structural break which has induced volatility in producer prices, not only making producer decisions more difficult, but removing any long-run equilibrium relationship.

This report has found that in addition to a structural break in the first quarter of 1990, the long-term trends of the various series fluctuate over time. This means that it is unlikely that the series under study, for example producer prices, will return to historical trends. Not only is there an effect on prices, but the introduction of imports has fundamentally changed the dynamics of the supply response. The analysis in this report suggests that the introduction of imports continues to have a lasting effect on domestic pigmeat prices received by producers.

Previous studies have contended that domestic prices are strongly influenced by domestic production, but this report has found that imports also play an important role. Unlike previous studies, this report has found a significant relationship between import volumes and import prices and domestic production and domestic prices at all levels of the marketing chain except retail prices.

The significant relationship between imports and producer prices has been in the form of imports both inducing increased volatility in prices and in inducing a fall in the producer price for baconers. Econometric modelling of the factors affecting producer prices indicates that for every additional 1000 tonnes of pigmeat imported, domestic producer prices fell by around $10¢/kg$ to $13¢/kg$. The effect of imports on producer prices is quite large, relative to the effect of domestic production on producer prices. One possible explanation of this is that domestic market intermediaries are able to bargain down domestic prices to the level of import prices.

Our results indicate that retail prices have declined by around $5¢/kg$ due to external events after November 1997, like the change in import protocols allowing already processed pigmeat from Canada and fresh, frozen pigmeat from Denmark to be imported. Producer prices have also been affected by the introduction of the new import protocols.

Economic theory predicts that in a perfectly competitive market there will be full price transmission between producer and retail prices. Our results suggest that the pig industry is not perfectly competitive when viewed vertically, although there is strong evidence in the speed of responses of producers to external shocks that producers themselves are highly competitive. The results suggest that increases in producer prices will be passed on in higher retail prices but higher retail prices will not be passed on as higher producer prices, indicative of an asymmetric price transmission mechanism seen in pig industries in many other countries.

The results indicate that import volumes and prices do not have a negative effect on retail prices. This implies that the assumed benefits of trade liberalisation, resulting from a reduction in consumer price, have not occurred.

While retail prices have not been affected by imports, and producer prices have, it is unclear whether wholesale prices have been affected. The lack of data on wholesale prices for products directly comparable with imports hampers any analysis. Analysis using wholesale prices for bone-in products indicate that imports do not effect wholesale prices, but analysis using wholesale prices for one individual processor (Darling Downs Bacon) suggests that the price of bone-out products ("as-like" products with imports) are significantly affected. Champagne Ham (bone-out) and Processed Shoulder Ham register declines in prices of $\$0.7039 \pm 0.3831/kg$ and $\$0.2692 \pm 0.1049/kg$ for every 1000 tonnes of imports respectively.

One of the contentions by the Government [6],[7] and ABARE [3] is that increases in production and changes in consumption patterns leading to an oversupply of pigmeat is the primary cause of the fall in producer prices.

We show that the increase in production, as asserted by ABARE [3], only refers to the period between 1995 and 1998, a time when production was in fact below historical patterns. Modelling work indicates that there has been a change in the underlying supply response of the domestic pig industry and that production is in fact significantly below what would be predicted by historical patterns. In terms of whether a persistent oversupply in production has been the cause of low producer prices, modelling work indicates that producers respond quickly to market signals and any oversupply in domestic pigmeat is cleared, to all intents and purposes, within three months. Declines in pigmeat consumption have not resulted in an oversupply of pigmeat in the domestic market because production has followed changes in consumption.

The introduction of new import protocols after November 1997 significantly decreases pigmeat production by around 1700 tonnes. Industry sources indicate that quota limits on contract sales to abattoirs have been strictly enforced during 1998 in an effort to restrict supply and this could be a possible explanation.

One of the problems with the standard model of international trade is that it assumes factor mobility across sectors and a perfectly competitive outcome under trade liberalisation lending itself naturally to the conclusion that liberalisation is preferable to any type of imperfect competition. If the institutional framework of the industry is such that there is a marketing chain, which is imperfectly competitive at each stage, then reform of one particular link on the marketing chain without reference to the others will result in a situation where the reform may actually decrease competition of the industry as a whole. With reference to the pig industry, consumers do not seem to be benefitting from trade reform while producers are seeing both prices and production (and therefore revenue) decline, with the benefits of trade reform seeming to be captured by increased marketing margins. In situations where there exists imperfectly competitive markets due to the institutional structures in an industry, it can be shown that countervailing powers actually increase both producer and consumer welfare.

When the government has a choice between imposing a quota, tariff or a subsidy (including a lump-sum compensation), economic theory shows that a subsidy is less distorting than a tariff, which is less distorting than a quota. We argue that if the political economy is such that lump-sum compensation is not feasible then under certain conditions a quota is preferable to a tariff. If tariffs are imposed in preference to quotas then the imposition of a \$/kg tariff will result in the same level of protection as a quota. If tariff revenue is directed towards domestic producer compensation then declines in domestic market share will be funded by exporters.

Chapter 2

Introduction

In response to producer concerns about the rapid and drastic decline in prices after the November 1997 decision by AQIS to relax the import protocols for importation of pigmeat from Canada and Denmark, the government initiated a productivity Commission inquiry into the pig industry. The government designated the Commission as the "Competent Authority" under the *Agreement on Safeguards*, GATT 1994 to determine whether there were grounds for safeguard measures to be applied. The Productivity Commission published an issues paper [76] outlining the six steps that were to be followed by the Commission in making a determination of Safeguard Action:

Step 1 Have imports increased?

Step 2 What is the industry?

Step 3 Has the industry suffered serious injury?

Step 4 Are imports causing serious injury?

Step 5 What safeguard measures would remedy serious injury?

Step 6 Views of other interested parties

In addition, under the auspices of the Productivity Commissions' charter, the inquiry is to address the general profitability and competitiveness of the industry.

This report, commissioned by the Department of Primary Industries, Queensland (QDPI), forms part of the QDPI submission to the Productivity Commission Inquiry. It explores recent changes in the Australian pigmeat industry, particularly any effect of imports on prices received by pig producers.

After briefly reviewing the 1992 Australian Customs Service Anti-Dumping Inquiry and the 1995 Industry Commission Research Report in chapter 3, chapter 4 highlights some of the issues needed to be taken into consideration when addressing the steps outlined by the Productivity Commission in its issues paper, in particular Steps 1 and 2: have imports increased and what constitutes the industry. The bulk of the report attempts to address Step 4 of the issues paper [76, p. 9], whether imports are causing serious injury, and in doing so also addresses the second part of the Productivity Commission Inquiry, the profitability and competitiveness of the industry. Chapter 5 outlines the data sources and definitions used in the subsequent analysis. Chapter 6 attempts to identify the correct data generating processes underlying prices and production in the pig industry. Chapter 7 identifies the effect of imports and other factors on domestic producer prices. Chapter 8 identifies the effect of imports and other factors on domestic production. Chapter 9 identifies the effect of imports and other factors on wholesale prices. Chapter 10 identifies the effect of imports and other factors on retail prices. Chapter 11 outlines a simultaneous equation approach to take into consideration the dynamics of supply and demand. Chapter 12 develops an econometric model which can be used for forecasting and simulation of the market equilibrium dynamics in the Australian pig industry. Chapter 13 extends this model to take into account the short-run deviations from the long-run equilibrium to increase the accuracy of the model predictions. Chapter 14 develops an econometric model to analyse the producer-to-retailer marketing margin for the Australian pig industry. Chapter 15 expands the analysis in the previous chapter and presents an econometric model of producer-to-retailer marketing margins for the Australian meat industry. Chapter 16 reviews the economic theory on trade liberalisation under imperfect competition. Chapter 17 attempts to address Step 5 and 6 of the Inquiry: what safeguard measures would remedy serious injury and whether the imposition of safeguard measures would be in the best interest of the pig industry. Finally, chapter 18 provides the main conclusions of the analysis.

Chapter 3

Background

3.1 The 1992 Australian Customs Service Inquiry

In 1990 the Federal Government made a decision to allow imports of frozen pigmeat from Canada into Australia. In response to a downward trend in prices, the pig industry made representations to the Australian Customs Service (ACS) and the Anti-Dumping Authority (ADA) to initiate anti-dumping and countervailing (ADCV) proceedings against the Canadian pig industry [9]. An application was lodged with the ACS on 27 July 1992 which resulted in an inquiry launched on 19 August 1992. The ACS preliminary finding on 27 November 1992 concluded that frozen pork exports from Canada had not caused and did not threaten material injury to the Australian industry. Accordingly there was not sufficient grounds for an ADCV notice.

The relevant points made by the inquiry were that:

1. The Australian industry comprised of pork producers and processors. (The Canadian Government had argued that the assessment be limited to processors).

2. In 1991-92 imports of pigmeat to Australia from Canada were 4,300 tonnes in a market of 217,000 tonnes (1.98%) for manufacturing pigmeat, while fresh sales accounted for a further 109,000 tonnes. However, the bulk of imports were hams, which accounted for more than 10% of the Australian ham market [10],[11].

3. Imports from Canada were priced at 10-15% below that of the local product. The ACS found that imports of pigmeat from Canada had caused price depression and suppression, and reduced profitability.

4. ACS rejected the Canadian Government claims that Canadian pork is superior to Australian pork.

5. ACS agreed with the Australian industry's view that Canadian Government indirect subsidies paid on inputs were a form of assistance and were therefore potentially countervailable.

The Anti-Dumping Authority (ADA) undertook a review of the ACS finding at the request of the Australian industry and on 25 January 1993 concluded that there was [12]:

1. No dumping of Canadian exports of frozen pork.

2. No subsidies paid to Canadian pork processors, nor that grain grower or pig producer subsidies in Canada affected the export of frozen pork from that country.

3. Insufficient evidence to conclude that material injury has been suffered, from any cause, by the Australian industry producing like goods.

4. No material injury nor threat of material injury caused by dumping or subsidisation of Canadian pigmeat.

In essence, the ADA report concentrated on the issue of dumping or subsidisation of Canadian pigmeat, which relies on a narrow (but technically correct) definition of dumping - that the product under investigation is offered at a lower price in the foreign country than it is in the domestic country. This narrow definition ignores the heterogeneity of most agricultural produce and assumes that there is no cross subsidisation between joint products. At issue is the different elasticities of demand for different components of the pig carcass across countries. In North America and Asia (for example Japan, Taiwan and Korea - significant export markets for Canadian and US pigmeat), there is considerable value placed on the forepart of the pig - especially pork bellies - whereas a much lesser value is placed on the hinds of the pig - the legs. As such, with consumer demand being for pork bellies, and the joint product nature of pig production, there is an oversupply of hinds leading to a lower price for hinds compared with fronts. Australian consumers place a much higher value on legs than on pork bellies and thus there is a natural arbitrage for exports of Canadian hinds into the Australian market. Any determination of dumping will conclude in the negative as hinds are offered at a lower price in both markets. In essence, hinds are dumped in both markets due to the higher valued pork bellies inducing producers to increase production to cater for that segment of the market. The cross subsidy between pork bellies and hinds due to the jointness of production makes it profitable for producers to sell hinds at a much lower, if not below cost level.

Despite the negative findings of the ADA report, the pig industry continued to believe that a contributing factor of declining prices, declining profitability, and closing of piggeries and processing plants was the imports of Canadian pigmeat. Accordingly, in 1995 the Federal Primary Industries Minister agreed to refer the matter to the Industry Commission.

The report handed down by the Industry Commission [53] after extensive consultation with interested parties had several main conclusions:

1. Imports of pigmeat formed only a small fraction of total supply on the domestic market and, as such, were unlikely to influence the demand and supply equilibrium.

2. Economic analysis by ABARE and the New South Wales Government found little support for the contention that imports had an effect on saleyard, or farmgate, pigmeat prices.

3. Increasing feed grain costs due to drought, declining beef prices and increasing domestic supply were plausible explanations for declining profitability and prices rather than imports.

4. Economy-wide trade liberalisation under GATT-WTO will bring long-term benefits to the economy which will more than offset the declining fortunes of the pig industry.

At the time of the Industry Commission 1995 Inquiry into the pig industry, Australian Quarantine Inspection Service (AQIS) protocols meant that only fresh frozen pigmeat[1] destined for further processing into cooked manufactured products such as hams and smallgoods could be imported. The Australian pig industry contends that the 7 November 1997 decision by the Federal Government to allow imports of already processed products from Canada and fresh, frozen, bone-out pigmeat from Denmark for further processing in Australia fundamentally changed the marketing chain and economic structure of the pig production and processing industry. Rather than there being a substitution between domestic and imported pigmeat at the processing stage, there is now substitution between all domestic and imported manufactured meat at the retail stage. Whereas previously imports

[1] Fresh, Frozen Pigmeat. FFP is the ABS acronym for Fresh, Frozen and Processed meat under ABS 7215-4. This should not be confused with what the industry terms fresh - or "wet" meat destined for the retail butcher market.

affected producers and only those processors who had long-term processing contracts with domestic producers, after the 7 November 1997 decision all producers and all processors have been affected because supermarkets can now source directly from imported materials. The economic effect of this was not foreseen, nor analysed, in the 1995 inquiry.

The decision on 7 November 1997 to allow imports of manufactured pigmeat from Canada and fresh pigmeat from Denmark, and the subsequent sharp fall in domestic prices, has prompted the Australian pig industry to again question previous conclusions about the effects of imports on the price of pigmeat.

3.2 The 1995 Industry Commission Inquiry

3.2.1 Introduction

In 1995 the Industry Commission was requested to undertake a review of the Australian pig industry and

> Specifically examine the effects of imports on pigmeat prices, investment, incomes, and profits in the domestic industries; and the effects on Australia of government assistance provided by other countries to their pigmeat industries.[53, p. XI]

The key findings of the review were that the current depression in prices and profitability were due to structural adjustment changes which had been going on for many decades and a temporary increase in feed grain prices due to the prevailing drought. Imports did have the potential to suppress prices, but by no more than 4%, and in any case imports were, and were expected to continue to be, a very small component of overall supplies. In terms of foreign government assistance to their own pig industries, the view was that assistance was minor, and not expected to greatly influence import volumes or prices.

The review relied heavily on two submissions, from ABARE [1] and the NSW Government [45], in order to come to their conclusions about the domestic impacts of imports. In this chapter we review the analysis undertaken in the two submissions and offer some explanation as to why no significant effects were found. We conclude that the original analysis undertaken was flawed and therefore the conclusions reached are of doubtful validity.

3.2.2 The 1995 ABARE submission

The 1995 ABARE submission to the Industry Commission Inquiry on the pig industry used econometric analyses to conclude that there was either no, or minimal, effect of imports on the domestic industry. The analysis was in two parts; the first part used simulations from EMABA (Econometric Model of Australian Broadacre Agriculture) [31] to conclude that an increase in imports (using a pulse effect rather than a shift effect) would not have long term effects on the supply and demand equilibrium and, secondly, that increases in feed grain prices - which account for about 65% of the cost of production - has a slight but rapidly decreasing effect on saleyard prices and production. The second part of the analysis used stationarity and cointegration analysis to conclude that there is no long-run equilibrium between import volumes and prices and domestic prices or production.

The EMABA structure assumes that the model variables are stationary, that is, the means and variances of the time series do not move over time. As a result it is not surprising that the model predicts that the equilibrium, once disturbed, will return to its long-run mean - especially since the simulated shocks are transitory in nature (a pulse) rather than permanent (a shift)[2]. Given that the ABARE report concludes in its econometric analysis section that prices and production are non-stationary, the use of a model that assumes stationarity as a prerequisite is unusual.

One of the more important aspects about the statistical analysis carried out in the ABARE study is the surprising rejection of any correction for seasonal effects in price.

> Although the saleyard pig price exhibited seasonality, no correction was made for this in performing these tests, as seasonally filtering the data will bias the test results (Davidson and Mackinnon 1993) [1, p. 43].

This lack of correction for seasonality is highly suspect. A general result of econometric analysis is that if data exhibit seasonal effects, and correction for that seasonality is not carried out, the subsequent results are misleading. The study quotes Davidson and Mackinnon (1993) [30], but does not report a page number. Hence it is difficult to identify what Davidson and Mackinnon were actually referring to, and whether or not their comments have been taken out of context. One suspects that Davidson and Mackinnon were referring to the biased ordinary least squares (OLS) statistic which occurs

[2] In section 6.5 we outline research which suggests that the a pulse effect on a non-stationary series will have a shift effect outcome.

as a result of differencing data - an effect that occurs in any case when testing for stationarity irrespective of whether the data have been adjusted for seasonality. The reason why the Dickey-Fuller test [32] and its augmented form [33] are carried out is to adjust for the biased OLS statistic using the τ statistic.

The ABARE study used the Augmented Dickey-Fuller test and the Phillips-Perron test [73] to test for stationarity. The Phillips-Perron test, although more powerful than the Augmented Dickey-Fuller (ADF) test, still has the weakness of the ADF test in that the test statistic will be unreliable in the presence of a structural break. Considering that the primary purpose of the study is to test for the effect of introducing imports into a market in equilibrium, such an introduction would presumably lead to a structural break and thus invalidate the ADF and Phillips-Perron test statistics. Perron [69],[70] and Perron and Vogelsang [71] outline an "additive outlier" test that is robust in the presence of structural breaks.

The second aspect worthy of comment about the statistical analysis carried out in the ABARE study is the testing for cointegrating relationships between pigmeat imports and prices. The study claims that

1. there are no long-run equilibrium relationships between pigmeat imports and pigmeat prices, but there are between saleyard beef price and saleyard pigmeat prices; and

2. there may be short-run relationships between pigmeat imports and prices - however, this question has not been explored.

With respect to the first point (that there are no long-run equilibrium relationships between imports and pigmeat prices, but there are between saleyard beef price and saleyard pigmeat prices), these results are tempered by the problems of seasonality mentioned above. It is to be expected from *a priori* economic theory that saleyard beef and saleyard pig prices would be cointegrated[3] and that this effect should come through even though the data have not been deseasonalised, due to the high degree of substitutability. The cointegrating relationship between pigmeat imports (volumes and prices) and pigmeat prices, *if one exists*, is expected to be less strong than that between saleyard beef prices and saleyard pigmeat prices due to the aggregated nature of the pigmeat prices and the relationship being actually between pigmeat imports (volumes and prices) and leg meat prices. In summary, the absence of a cointegrating relationship between imports and pigmeat prices could be

[3] Under the assumption of no marketing margin driving a wedge between producer and retail prices.

due to either a weak, but still present, relationship between imports and leg meat prices; a relationship between pigmeat imports and pigmeat prices which has not been identified due to the failure to account for seasonality; or in fact no true relationship exists. In all cases further study is warranted.

The choice of procedure used to test for cointegration in the ABARE study is not reported. The study does not explain whether a simple Augmented Dickey-Fuller and Phillips-Perron test was used, or whether the more generally accepted Engle-Granger [37] two-step procedure was used. Once the study established the existence or non-existence of cointegration the next logical step would have been to estimate what that relationship was. In the presence of seasonal cointegration the more appropriate test would have been the seasonal extension to the Johansen maximum likelihood procedure [54]. Where there are several variables that are likely to be cointegrated (pigmeat imports and pigmeat prices, beef prices and pigmeat prices) it is more appropriate to test for cointegration in a simultaneous framework. The Johansen procedure tests for the presence of cointegrating vectors as well as estimating the form of the cointegrating relationship. The estimated relationship can then be used to formulate an Error Correction Model (ECM). An ECM shows the short-run dynamics in a long-run equilibrium relationship - something not explored in the ABARE study.

3.2.3 The ABARE 1998 reassessment

In a Pork Council of Australia draft submission to the Rural Adjustment Scheme Advisory Council [75], the Council in summarising correspondence with the Minister for Primary Industries and Energy said:

> In response on 29 April [1998], the Minister stated that he recognised the "very serious difficulties being experienced by the industry as a result of the dramatic collapse of pigmeat prices in recent months." He said that he had instructed the Australian Bureau of Agriculture and Resource Economics (ABARE) as a matter of urgency to conduct an assessment of the current industry circumstances. [75, p. 14]

This new 1998 ABARE report [3] needs to be reviewed as well in light of our criticisms of the 1995 report. In our view, the new report adds nothing to the debate and is a descriptive narrative of the current state of the industry which presents arguments which are not supported by statistical analysis. Its arguments are not consistent with the 1995 ABARE report, and yet this report reaches the same conclusion that falls in pigmeat prices are unrelated to pigmeat imports. Specifically, the report:

1. claims that prices are low due to an increase in production [3, p. 4, Tables 1 and 2] but does not give any indication of the distribution from which these price and production data are derived. Without a measure of the distribution of prices and quantities, statistical inferences cannot be drawn as it is uncertain whether these data are due to chance or are statistically significant.

2. claims to use regression analysis (but presents neither coefficients nor standard errors)[4] to back up its assertion that prices are following a long-term trend. Firstly, the 1995 report found evidence of non-stationarity, so a long-term trend does not exist as the trend is fluctuating over time, and, secondly, the new report claims that "since March 1994, production has moved away from the steady trend and prices have again started to fluctuate over a wider and non-seasonal range." [3, p. 1] As our analysis below suggests, this is evidence of a structural break with a non-stationary process after the structural break. Therefore, not only does the long-term trend fluctuate, but it is fluctuating in a different region from that of the pre 1994 data. The report's analysis is an invalid application of statistical techniques.

3. uses the period March 1984 to March 1994 as a base on which to conduct comparative analysis. As the industry is claiming that 1990 is the beginning of a structural break due to the introduction of imports changing the supply and demand relationship it seems logical to test this hypothesis rather than to calculate a base period straddling the proposed structural break.

4. asserts that there is a global downward long-term trend in pigmeat prices and feed grain prices in real terms, but no analysis is made to support this contention. For example, no estimates of the rate of long-term price change are made. There is an implication that the observed

[4] It is uncertain what regression was actually carried out. From a reading of the report it seems that it is a simple regression of the series on a time trend

$$y_t = \alpha_0 + \alpha_1 T + \varepsilon_t \tag{3.1}$$

Conducting this regression yields the following statistics

$$\hat{y}_t = \underset{(0.035201)}{2.4789} - \underset{(0.0012014)}{0.014186}\; T$$

$R^2 = 0.74389$, DW-statistic $= 0.15672$, heteroscedasticity $\chi^2_1 = 6.1959^*$, where the standard errors are in brackets. The regression exhibits serial correlation, according to the Durbin-Watson Statistic, and is heteroscedastic (non-constant variance). The plot of actual versus fitted values is presented in Figure 3.1. This is virtually identical to Chart 1 in the ABARE report [3, p. 3].

fall in pigmeat prices in Australia (2% per annum over 25 years and 8% per quarter in the last year) is an inevitable trend.

5. asserts that "this downward trend is a common feature of all commodity prices over the longer term."[3, p. 2] It is not correct to apply a generalisation to a specific industry at a particular point in time. Counter-cyclical and counter-trend effects in particular industries are a common feature of commodity based industries.

6. includes a table demonstrating increasing gross operating surplus per farm in the pig industry as against falling gross operating surplus for sheep and beef. This may not be a particularly fair comparison, in that the structure of the pig industry would appear to have changed considerably over the decade, with smaller producers leaving the industry.

7. uses EMABA simulations to back its claim that production is the cause of the depression in price. The critique of EMABA leveled against the 1995 ABARE report would still appear to hold.

3.2.4 The NSW Government submission

The submission by the NSW government to the 1995 Industry Commission Inquiry included an appendix on causality analysis [45]. The submission reported Granger and Sims Causality tests on imports and prices of legs and loins. One of the major problems with the study was the lack of rigorous testing for stationarity. Rather than use Augmented Dickey-Fuller (ADF), Phillips-Perron, or Perron additive outlier tests to test for the presence of unit roots (non-stationary means), the NSW Government submission preferred to compare Causality tests with and without first differencing. While it is acknowledged that most economic series exhibit an I(1) data-generating process (DGP) (that is, taking first-differences of the data series will induce stationarity), these assumptions can easily be, and should be, tested in an analytical framework rather than relying on ad-hoc assumptions. The second deficiency in the NSW Government submission was the lack of testing for seasonality, especially since the analysis used monthly data. The same criticisms about seasonality apply to this submission as applied to the 1995 ABARE study.

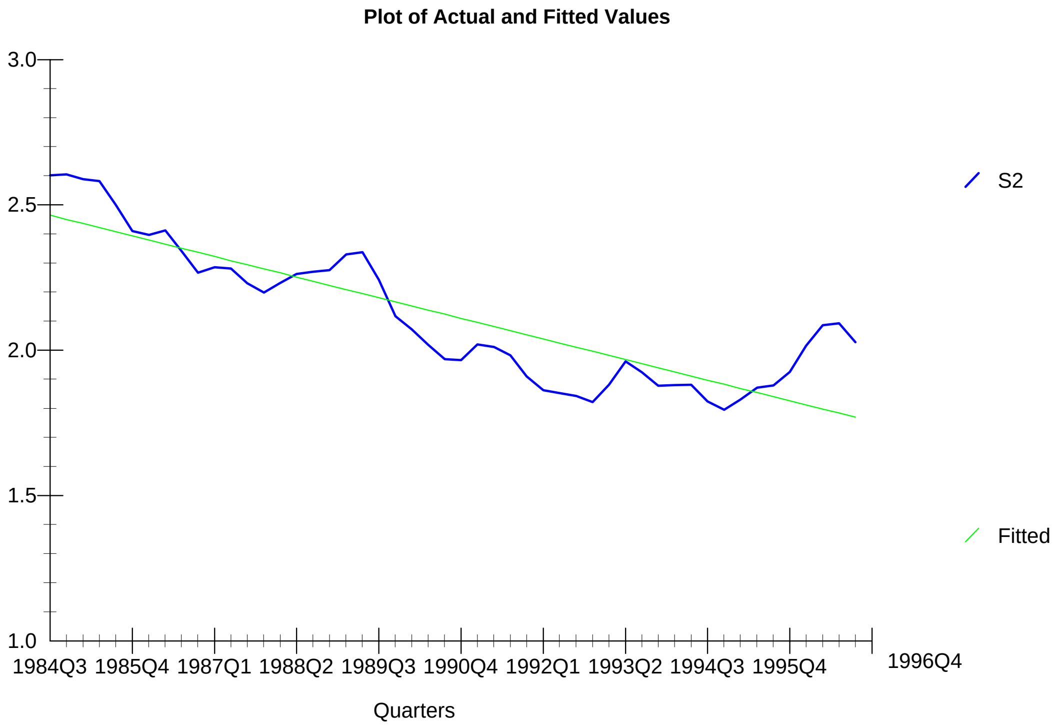

Figure 3.1: Real quarterly indicator pig price with trendline.

Chapter 4

The 1998 Productivity Commission Inquiry

4.1 Introduction

This chapter attempts to address the steps raised in the Productivity Commission issues paper [76]. In doing so we decided to leave Step 3, whether the industry has suffered serious injury, to more competent authorities. Any determination of serious injury needs to take into consideration whether the drop in producer prices would have a significant, deleterious effect on producer profitability and indebtedness. Measures of producer profitability and indebtedness would need to collected on an individual producer basis via a survey. This chapter first outlines issues dealing with Steps 1 and 2 of the issues paper before outlining the rest of the report in dealing with Steps 4, 5 and 6.

4.2 Step 1 - Have imports increased?

The first question raised by the Productivity Commission in its issues paper [76, p. 6] is whether imports have increased in absolute terms or relative to production. Naturally this question relies on some determination as to what is the appropriate time period for comparison. Moulis [62, pp. 5-6] suggests that the appropriate time period is 1995:1 onwards, and bases this argument on the negative findings of the 1992 ACS inquiry and the 1995 Industry Commission inquiry and on the *emergency* context of Article XIX of the GATT 1994.

This argument is flawed for two reasons:

1. The negative findings of the 1992 ACS and 1995 Industry Commission inquiries were based on economic analysis which we have shown in chapter 3 to be flawed in their application of economic and statistical techniques, leading to their conclusions being suspect.

2. Moulis' interpretation of the *emergency* context of Article XIX of the GATT 1994 implicitly assumes that there is a sudden exogenous shock causing immediate serious injury to a domestic industry, and therefore denies the scenario of a transition period before the full effects of a exogenous shock impact on the industry. Any arbitrary imposition of a structural break to capture an exogenous shock that has no basis in fact or theory does nothing to enhance the analysis of the data generating process underlying price and production relationships.

In any examination of the effect of imports on the pig industry there are two shocks to the market equilibrium that need to be considered. The first shock occurred in 1990:1 (1^{st} quarter 1990), with the removal of quarantine restrictions on the importation of fresh, frozen, (FFP) bone-out pigmeat from Canada - to be used in the processed meat sector of the pigmeat industry. The second shock occurred in 1997:11 (November 1997), with the removal of quarantine restrictions on the importation of fresh, frozen, bone-out pigmeat from Denmark, to be used in the processed meat sector of the pigmeat industry, and the approval for the importation of already processed pigmeat from Canada.

Taking these considerations into account, and irrespective of the time frame used, Figure 4.1 indicates that imports (from all sources) have been consistently increasing in both absolute terms and relative to production. The last data point on the graph suggests that imports have actually fallen in recent months. This would be an erroneous conclusion as although data for overall imports after March 1998 are not available, imports from Canada, data for which is available, suggests that imports are in fact increasing (See Table 4.1).

4.3 Step 2 - What is the industry?

One of the questions raised by the Productivity Commission in its issues paper [76, p. 6] concerns the definition of the "industry" as producers of "like" or "directly competitive" goods. Moulis [62, pp. 4-5] argues out that imports from Canada are of bone-out frozen legmeat, not of whole carcasses, and thus do not constitute a "like" product to the output of the pig producing sector of the pig industry. The question of whether whole carcasses constitute

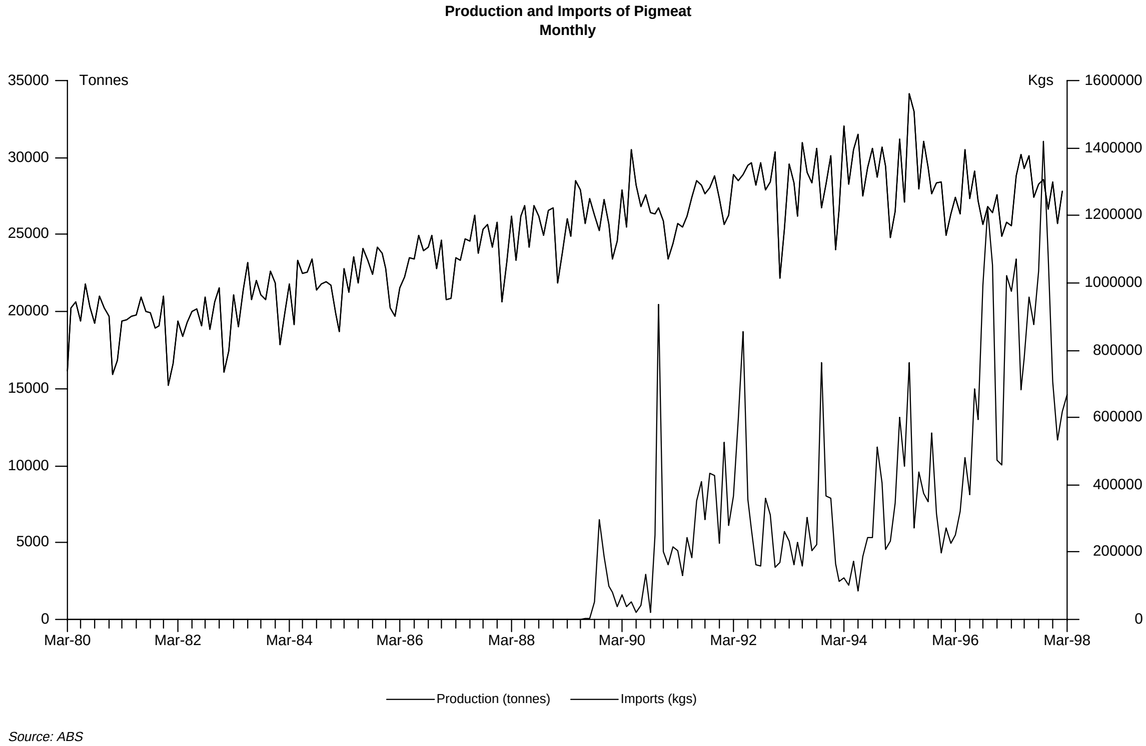

Figure 4.1: Monthly production and imports of pigmeat into Australia

Table 4.1: Monthly production and imports (tonnes)

Month	Production	Imports	Canadian Imports
Jan-98	25653	530.901	323.221
Feb-98	27745	617.742	489.080
Mar-98	n.a.	664.804	430.769
Apr-98	n.a.	n.a.	503.567
May-98	n.a.	n.a.	404.594
Jun-98	n.a.	n.a.	864.971

Source: ABS

"directly competitive" goods needs to be considered in the context of the processing chain.

The Australian pig industry is highly vertically integrated at the producer - abattoir - processor level with producers contracted to particular abattoirs and processors and some producers being members of producer - abattoir - processor cooperatives, like Darling Downs Bacon (DDB). The decline in producer prices from November 1997 has seen DDB accept a reduction in their margins as they provide assistance to their producer members in the form of higher than market prices [28]. The difficulty in separation of the processing chain into its component parts suggests that, in an economic sense, whole carcasses should be considered as "directly competitive" with the imported product.

The 1995 ABARE report [1] highlighted the issue of crowding out, that the imports of Canadian pigmeat would divert domestic supplies of legs to the fresh or "wet" meat sector, as well as to other processing end-uses. Due to this diversion there is the expectation that imports would have an effect on volumes and prices of other pigmeat products (not only pork legs), a question which will be addressed in chapter 9. The structure of the pigmeat processing and marketing chain is such that there is approximately a 40:60 split between fresh or "wet" meat and processed or manufactured meat, as shown in Figure 4.2. The manufactured meat is further divided into legs, for ham, and middles for bacon and other smallgoods. There is a high substitutability between legs for ham and further processing of legs into other smallgoods.

4.4 Step 4 - Are imports causing serious injury?

The 1995 Industry Commission Inquiry into the pig industry relied heavily on analysis submitted by ABARE [1, p. 43] and the NSW Government [45]. The submissions found no evidence of any effect of imports on the price or production of pigmeat. In the following chapters we undertake our own analysis using the same variables, but with an updated dataset. Our analysis corrects for the deficiencies highlighted in the original reports submitted by ABARE and the NSW Government and extends their work to identify patterns in the data previously obscured.

As with the ABARE and NSW Government submissions to the 1995 Industry Commission Inquiry, we first test the variables to see whether their mean changes over time, as analysis on variables with a changing mean may indicate that a relationship exits between two or more variables when in fact

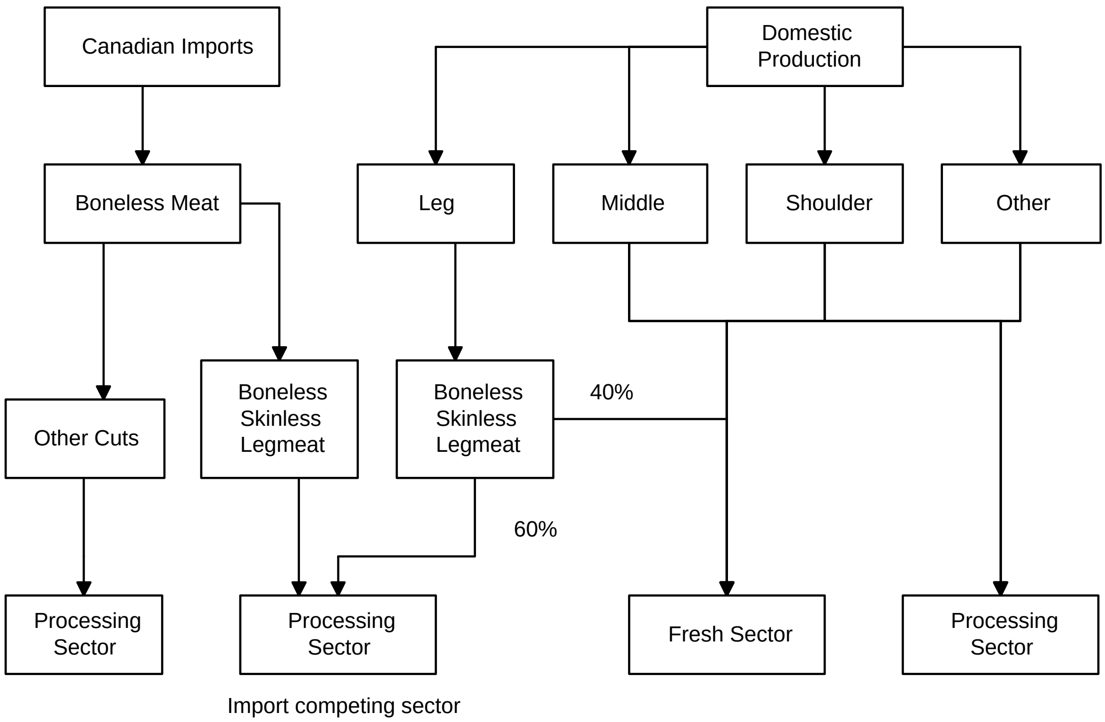

Figure 4.2: Marketing Chain for Pigmeat

that relationship is just the shifting mean.

We then extend the original analysis to test for parameter constancy - as one of the assumptions of statistical analysis is that the coefficients, or parameters, do not change over time. If parameters are changing over time then this is an indication of a structural break, or a change in the underlying market equilibrium due to an exogenous shock. As the fundamental question of this inquiry is whether or not imports have had an effect on the pig industry we argue that logically, any examination should test for the presence of structural breaks.

After determining whether the introduction of imports have had an effect on the Australian pig industry we then attempt to quantify that effect, using autoregressive distributed lag (ADL) models which capture the underlying data generating process (DGP). We are concerned with capturing the exact effects of all the contributing factors to the DGP, rather than imposing an ad-hoc structure and testing to see whether the DGP fits this structure. In doing so we are indirectly addressing the second component of the inquiry, *What are the major factors driving structural change in the industry? Which factors are likely to be significant in future?* [76, p. 11]

The ABARE submission examined prices and imports to see whether there was a long-run relationship between them. We extend their work to test for a long-run relationship in a multivariate framework - to see whether there is more than one long-run relationship amongst all the prices and quantities impacting on the supply of pigmeat.

The NSW Government submission attempted to investigate whether or not imports had a cause and effect relationship with domestic prices and production. In addition, the ABARE submission relied on simulations with EMABA to show long-run patterns in supply and demand in the pig industry. We extend both analyses by building a model that will allow causal effects and relationships between prices and quantities to be examined in a theoretically correct framework.

Chapter 5

Dataset used in the analysis

The analysis undertaken in this report does not explore the dynamics of the post 1997:10 market equilibrium as delays in obtaining an updated dataset prevented a full analysis and the short time period since 1997:10 means that accurate estimation of the data generating process is difficult to achieve. Data constraints have meant that the analysis could not be conducted on data with a higher frequency (i.e. monthly or weekly). Whereas weekly data exist for saleyard prices for baconers, and monthly data exist for saleyard prices for cattle, wholesale prices, import prices and volumes for Canadian pigmeat, only quarterly data exist for retail beef and baconer prices. Export data, while available, are not used in the analysis. It has proven impossible to obtain accurate export data, as there is no information on exports of farmed pigmeat as opposed to feral pigmeat. Published data suggests that exports of pigmeat is quite minor, with a range of 1561 to 264 tonnes per month with an average of 657 tonnes per month. With such a minor export industry it is unlikely that exports will play an important role in determining the data generating process. Regression estimates of producer and wholesale prices taking into consideration exports (not reported) suggest that exports do not contribute significantly to changes in producer or wholesale prices.

The analysis which follows does explore the dynamics of the post 1989:4 market equilibrium. There is the issue of what is the more appropriate level of aggregation on which to conduct the analysis. Both the 1995 ABARE [1] and the NSW Government submission [45] to the 1995 Industry Commission Inquiry [53] used highly aggregated data - retail prices of beef and retail prices of pork - in their analysis, while admitting that a more appropriate level of aggregation would be at the level of direct substitutes - for example wholesale and retail prices of pork legs or hams. Any study of the effect of imports on aggregate pigmeat prices will be obfuscated by the extraneous supply-and-demand relationships between wet meat quantities and prices and the low-substitutability between the end products of legs and middles used in manufacturing meat.

In consideration of these issues it would be appropriate to include in the analysis not only wholesale and retail prices of pork legs but also wholesale and retail prices of other pigmeat products - to incorporate the dynamics of substitution.

Monthly and Quarterly data for prices[1] and quantities were collected. The dataset[2] comprises of

1. Saleyard Price for Baconers ($¢/kg$) (SP) Average of dressed weight stock prices weighted by production in each state [2],[80][3].

2. Saleyard Price for Beef Cattle ($¢/kg$) (SBF). Average of dressed weight stock prices weighted by production in each state [2].

3. Quarterly Saleyard Price for Lamb ($¢/kg$) (SPL). Average of dressed weight stock prices weighted by production in each state [2].

4. Retail Price for Beef ($¢/kg$) (RBF). Actual average price of beef in Dec-73 indexed forward by beef subgroup index of the CPI [2].

5. Retail Price for Pork ($¢/kg$) (RP). Actual average price of pork in Dec-73 indexed forward by beef subgroup index of the CPI [2].

6. Retail Price for Pork Leg ($¢/kg$) (RPL). Average across capital cities [8, Series PS-9014].

7. Retail Price for Pork Loin Chops ($¢/kg$) (RPLC). Average across capital cities [8, Series PS-9013].

[1] All prices are quoted in cents per kg (Australian dollars) and prices for baconers are expressed as Hot Standard Carcase Weight (HSCW). All prices are in nominal terms, that is, no allowance has been made for inflation. This is to ensure direct comparability with previous studies [1], [45] using the same dataset. By taking into account non-stationarity in the modelling framework we explicitly cater for inflation effects with the added bonus of not losing valuable information about the short term dynamics of the data generating process. Pre-filtering of the data by deflating with a price index loses information about the short-run dynamics of the DGP.

[2] The dataset variables are denoted by appending Q (quarterly) and M (monthly).

[3] Simple average of producer prices by state, indicative only. Jan-84 to Jun-97 from ABARE, Jul-97 to May-98 from Queensland Pork Producers Organisation. The term "Saleyard price" is used used interchangeable with producer prices - pigs are sold direct to abattoirs rather than sold via a saleyard - as this is consistent with ABARE and ABS terminology.

8. Quarterly Retail Price for Lamb ($¢/kg$) (RPQL). Average across capital cities [2]

9. Quarterly Retail Price for Chicken ($¢/kg$) (RPQC). Average across capital cities [2]

10. Sydney market wholesale price pork leg square cut (bone-in) ($¢/kg$) (WP)[77]

11. Imports of Fresh, Frozen Pigmeat from Canada (kg) (CAMV) [8, Series PS-10010].

12. Import Prices for Pigmeat from Canada ($¢/kg$) (CAMP) Unit value [8, Series PS-10010].

13. Domestic Production of Pigmeat (kg) (PPD) [4, Table 7215-2].

14. Per capita consumption of pigmeat (kg) (CONS) [4, Table 7215-2]

15. Estimated Resident Population ($No.$) (POP) [4, Table 3101.1]

The dataset is presented in graphical form in Figures 5.1 to 5.6.

The quarterly saleyard price for baconers exhibits what appears to be a significant seasonal pattern. In 1990 the Federal Government decided to allow imports of pigmeat from Canada. On either side of this point there appears to be a slight difference in the long-term trend line. Prior to 1990 the saleyard price of baconers long-term trend seems to be increasing at a greater rate than the trend post 1990. Further, and more significantly the variability around the long-term trend seems to be greater in the post 1990 period than before. The period between late 1996 to early 1998 shows extreme swings in price that is unprecedented over the historical period.

While producer prices have experienced increased volatility over the period under analysis, retail prices remain relatively unaffected. There do not appear to be any seasonal effects influencing retail prices of beef and pork, and only slight seasonal effects for retail prices of pork loin chops. There do appear to be some seasonal effects at work for the retail price series for pork leg and lamb, but it is unclear whether this is a statistically significant effect. For all retail prices except chicken the long-term trend is for increasing prices, in contrast to the almost flat (in nominal terms) trend for saleyard prices for baconers.

Production of pigmeat exhibits a highly seasonal upward trend. There appear to be two significant shocks to the series. The first shock which drastically dropped production, was around 1973-74, corresponding to the

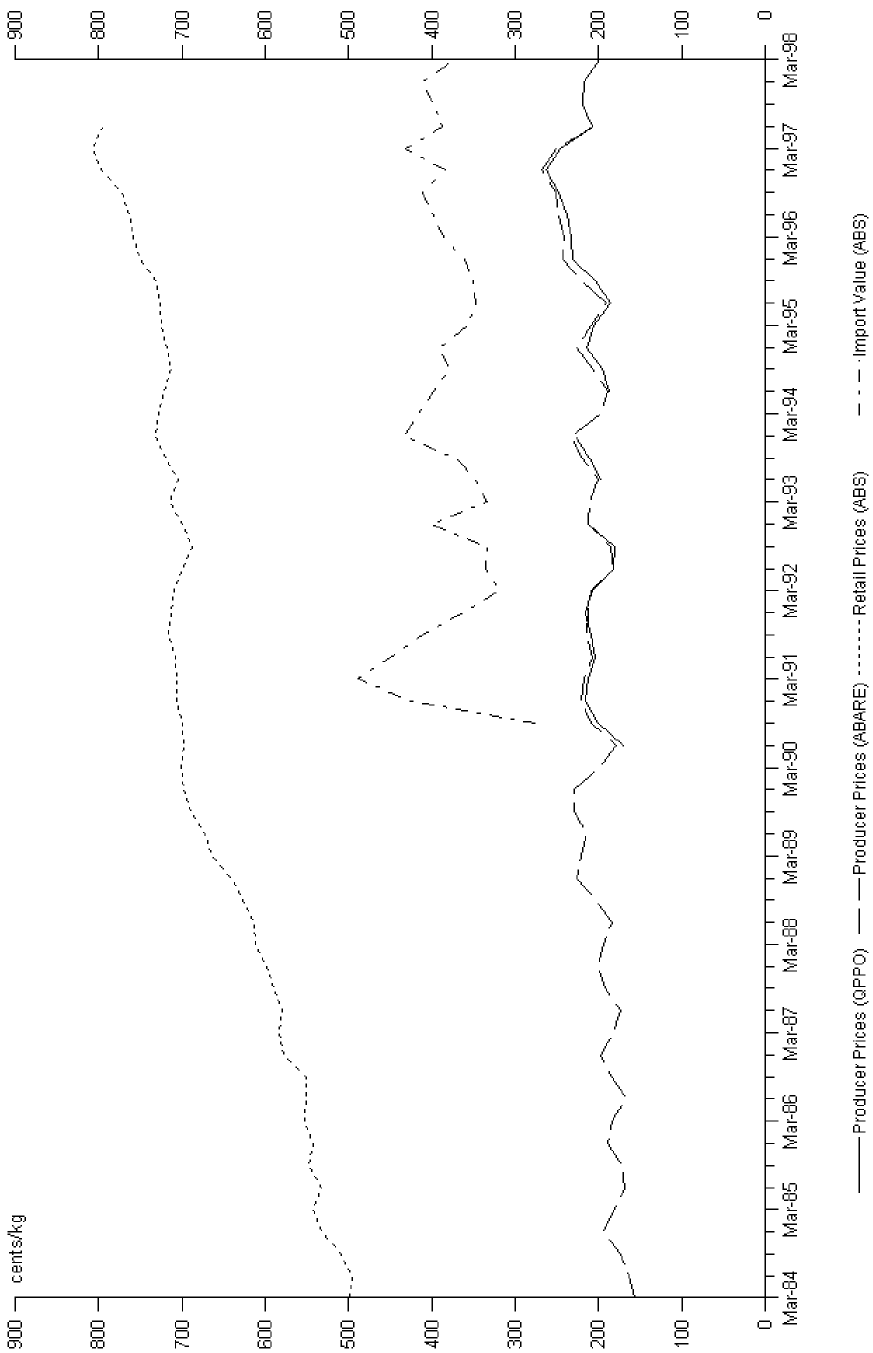

Figure 5.1: Australian producer, retail, and import prices for pigmeat

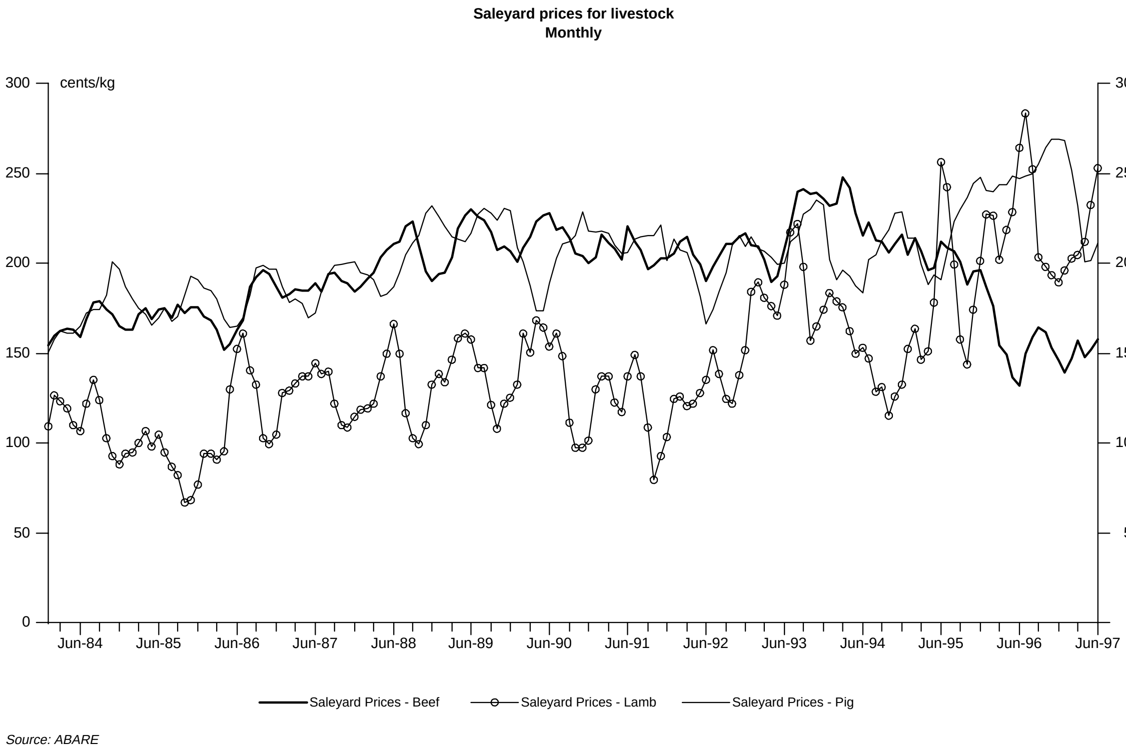

Figure 5.2: Monthly saleyard prices for livestock

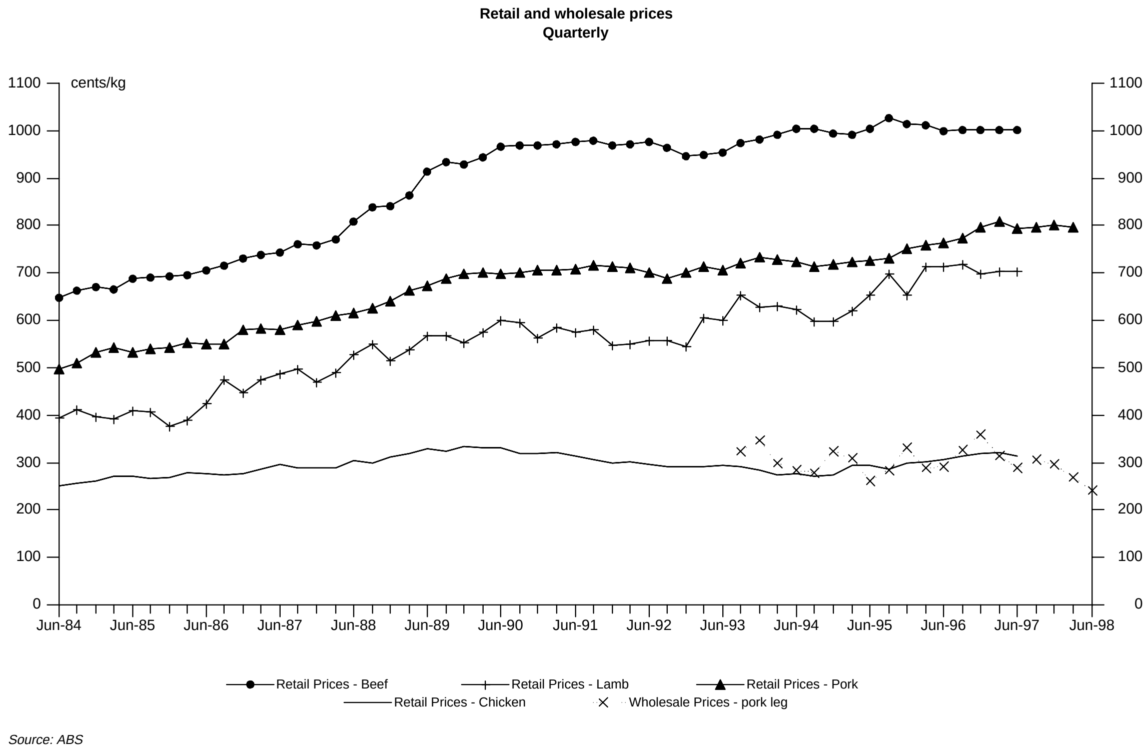

Figure 5.3: Retail and wholesale prices for meat

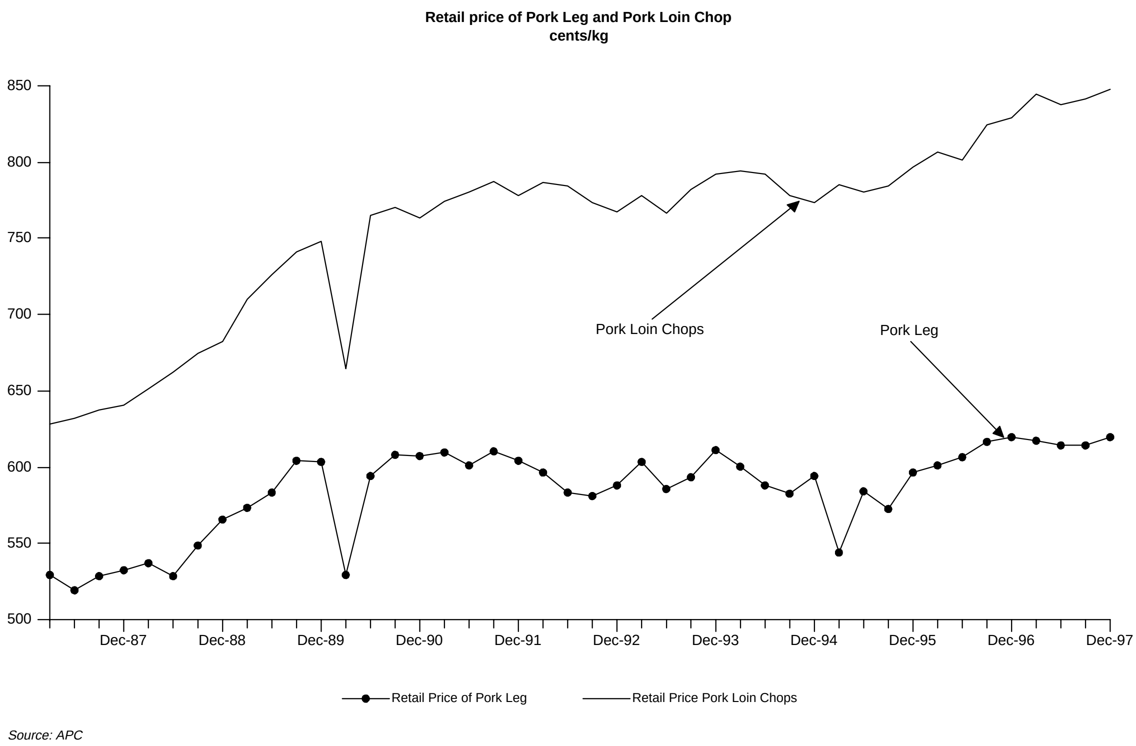

Figure 5.4: Retail prices for Pork Leg and Pork Loin Chops

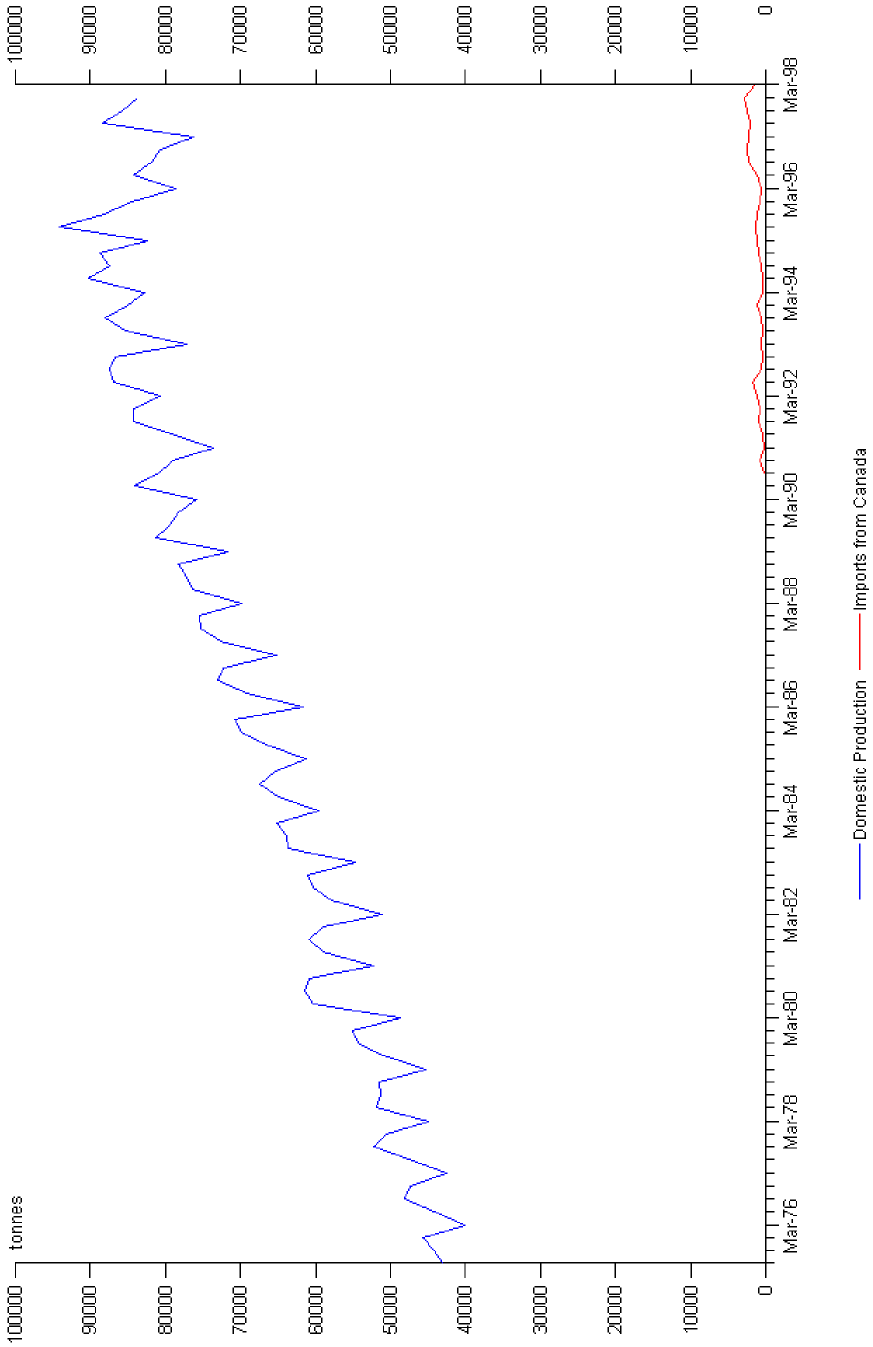

Figure 5.5: Domestic production and imports of pigmeat

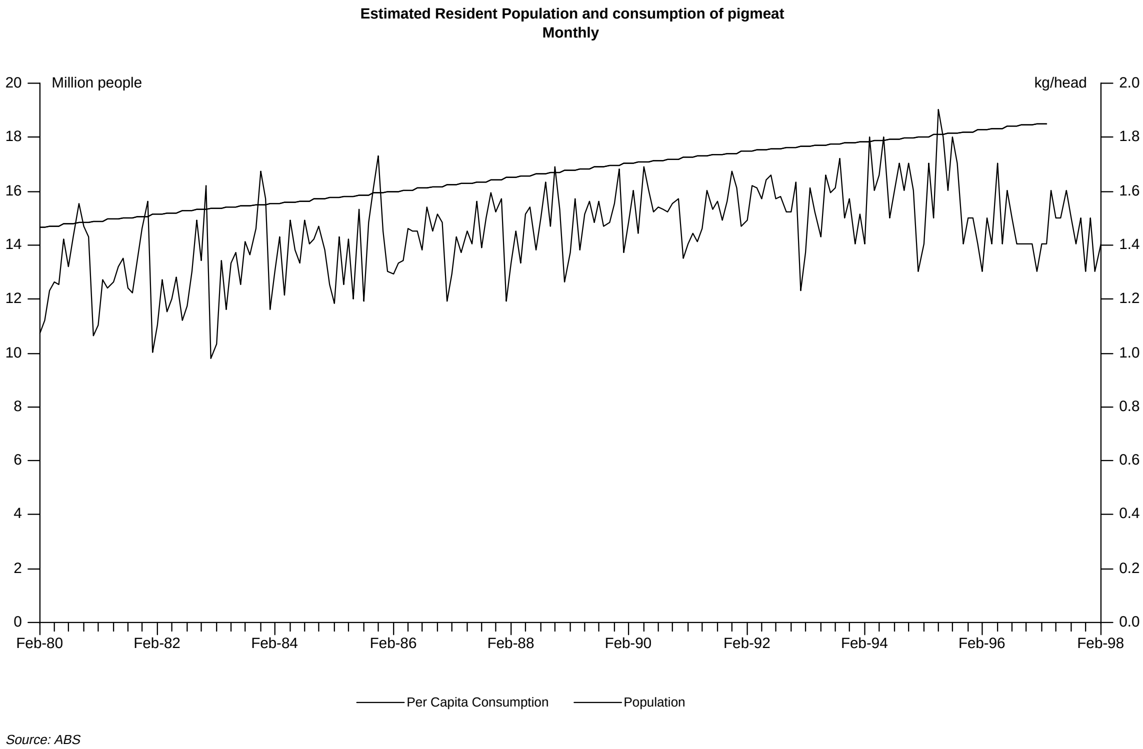

Figure 5.6: Monthly estimated resident population and per capita consumption of pigmeat

Table 5.1: Correlation Matrix

	CAMPQ	CAMVQ	PPDQ	RBFQ	RPQ	RPQC	RPQL
CAMPQ	1.00000						
CAMVQ	0.29256	1.00000					
PPDQ	−0.52650	−0.33420	1.00000				
RBFQ	−0.56284	−0.52370	0.29493	1.00000			
RPQ	0.45650	0.80789	−0.60312	−0.43478	1.00000		
RPQC	0.21778	0.81296	−0.54347	−0.41358	0.91929	1.00000	
RPQL	0.16172	0.59156	−0.43742	−0.10338	0.78442	0.84623	1.00000
SBFQ	−0.20036	−0.71026	0.46690	0.18886	−0.87405	−0.87452	−0.81067
SPQ	0.33852	0.45864	−0.66884	−0.17176	0.56401	0.59997	0.54345
SPQL	0.12172	0.46079	−0.26219	−0.23621	0.62132	0.73560	0.91194
WPQP	0.38905	0.37907	−0.45451	−0.52119	0.31011	0.29884	0.03101
	SBFQ	SPQ	SPQL	WPQP			
SBFQ	1.00000						
SPQ	−0.57601	1.00000					
SPQL	−0.64794	0.35271	1.00000				
WPQP	−0.07286	0.67122	−0.05306	1.00000			

oil-price shock and the subsequent collapse of commodity markets. There also appears to be another shock to production, around 1995-96 which also dropped production levels. Since this is at the end of the data series it is unclear whether this is a short term deviation from the long run trend, or whether there is a structural break.

Import volumes and prices show a seasonal effect but this is not as regular as domestic prices or production series. The long-term trends for both appear to be rather flat. Import volumes start to rise from around March 1996. This corresponds to an equivalent rise in the saleyard price for baconers and a drop in domestic production, although it appears that the drop in domestic production occurred first.

Saleyard prices for beef cattle also show seasonal effects with an upward trending price over time up to June 1994. The period post June 1994 shows prices crashing to historical lows over the dataset period.

To give an idea of the strength of the relationship between the variables in the dataset the correlation matrix is computed and presented in Table 5.1.

The results suggest that import prices have a low correlation with prices and production but import volumes have a high correlation with the retail price of pork, the saleyard price of cattle and the retail price of chicken. The wholesale price has a low correlation with the other prices and production and the retail price of pork has a low correlation with saleyard price for baconers.

Even though exploratory analysis is useful in identifying interesting features of the time series, since the time series is just a random sample from the underlying population, it is uncertain whether or not a feature is part of the underlying economic relationship, or just an artefact of the sample dataset. Statistical inference, and its econometric extensions, needs to be used in order to test rigorously whether or not a perceived relationship is actually significant. In the following chapters we present a framework that subjects the data to rigorous scientific analysis in order to prove, or disprove, our initial observations.

Chapter 6

Non-stationarity and seasonality in the Australian pig industry

6.1 Introduction

An important result of the new econometric methodology, as distinct from the more traditional "Cowles Commission" approach, is the finding that many economic variables are changing over time and that traditional regression techniques assume that they are not. A simple example of this is the inflationary effect on prices. The consequence of neglecting to take into account the non-stationarity of variables is that a significant relationship may be discovered between variables which is in fact spurious. This chapter reviews the relevant econometric theory behind testing for stationarity. It builds from the specific case of non-seasonal data to the case of seasonal data and then examines testing for stationarity in the presence of a structural shift. Finally, this chapter puts all the theory into a coherent framework for simultaneous testing of seasonally integrated, non-stationary data in the presence of a structural shift.

6.2 Data transformations

Granger and Newbold [43] suggest that two basic differences between the General to Specific approach expounded by Davidson, Hendry, Srba and Yeo (DHSY)[29] and traditional econometrics are the determination of the lag structure of the model and the handling of the residuals. In an attempt to capture the time series dynamics DHSY models typically contain more lags.

In the traditional approach residual terms are treated as casual "add-ons" to equations to account for such things as model mis-specification and variable measurement error. The traditional approach has been to assume that the residuals are white noise (no serial correlation, or due only to random error) and to check this assumption with reference to the Durbin-Watson d statistic, which effectively measures the first-order serial correlation of the residuals. If evidence of significant first order serial correlation is found, the residuals are assumed to be first order autoregressive [42].

If the variables are random walks or autoregressive integrated moving average (ARIMA) processes then spurious relationships will often be found by adopting the classical estimation procedures. A method that is frequently used by econometricians to reduce the problem of serial correlation is to take the first difference in the data. Both first differencing and seasonal adjustment are steps toward prewhitening the data, that is, producing a series having a generally flatter spectrum than the original [43].

If the data are initially in what is termed a "raw data in levels" state, that is, they are not expressed in a natural logarithm form, transforming the raw data into logged data before analysis has been shown to be justified on the grounds of statistical and economic theory [19], [37], [43], [83]. Most agricultural commodities exhibit seasonality, a Cobb-Douglas-like nonlinear production function, and non-constant variance dependent on its level[1]. The logging of the data overcomes heteroscedasticity (non-constant variance) of data in level form [27] and transforms nonlinear relationships into linear relationships. Moreover, differencing data enables trend and seasonal effects to be modelled without the corresponding loss in degrees of freedom which occurs when time trends and seasonal dummies are used [19][2].

---

[1] That is, the untransformed data point of a series.

[2] There is a procedure for testing the appropriateness of a log transformation. A stationary p^{th} order autoregressive process with normally distributed white noise innovations

$$(1 - \Theta(B^p))(X_t - \mu_X) = \epsilon_t \tag{6.1}$$

is fitted to the data in both levels and logged form and the log likelihood values compared. The transformation with the highest log likelihood ratio is chosen as the more appropriate transformation. This is a somewhat circular argument, because the determination of a stationary process and the appropriate transformation of the variable are linked. On balance, the literature suggests that log-transforming the data is a more appropriate action to take than undertaking stationarity and cointegration analysis on the levels form.

6.3 Non-stationarity and unit roots

Once the variables are log-transformed they need to be tested for stationarity. A stationary variable is where the mean, variance and covariance do not change over time.

A stochastic process $\{X_t\}$ is said to be covariance stationary if:

(1) $E(X_t) = \text{constant}=\mu$;

(2) $Var(X_t) = \text{constant} =\sigma^2$; and

(3) $Cov(X_t, X_{t+j}) = \sigma_j$

If one or more of the conditions above is violated then the series is said to be nonstationary. Nonstationarity in time series, where the mean, variance and covariance of the series change over time, can lead to spurious correlation and regression results because tests of significance indicate a relationship when in fact none exist.

Since regression analysis makes sense only for data which are not subject to a trend in the mean, variance and covariance, and almost all economic data series contains trends, it follows that these series have to be detrended before any sensible regression analysis can be performed [19].

A convenient way to remove a trend in a time series is to first-difference the data: $\Delta y_t = y_t - y_{t-1}$. However it may be necessary to difference the data more than once to achieve stationarity. The concept of Integration [37] defines a nonstationary series that can be transformed to a stationary series by differencing d times as being integrated of order $d : y_t \sim I(d)$. Thus, for example, if $y_t \sim I(2)$, then to achieve stationarity: $\Delta\Delta y_t = \Delta^2 y_t = (y_t - y_{t-1}) - (y_{t-1} - y_{t-2}) \sim I(0)$

To test for the order of integration the Augmented Dickey-Fuller (ADF) test [33] can be used which tests the hypothesis that, in the AR(p) equation

$$y_t = \sum_{i=1}^{p} \rho y_{t-i} + \varepsilon_t \tag{6.2}$$

$\rho < 1$ and thus $y_t \sim I(0)$. The ADF test regresses the equation:

$$y_t = \alpha_0 + \alpha_1 T + \rho y_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + u_t \tag{6.3}$$

for a sufficient number of lags (p) until the residuals become white noise, and simultaneously the Akaike Information Criterion (AIC) [5] :

$$AIC(p,q) = \ln \hat{\sigma}^2 + \frac{2(p+k)}{n} \tag{6.4}$$

gives a minimum value[3]. The residuals can be tested for white noise, or non serial correlation, with the Ljung-Box Q statistic:

$$Q = n(n+2)\sum_{j=1}^{p}\frac{r_j^2}{(n-j)} \sim \chi_p^2 \tag{6.6}$$

where r_j is the j^{th} autocorrelation coefficient under $H_o : E(\varepsilon_i, \varepsilon_j) = 0 \quad i \neq j$ (the residuals are white noise).

When the residuals are white noise and the AIC is at its minimum, an examination of the Student-t ratio for ρ ($H_0 : \rho = 1$, nonstationary; $H_1 : \rho < 1$, stationary) using the critical $\hat{\tau}_{\beta T}$ values in Dickey and Fuller [33, p. 1062, Table III] determines whether or not the series is stationary.

There is a potential problem with $I(d)$ series where $d > 1$. The Said-Dickey approach [81] provides a procedure for ARMA processes where the DGP is of the form

$$\Delta y_t = \alpha_0 + \alpha_1 T + (\rho - 1) y_{t-1} + \sum_{i=1}^{k}\beta_i \Delta y_{t-1} + v_t \tag{6.7}$$

or more generally

$$\Delta^d y_t = \alpha_0 + \alpha_1 T + (\rho - 1)\Delta^{d-1} y_{t-1} + \sum_{i=1}^{k}\beta_i \Delta^d y_{t-1} + v_t \tag{6.8}$$

where $\Delta^d y_t = \Delta y_t - \Delta y_{t-1} - ... - \Delta y_{t-d}$. If the series is stationary for $\Delta^d y_t$ then $y_t \sim I(d)$. The problem lies in the specification of the null and alternative hypotheses. The alternative hypothesis is that $H_1 : \rho < 1$, the series is stationary, $y_t \sim I(0)$, which clearly is not the case if we reject the null hypothesis that $y_t \sim I(d)$. Dickey and Pantula [35] take a sequential approach to testing: $H_0 : \rho = 1$, $y_t \sim I(d)$ versus $H_1 : \rho < 1$, $y_t \lesssim I(d)$, and decrease the order of differencing each time the null hypothesis is rejected[4].

[3] This version of the AIC is taken from Judge *et al.* [57, p. 728] which is slightly different but analogous to other versions like, for instance,

$$AIC = \frac{-2 \cdot \ln L(\bullet) + 2 \cdot k}{T} \tag{6.5}$$

where $\ln L(\bullet)$ is the value of the loglikelihood function of the estimated model [20, p. 251] and k is the number of parameters estimated.

[4] There is an important point to make about the specification of the null and alternative hypothesis. The null hypothesis is that there is no change from the status quo, or no change from the previous position. The alternative hypothesis is that there has been a change from the previous position. Inferential statistics is based on the concept of random

6.4 Incorporating seasonality effects into non-stationary time series

Testing for unit roots (non-stationarity) becomes more complicated when dealing with data subjected to seasonal fluctuations. Seasonality can present itself in two forms, deterministic seasonality - modelled by the inclusion of seasonal dummies and stochastic seasonality - modelled by seasonal differences.

Definition 1 *A nonstationary series is* $y_t \sim SI_s(d, D)$ *if seasonal differences of* D *times and then first differences of* d *times is required to make the series stationary -* $y_t \sim SI_s(0, 0)$[5] *[20, p. 98].*

The HEGY test, proposed by Hylleberg, Engle, Granger and Yoo [51], allows seasonal dynamics to be captured. The HEGY test for quarterly data, with a constant term[6], deterministic seasonality and augmentation like that for the ADF test, is

$$\Delta_4 y_t = \pi_0 + \sum_{i=1}^{4} \pi_i Y_{i,t-1} + \sum_{i=1}^{4} b_i Q_t^i + \sum_{i=1}^{k} \delta_i \cdot \Delta_4 y_{t-i} + \varepsilon_t \qquad (6.9)$$

where Δ_4 is the order of seasonal differencing (Δ_s), Q_t^i denote seasonal dummy variables, the $Y_{i,t}$ are constructed from

$$Y_{1,t} = y_t + y_{t-1} + y_{t-2} + y_{t-3} \qquad (6.10)$$

---

samples being drawn from a population and, on the basis of those samples, some inference being drawn about the population. Since the value of the sample statistic, or estimate of the population parameter, (e.g. the sample mean or variance) could be due to chance (since we are drawing random samples from the population) we can never accept the null hypothesis, that there has not been a change from the original position. We can reject the null hypothesis, with some degree of certainty called the significance level, but the best we can do about the null hypothesis is to state that "there is insufficient evidence to reject the null hypothesis". Further, rejection of the null hypothesis does not automatically mean the acceptance of the alternative hypothesis either.

A practical example is a paddock full of white sheep (a sample of the entire population of sheep). We cannot conclude that all sheep are white (the null hypothesis) since this does not allow for the existence of black sheep. However, if there is one black sheep in the paddock we can reject the null hypothesis with certainty. Rejection of the null, however, does not automatically mean that we accept the alternative (that black sheep also exist) since this precludes the existence of, for example, green sheep.

[5] In most cases, where the seasonality is additive, seasonal differencing alone is all that is required to achieve stationarity even if $y_t \sim SI_s(1, 1)$. In the case where seasonality is multiplicative, or the trend is non-linear, first differences may also be required

[6] Seasonal differencing removes the trend component, but when the trend is non-linear the series may need to be differenced twice to achieve stationarity.

$$
\begin{aligned}
Y_{2,t} &= -y_t + y_{t-1} - y_{t-2} + y_{t-3} && (6.11)\\
Y_{3,t} &= -y_t + y_{t-2} && (6.12)\\
Y_{4,t} &= -y_{t-1} + y_{t-3} && (6.13)
\end{aligned}
$$

and the π_i's have the following interpretation [20, pp. 108-109]:

$$
\begin{aligned}
\pi_1 &= 0 \quad \text{a unit root at zero frequency}\\
\pi_2 &= 0 \quad \text{a unit root at semi-annual frequency}\\
\pi_3 &= \pi_4 = 0 \quad \text{a unit root at annual frequency}
\end{aligned}
$$

The HEGY test has been shown [68] to be asymptotically equivalent to the Dickey, Hasza and Fuller [34],[67] test (DHF), which is much simpler to implement and has readily available critical values for monthly as well as quarterly data. The test estimates the equation

$$\Delta_s y_t = \alpha_0 + \delta \cdot z_{t-s} + \sum_{i=1}^{k} \delta_i \cdot \Delta_s y_{t-i} + \varepsilon_t \qquad (6.14)$$

where z_{t-s} is constructed[7] from the equation

$$z_t = y_t - \sum_{i=1}^{h} \hat{\lambda}_i \cdot y_{t-i} \qquad (6.15)$$

where $\hat{\lambda}_i = \left(\hat{\lambda}_1, \hat{\lambda}_2, ..., \hat{\lambda}_h\right)$from the estimated equation

$$\Delta_s y_t = \sum_{i=1}^{h} \lambda_i \cdot \Delta_s y_{t-i} + \xi_t \qquad (6.16)$$

Again, like the ADF test, the choice of h and k is determined by a minimum value for the AIC and simultaneous white noise residuals. If the null hypothesis of a unit root $(H_0 : \delta \geq 0)$ is rejected then there is no stochastic seasonality, or none that can be removed by seasonal differencing. If the null hypothesis is not rejected then we cannot conclude that there does not exist stochastic seasonality which can be removed by seasonal differencing. It is the general case that economic series are either $SI_s(0,0)$, $SI_s(0,1)$, or $SI_s(d,1)$ - that is, $SI_s(d,D)$, where $D \geq 2$, is not expected.

After the order of seasonal integration is determined the order of non-seasonal integration needs to be considered. In this situation a new test is

[7] Constructed, not estimated.

constructed; $H_0 : \delta \geq 0,\ y_t \sim SI_s\left(1,1\right),$ versus $H_1 : \delta < 0,\ y_t \sim SI_s\left(0,1\right)$ with the estimated equation

$$\Delta\Delta_s y_t = \delta \cdot \Delta_s y_{t-1} + \sum_{i=1}^{k} \delta_i \cdot \Delta\Delta_s y_{t-i} + \varepsilon_t \tag{6.17}$$

If the null hypothesis in this case is not rejected then the test is repeated with $\Delta^2\Delta_s y_t$ etc. Again, the order of augmentation needs to be determined from the AIC and Ljung-Box Q Statistic. Applying the Dickey and Pantula [35] procedure means that the test

$$\Delta^2\Delta_s y_t = \delta \cdot \Delta\Delta_s y_{t-1} + \sum_{i=1}^{k} \delta_i \cdot \Delta^2\Delta_s y_{t-i} + \varepsilon_t \tag{6.18}$$

for $H_0 : \delta \geq 0,\ y_t \sim SI_s\left(2,1\right),\ H_1 : \delta < 0,\ y_t \sim SI_s\left(1,1\right)$ is applied first and then the test

$$\Delta\Delta_s y_t = \delta \cdot \Delta_s y_{t-1} + \sum_{i=1}^{k} \delta_i \cdot \Delta\Delta_s y_{t-i} + \varepsilon_t \tag{6.19}$$

for $H_0 : \delta \geq 0,\ y_t \sim SI_s\left(1,1\right),\ H_1 : \delta < \ 0,\ y_t \sim SI_s\left(0,1\right)$ is carried out.

6.5 Unit roots in the presence of structural breaks

Structural breaks in time series can take the form of either a 'pulse' (P_t) or a 'shift' (S_t) where

$$P_t = \begin{cases} 1 & \text{if} \quad t = b \\ 0 & \text{otherwise} \end{cases} \tag{6.20}$$

$$S_t = \begin{cases} 1 & \text{if} \quad t \geq b \\ 0 & \text{otherwise} \end{cases} \tag{6.21}$$

respectively and b is the time period where the event occurs [20, p 116]. In a stationary time series the pulse effect is temporary and the shift effect is permanent but in the case of an $I\left(1\right)$ series the pulse effect is permanent[8]. The presence of structural breaks in potentially non-stationary series has been shown by Perron [69, 70], and Perron and Vogelsang [71] to bias the DF and ADF tests towards non-rejection of the unit root null because of a

[8] An example is provided in [20, pp. 116-117].

confounding effect of a non-stationary mean with the effect of a change in the mean due to a structural break at a known point. Perron suggests a two-step procedure to test for the presence of a unit root in a series with a shift or a pulse structural break.

The first step is to estimate the equation

$$y_t = \mu + \delta S_t + \varepsilon_t \tag{6.22}$$

and obtain the residuals which have been stripped of any shift structural break. The second stage is to estimate the ADF analogue:

$$\Delta e_t = \omega S_t + \alpha^* e_{t-1} + \sum_{i=1}^{k} \alpha_i^* \cdot \Delta e_{t-i} + \nu_t \tag{6.23}$$

for a sufficient number of lags (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated. At this stage α^* is examined and compared with the Perron 'additive outlier' critical values with the λ parameter being the proportion of the shift relative to the whole sample period. The hypotheses are:

$$\begin{aligned} H_0 &: \alpha^* \geq 0, \qquad y_t \sim I(1) \\ H_1 &: \alpha^* < 0, \qquad y_t \sim I(0) \end{aligned}$$

so a rejection of the null hypothesis indicates that the series is stationary with a shift function[9]. Again, the Dickey-Pantula procedure can be adopted to test for higher orders of integration.

6.6 A framework for testing seasonal integration in the presence of a structural break

The DHF test initially regresses the equation

$$\Delta_s y_t = \sum_{i=1}^{h} \lambda_i \cdot \Delta_s y_{t-i} + \xi_t \tag{6.24}$$

[9] The Perron 'additive outlier' test actually tests in the second stage for the presence of a pulse structural break, i.e. the null hypothesis is that the series follows a non-stationary process with a pulse and the alternative hypothesis is that the series follows a stationary process with a shift. $H_0 : y_t = \mu + \gamma P_t + y_{t-1} + \varepsilon_t$ and $H_1 : y_t = \mu + \delta S_t + \varepsilon_t$ leading to the ADF analogue being $\Delta e_t = \omega P_t + \alpha^* e_{t-1} + \sum_{i=1}^{k} \Delta e_{t-i} + \nu_t$. In this particular case we are interested in the null hypothesis being that the process is non-stationary with a shift structural break rather than a pulse.

for a sufficient number of lagged terms (h) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated.

The estimated coefficients from the reduced equation are used to construct the variable z_t

$$z_t = y_t - \sum_{i=1}^{h} \hat{\lambda}_i \cdot y_{t-i} \tag{6.25}$$

which is then used in the regression

$$\Delta_s y_t = \alpha_0 + \delta \cdot z_{t-s} + \sum_{i=1}^{k} \delta_i \cdot \Delta_s y_{t-i} + \varepsilon_t \tag{6.26}$$

where the terms $\Delta_s y_{t-i}$ are lagged for a sufficient number (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated.

At this point δ is examined and the t-statistic is compared with the critical values for the DHF test with intercept. The hypotheses are:

$$\begin{aligned} H_0 &: \delta \geq 0 \quad \text{the series is seasonally integrated} \\ H_1 &: \delta < 0 \quad \text{the series is not seasonally integrated} \end{aligned}$$

If the null hypothesis is not rejected then we cannot conclude that there does not exist stochastic seasonality which can be removed by seasonal differencing.

After the order of seasonal integration is determined the order of non-seasonal integration needs to be considered. Under the hypotheses

$$\begin{aligned} H_0 &: \delta \geq 0, \qquad y_t \sim SI_s(2,1) \\ H_1 &: \delta < 0, \qquad y_t \sim SI_s(1,1) \end{aligned}$$

the ADF test regresses the equation

$$\Delta^2 \Delta_s y_t = \alpha_0 + \delta \cdot \Delta\Delta_s y_{t-1} + \sum_{i=1}^{k} \delta_i \cdot \Delta^2 \Delta_s y_{t-i} + \varepsilon_t \tag{6.27}$$

for a sufficient number of lags (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated. At this stage δ is examined and the t-statistic is compared with the $\hat{\tau}_{\beta\tau}$ critical values for the ADF test with intercept. If the null hypothesis is not rejected then we cannot conclude that there does not exist $SI_s(2,1)$ integration which can be removed by first differencing twice. If the null hypothesis is rejected then the ADF test is repeated for

$$\begin{aligned} H_0 &: \delta \geq 0, \qquad y_t \sim SI_s(1,1) \\ H_1 &: \delta < 0, \qquad y_t \sim SI_s(0,1) \end{aligned}$$

with the test

$$\Delta\Delta_s y_t = \alpha_0 + \delta \cdot \Delta_s y_{t-1} + \sum_{i=1}^{k} \delta_i \cdot \Delta\Delta_s y_{t-i} + \varepsilon_t \tag{6.28}$$

for a sufficient number of lags (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated. At this stage δ is examined and the t-statistic is compared with the $\hat{\tau}_{\beta\tau}$ critical values for the ADF test with intercept. If the null hypothesis is not rejected then we cannot conclude that there does not exist $SI_s(1,1)$ integration which can be removed by first differencing. If the null hypothesis is rejected then the series is stationary.

If we test for the presence of a shift structural break the ADF test now becomes a two-step procedure. First the equation

$$\Delta_s y_t = \mu + \delta S_t + \varepsilon_t \tag{6.29}$$

(a seasonally integrated stationary process subject to a shift) is estimated and then the residuals are taken and used in the second stage regression

$$\Delta^2 e_t = \omega S_t + \alpha^* \Delta e_{t-1} + \sum_{i=1}^{k} \alpha_i^* \cdot \Delta^2 e_{t-i} + \nu_t \tag{6.30}$$

for a sufficient number of lags (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated. At this stage α^* is examined and the t-statistic is compared with the Perron 'additive outlier' critical values with the λ parameter being the proportion of the shift relative to the whole sample period. The hypotheses are:

$$\begin{aligned} H_0 &: \alpha^* \geq 0, \qquad y_t \sim SI_s(2,1) \\ H_1 &: \alpha^* < 0, \qquad y_t \sim SI_s(1,1) \end{aligned}$$

If the null hypothesis is rejected then the test is repeated for

$$\Delta e_t = \omega S_t + \alpha^* e_{t-1} + \sum_{i=1}^{k} \alpha_i^* \cdot \Delta e_{t-i} + \nu_t \tag{6.31}$$

for a sufficient number of lags (k) until the AIC is at a minimum and the residuals are white noise. The t-statistics for the lagged terms are examined, non-significant lagged variables are eliminated and the reduced equation is re-estimated. At this stage α^* is examined and the t-statistic is compared with the Perron 'additive outlier' critical values with the λ parameter being the proportion of the shift relative to the whole sample period. The hypotheses are:

$$\begin{aligned} H_0 &: \alpha^* \geq 0, & y_t \sim SI_s(1,1) \\ H_1 &: \alpha^* < 0, & y_t \sim SI_s(0,1) \end{aligned}$$

so a rejection of the null hypothesis indicates that the series is stationary with a shift function.

6.7 Results

The variables were tested for the presence of unit roots. The Dickey-Hasza-Fuller (DHF) test for seasonally integrated variables was carried out. The first step is to calculate the z_t coefficients[10] [11] which are used in the DHF analogue of the ADF test. The results are presented in Tables 6.1 to6.4[12].

[10] In determining the optimal lag length for Pork Leg and Pork Loin Chops retail price the AIC does not appear to reach a minimum when the lag lengths are augmented, i.e. there appears to be a flattening out of the AIC on lag-length curve but then the AIC continues to drop beyond a reasonable lag length. This flattening out appears to occur between 3 and 4 lag lengths for Pork Leg and 4 and 5 for Pork Loin Chops. It was decided to take 3 lag lengths and 4 lag lengths respectively as being the optimum.

[11] In addition to the problem of a non-minimum AIC noted above, all the lags of the Pork Loin Chop retail price are non-significant with an augmentation of 4 lag lengths. Ng and Perron [65] choose lags based on sequential tests over those based on information criteria such as AIC or SBC because the sequential tests show less size distortion than the information criteria. Sequentially reducing the lag length shows that lags 1 and 2 are significant and the OLS parameter estimates of these are taken as the coefficients used in the construction of $z_{t.}$

[12] The test statistics are presented with corresponding critical values. * indicates a significance level of 5%, that is, we are 95% confident of rejecting the null hypothesis correctly. ** indicates a significance level of 1%, that is we are 99% confident of rejecting the null hypothesis correctly.

Table 6.1: DHF seasonal integration test - Determination of z_t (I)

Variable	Lag	AIC	Ljung-Box[p-value]	z_t coefficients $\hat{\lambda}_1$	$\hat{\lambda}_2$
Δ_4SPQ	1	61.9749	3.5310[.060]		
	2	62.6516	0.33993[.560]		
	3	61.1650	0.42789[.513]	0.76673	
	4	62.2746	0.26825[.605]		
Δ_4SBFQ	1	55.1882	0.53213[.466]		
	2	53.2564	0.0078093[.930]		
	3	50.9386	0.022879[.880]		
	4	50.3499	0.43065[.512]	0.72271	
	5	50.6889	0.0003647[.985]		
Δ_4RBFQ	1	134.4315	4.4467[.035]	0.95567	
Δ_4RPQ	1	122.5675	0.11047[.740]		
	2	118.6040	0.020582[.886]		
	3	115.2706	0.15866[.690]	0.88167	
	4	115.7511	0.77603[.378]		
Δ_4RPLQ	1	65.2405	0.52920[.467]		
	2	62.5491	0.014028[.906]		
	3	59.6039	0.12597[.723]	0.45660	
	4	59.5751	0.0089766[.925]		
Δ_4RPLCQ	1	68.4750	3.9665[.046]		
	2	67.5478	0.63804[.424]		
	3	65.2805	0.010268[.919]		
	4	63.6507	0.024224[.876]	0.36126	0.32304
	5	63.2713	0.56952[.450]		

Table 6.2: DHF seasonal integration test - Determination of z_t (II)

Variable	Lag	AIC	Ljung-Box[p-value]	z_t coefficients $\hat{\lambda}_1$	$\hat{\lambda}_2$
Δ_4CAMVQ	1	-34.6090	0.78692[.375]	0.32612	
	2	-33.5916	0.78281[.376]		
Δ_4CAMPQ	1	14.4982	5.1369[.023]		
	2	20.5841	3.0116[.083]	0.88296	-0.37639
	3	21.9393	0.12505[.724]		
Δ_4PPDQ	1	255.9056	0.17929[.672]		
	2	253.5682	0.44850[.503]	0.79939	
	3	262.2354	1.2691[.260]		
Δ_{12}WPM	1	68.5725	0.15407[.695]		
	2	66.8838	0.060793[.805]		
	3	65.4400	0.0096224[.922]		
	4	62.6025	0.0012117[.972]		
	5	60.0790	0.2751×10^{-4}[.996]		
	6	58.6294	0.0084830[.927]		
	7	55.9087	0.0041355[.949]		
	8	53.0245	0.025326[.874]	0.89769	
	9	53.6555	0.071438[.789]		

Table 6.3: DHF seasonal integration test - determination of seasonality (I)

Variable	Lag	AIC	Ljung-Box[p-value]	z_{t-4} $t\,(df)$
Δ_4SPQ	1	65.7561	1.4975[.221]	$-3.4852\,(49)^{**}$
	2	65.8681	0.33088[.565]	
Δ_4SBFQ	1	63.1350	0.023983[.877]	
	2	60.3737	0.00008476[.993]	
	3	59.5304	0.078765[.779]	
	4	56.7548	0.12161[.727]	
	5	55.6339	1.0917[.296]	
	6	54.3718	0.43568[.509]	
	7	53.0876	0.79628[.372]	$-4.7968\,(46)^{**}$
	8	53.1459	0.75526[.385]	
Δ_4RBFQ	1	143.6958	2.7828[.095]	$-5.1271\,(46)^{**}$
Δ_4RPQ	1	129.6926	2.1444[.143]	
	2	127.6496	1.7939[.180]	
	3	125.1608	0.77385[.379]	$-4.1125\,(46)^{**}$
	4	128.0569	3.6307[.057]	
Δ_4RPLQ	1	76.0553	0.35465[.551]	
	2	74.5859	0.35245[.553]	
	3	71.3504	0.46405[.496]	
	4	67.8555	0.52177[.470]	
	5	64.8032	0.22675[.634]	
	6	61.2599	0.21883[.640]	
	7	58.3611	0.11895[.730]	
	8	55.0690	0.064384[.800]	$-4.7829\,(37)^{**}$
	9	65.1616	0.044268[.833]	
Δ_4RPLCQ	1	78.6160	0.020591[.886]	$-5.3750\,(35)^{**}$
	2	79.2860	0.041724[.838]	

Table 6.4: DHF seasonal integration test - determination of seasonality (II)

Variable	Lag	AIC	Ljung-Box[p-value]	z_{t-4} $t\,(df)$
Δ_4CAMVQ	1	-25.8789	6.2973[.012]	
	2	-25.5479	6.0904[.014]	
	3	-23.9916	5.6798[.017]	
	4	-23.2825	3.9608[.047]	
	5	-22.6394	1.3585[.244]	$-1.2040\,(15)$
	6	-18.3240	.015122[.902]	
Δ_4CAMPQ	1	16.4364	.040388[.841]	$0.74938\,(22)$
	2	20.6854	4.6704[.031]	
Δ_4PPDQ	1	260.4600	1.8386[.175]	$-3.2489\,(149)^{**}$
	2	260.9578	.26440[.607]	
Δ_{12}WPM	1	76.8070	1.9862[.159]	$-4.7352\,(48)^{**}$
	2	74.7881	1.3920[.238]	

The results show that there is stochastic seasonality for import volumes[13] and prices for Canadian pigmeat but all other variables[14] do not exhibit any stochastic seasonality (which can be removed by seasonal differencing).

The order of non-seasonal integration needs to be determined as well. For import volumes and prices this can be determined within the framework of the DHF test. The results are shown in Table 6.5. For the other, non-seasonally integrated variables a simple ADF test will suffice. The Perron 'additive outlier' test for structural breaks does not need to be carried out for import volumes and prices - as they are the cause of the proposed structural break itself.

[13] The import volume of pigmeat from Canada exhibited significant serial correlation up to an augmented lag length of 5. The fifth lag length had the minimum AIC for non-significant serial correlation compared to subsequent lag lengths. It was decided not to eliminate the non-significant lag lengths (lags 3-5) as per the general-to-specific approach since this would have re-introduced serial correlation in the re-estimated model. As a consequence the t-statistic for z_{t-4} is not significant, indicating that the series is seasonally integrated. If the non-significant lag lengths had been eliminated then the t-statistic would have been highly significant, indicating that the series is not seasonally integrated. This naturally leads to another question, if the non-significant lag lengths had not been eliminated from the other variables' DHF tests would this have changed their test results, i.e. would they have been seasonally integrated? A check of the z_{t-4} t-statistics for the other variables at their minimum AIC and non-significant Ljung-Box Q statistic augmented lag lengths reveals that the t-statistics are robust to changes in lag length.

[14] The AIC for both the retail price of beef and the wholesale price for pork does not reach a minimum for a realistic set of lags for the augmentation. Ng and Perron's [65] sequential testing procedure is used instead, starting of at a lag length of 10. Only the first augmented lag is significant.

Table 6.5: ADF tests of non-seasonal integration for imports

Variable	Lag	AIC	Ljung-Box[p-value]	$\Delta^{d-1}\Delta_s y_{t-1}$ $t\,(df)$
$\Delta^2\Delta_4$CAMVQ	1	-34.2234	.85712[.355]	$-4.7145\,(21)^{**}$
	2	-32.4871	.38550[.535]	
$\Delta\Delta_4$CAMVQ	1	-34.2570	.90273[.342]	$-2.7371\,(22)^{*}$
	2	-29.5219	.043046[.836]	
$\Delta^2\Delta_4$CAMPQ	1	15.3448	.054381[.816]	
	2	14.5387	.60205[.438]	$-5.2157\,(23)^{**}$
	3	15.8131	.20284[.652]	
$\Delta\Delta_4$CAMPQ	1	19.5863	2.9905[.084]	$-3.2869\,(22)^{**}$
	2	21.1335	.10760[.743]	

The results show that import volumes and prices are stationary, i.e. CAMVQ and CAMPQ $\sim SI_4\,(0,1)$.

The other variables need to be tested for non-seasonal integration. The test for seasonal integration carried out above tested for stochastic seasonality, not for deterministic seasonality. In addition to testing the variables for an $I\,(d)$ stochastic process all the variables, including import volumes and prices but excluding the wholesale price for pork[15], are tested for deterministic seasonality using seasonal dummies[16] (see Tables 6.6 and 6.7).

The results show that for the test of non-seasonal integration with deterministic seasonality:

1. The import volume and unit value of pigmeat from Canada (CAMVQ and CAMPQ) are stationary without any deterministic seasonality, i.e. both are $SI_4\,(0,1)$

2. The saleyard price for baconers (SPQ)[17] is non-stationary $I\,(1)$ with

[15] The wholesale price for pork was not tested using seasonal dummies, since critical values have not been tabulated for monthly data. Instead a standard ADF test, with intercept and trend was calculated.

[16] Seasonal dummy variables affect both the mean and the trend of a series. Johansen[55, p 84] recommends using centred (orthogonalized) seasonal dummy variables, which shift only the mean without contributing to the trend. When centred seasonal dummies are used in the ADF test the correlation matrix is near singular, indicating possible multicollinearity. Since neither an intercept nor a trend is used in the ADF test, due to critical values not being tabulated for this scenario, it was decided to use normal seasonal dummies (uncentered) which will incorporate any trend component left out of the explicit ADF regression.

[17] The saleyard price for baconers did not have a minimum AIC for a realistic set of augmented lags. Applying Ng and Perron's [65] general-to-specific procedure reduced the augmented lags to 3 for Δ^2 and no augmentation for Δ. The seasonal dummies are all

Table 6.6: ADF tests of unit roots with deterministic seasonality (I)

Variable	Lag	AIC	Ljung-Box[p-val]	$\Delta^{d-1}y_{t-1}$ $t\,(df)$	Q_t^i $(p \leq 0.05)$
$\Delta^2\Delta_4$CAMVQ	1	-37.0604	0.90770[.341]	$-6.8380\,(20)^{**}$	
	2	-35.2908	0.37033[.543]		
$\Delta\Delta_4$CAMVQ	1	-37.1742	0.86834[.351]	$-4.7129\,(24)^{**}$	
	2	-32.2872	0.047708[.827]		
$\Delta^2\Delta_4$CAMPQ	1	12.5382	0.081912[.775]		
	2	11.8815	0.51657[.472]	$-5.3544\,(23)^{**}$	
	3	12.8672	0.23925[.625]		
$\Delta\Delta_4$CAMPQ	1	16.8330	2.8958[.089]	$-3.3631\,(23)^{*}$	
	2	18.2095	0.078174[.780]		
Δ^2SPQ	1	81.7042	0.0010456[.974]		
	2	79.0847	0.032836[.856]		
	3	78.8853	0.27365[.601]	$-4.1724\,(44)^{**}$	$Q_t^1, Q_t^2, Q_t^3, Q_t^4$
ΔSPQ	0	87.9129	1.0586[.304]	$-2.6239\,(51)$	$Q_t^1, Q_t^2, Q_t^3, Q_t^4$
	1	86.1828	0.014011[.906]		
Δ^2SBFQ	1	65.7687	0.25238[.615]	$-7.3308\,(49)^{**}$	
ΔSBFQ	0	67.4941	0.18872[.664]	$-.12605\,(51)$	
	1	65.9565	0.0083684[.927]		
Δ^2RBFQ	0	149.7419	1.0388[.308]	$-5.0614\,(50)^{**}$	Q_t^2
	1	147.5309	0.093749[.759]		
ΔRBFQ	1	153.4180	0.8455×10^{-3}[.977]		
	2	148.9561	0.0082833[.927]		
	3	146.6394	0.010176[.920]		
	4	144.0351	0.16252[.687]		
	5	140.4477	0.40303[.526]	$-2.4244\,(46)$	$Q_t^1, Q_t^2, Q_t^3, Q_t^4$
	6	140.8569	0.20908[.647]		
Δ^2RPQ	0	146.8428	0.018906[.891]	$-7.1298\,(48)^{**}$	Q_t^1, Q_t^3, Q_t^4
ΔRPQ	1	148.1809	0.2822×10^{-5}[.999]		
	2	144.5468	0.13309[.715]		
	3	142.6407	0.13465[.714]		
	4	140.7789	0.4104×10^{-3}[.984]	$2.8301\,(47)$	
	5	141.2661	0.39084[.532]		

Table 6.7: ADF tests of unit roots with deterministic seasonality (II)

Variable	Lag	AIC	Ljung-Box[p-val]	$\Delta^{d-1}y_{t-1}$ $t\,(df)$	Q_t^i $(p \leq 0.05)$
Δ^2RPLQ	0	80.9215	.21608[.642]	$-9.4955\,(41)^{**}$	
ΔRPLQ	0	82.8526	3.2410[.072]	$-2.5068\,(38)$	$Q_t^1, Q_t^2, Q_t^3, Q_t^4$
Δ^2RPLCQ	0	85.8365	.46775[.494]	$-9.1418\,(41)^{**}$	
ΔRPLCQ	1	86.7634	.74251[.389]	$2.1180\,(40)$	
Δ^2PPDQ	1	269.9393	.12119[.728]		
	2	264.9399	4.4606[.035]	$-12.6465\,(160)^{**}$	Q_t^1, Q_t^2, Q_t^4
	3	287.3091	1.1756[.278]		
ΔPPDQ	0	251.4199	3.4550[.063]		
	1	250.6376	.45374[.501]	$4.1120\,(162)$	Q_t^1, Q_t^2
	2	256.6865	.44828[.503]		
Δ^2WPM	1	88.7682	.012489[.911]		
	2	85.9293	.0037328[.951]		
	3	83.2576	.079132[.778]		
	4	83.7002	.24223[.623]	$-4.9701\,(50)^{**}$	
	5	83.2499	.22458[.636]		
ΔWPM	1	86.6015	.0030216[.956]		
	2	85.6179	$.8658 \times 10^{-3}$[.977]	$-3.0139\,(52)$	
	3	86.7865	.066196[.797]		

deterministic seasonality where all four quarters have a significant effect.

3. The saleyard price for beef cattle (SBFQ)[18] is non-stationary $I(1)$ without any deterministic seasonality.

4. The retail price of beef (RBFQ)[19] is non-stationary $I(1)$ with deterministic seasonality where all four quarters have a significant effect.

5. The retail price of pork (RPQ) is non-stationary $I(1)$ without any deterministic seasonality.

6. The retail price of pork legs (RPLQ) and pork loin chops (RPLCQ)[20] are non-stationary $I(1)$ where the seasonal dummies were all significant for the price of pork legs, but not for the price of the pork loin chops.

7. The production of pigmeat (PPD) is non-stationary $I(1)$ with deterministic seasonality significant in the first two quarters.

8. The wholesale price of pork legs (WPM) is non-stationary $I(1)$[21].

In addition to testing for unit roots with deterministic seasonality present, the variables need to be tested for unit roots in the presence of structural breaks because the DF and ADF tests are biased towards non-rejection of the unit root null in the presence of a structural break. The Perron 'additive outlier' test is carried out on all the variables except import volume and unit value and wholesale price of pork legs[22] (see Table 6.8).

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significant in both cases.

[18] The saleyard price for beef cattle did not have a minimum AIC for a realistic set of augmented lags. Applying Ng and Perron's [65] general-to-specific procedure reduced the augmented lags to 1 for Δ^2 and no augmentation for Δ. The seasonal dummies are non-significant in both cases.

[19] The retail price for beef and pork did not have a minimum AIC for a realistic set of augmented lags for Δ^2. Applying Ng and Perron's [65] general-to-specific procedure resulted in no augmentation for Δ^2 for both prices.

[20] The retail prices for pork leg and pork loin chops did not have a minimum AIC for a realistic set of augmented lags. Applying Ng and Perron's[65] general-to-specific procedure resulted in no augmentation for Δ^2 and Δ for the price of pork legs, no augmentation for Δ^2 for the price of pork loin chops, but 1 lagged augmentation for Δ for the price of pork loin chops.

[21] Regressions of the wholesale price for pork legs suggest that monthly dummies are significant, indicating that some level of deterministic seasonality exists.

[22] The residuals for PPDQ - the production of pigmeat show a significant shift due to the oil-price shock 1973-1974. As a consequence, the residuals for PPDQ are estimated from 1975:1 onwards. None of the other series has data over that time period. The wholesale price for pork legs does not have data over the period of the first structural break, in 1990:1 and thus is not tested for a structural break.

Table 6.8: Perron 'additive outlier' unit root test

Residuals	Lag	AIC	Ljung-Box[p-value]	$\Delta^{d-1}e_{t-1}$ $t\,(df)$
Δ^2SPQ	1	69.9057	.48320[.487]	$-10.3561\,(51)^{**}$
	2	70.1155	$.1306E-5$[1.00]	
ΔSPQ	1	65.2656	1.0135[.314]	$-4.1225\,(52)^{*}$
	2	71.4099	1.0098[.315]	
Δ^2SBFQ	1	66.7948	.031445[.859]	$-7.7078\,(51)^{**}$
ΔSBFQ	1	65.0056	.0041615[.949]	$-1.5778\,(51)$
	2	65.8282	.043357[.835]	
Δ^2RBFQ	0	93.4573	.013664[.907]	$-7.0765\,(51)^{**}$
ΔRBFQ	0	98.1078	.023432[.878]	$-2.1689\,(51)$
Δ^2RPQ	0	100.0009	.028605[.866]	$-6.6084\,(50)^{**}$
ΔRPQ	0	104.5708	.27185[.602]	$-2.1162\,(51)$
Δ^2RPLQ	0	82.6335	.33530[.563]	$-11.0462\,(40)^{**}$
ΔRPLQ	1	84.7509	.071951[.789]	$-2.4982\,(39)$
Δ^2RPLCQ	0	82.2702	.17381[.677]	$-11.6382\,(40)^{**}$
ΔRPLCQ	1	83.3094	.029426[.864]	$-1.9943\,(39)$
Δ^2PPDQ	1	92.8509	1.9167[.166]	$-9.9535\,(86)^{**}$
	2	101.9767	4.2188[.040]	
ΔPPDQ	1	94.2232	.47191[.492]	$-2.6044\,(87)$
	2	94.3877	1.5482[.213]	

The results, for the main part, confirm the earlier unit root tests. All the variables follow an $I(1)$ process except for the saleyard price for baconers. The saleyard price for baconers appears to follow an $I(0)$ process with a shift due to the introduction of imports. The residual plot for the baconer saleyard prices Perron 'additive outlier' regression

$$\Delta e_t = \omega S_t + \alpha^* e_{t-1} + \sum_{i=1}^{k} \alpha_i^* \Delta e_{t-1} + \nu_t \tag{6.32}$$

shows a structural shift at the beginning of 1990 (see Figure 6.1). This result is tempered by conflicting test diagnostics[23] and there is a debate[24] about the appropriate method of conducting ADF tests and the optimal lag length to use.

6.8 Summary

The results for the tests of unit roots under seasonal integration suggest that imports volumes and prices of pigmeat from Canada follow a stochastic seasonality non-stationary process, that is, there is a correlation between respective seasons which shifts over time. This non-stationary process can be eliminated by differencing between respective seasons. This result indicates that previous studies using the same dataset [1], [45], which did not take into

[23] The ad-hoc approach using a minimum AIC with no serial correlation identifies an optimal, parsimonious lag length. Increasing the lag length beyond this point increases the AIC. The lag lengths become significant and α^* becomes insignificant, indicating that saleyard baconer prices are in fact $I(1)$. The general-to-specific approach advocated by Ng and Perron would have reached an optimal lag length that was in fact longer than that achieved by the minimum AIC approach, and thus concluded that saleyard baconer prices were $I(1)$. However, increasing the lag lengths beyond that adocated by a minimum AIC shows that every second additional lag length is significant, and, more importantly, that the residuals exhibit significant serial correlation. The implication is that the $I(1)$ process observed using the Ng and Perron procedure is an artifact of serial correlation, rather than the data generating process.

[24] A recent discussion on the econometric-research mailing list focused on this topic. A summary has been posted on the internet at

http://www.mailbase.ac.uk/lists/econometric-research/archive.html

in the file adf_test_lags.txt

The broad conclusions of the debate identified two alternative approaches to testing for the optimal lag length for ADF tests - the Ng and Perron [65] general-to-specific approach which starts a high lag length and restricts down until the t-statistics for the lag lengths become significant, and the ad-hoc approach which uses information criteria like AIC or SBC to identify a parsimonious lag length.

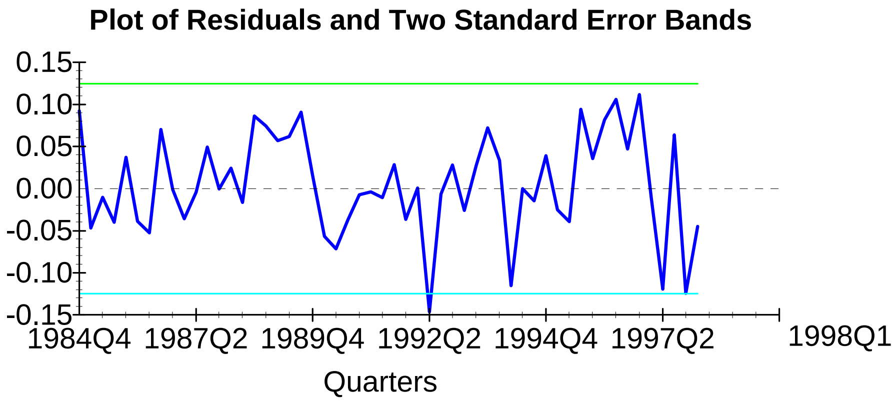


Figure 6.1: Saleyard price for Baconers: Residuals of Perron 'additive outlier' unit root test

account this seasonal effect, may result in biased results and consequently reach a misleading conclusion.

The other variables under consideration do not follow a stochastic seasonality non-stationary process, but do follow a difference-stationary process, that is, taking first differences of the time series will result in a stationary process. Deterministic seasonality does not appear to have an effect on the saleyard price of beef cattle, the retail price of pork, nor the retail price of pork loin chops. However, the retail price of beef and pork legs, as well as the production of pigmeat did exhibit some deterministic seasonality which has to be taken into consideration when modelling their data generating process. Again, the previous studies that did not take into account this seasonal effect may result in biased results and consequently reach a misleading conclusion.

The important result from this chapter is the implication that the saleyard price for baconers is in fact stationary, rather than non-stationary as was asserted in the 1995 ABARE submission to the Industry Commission Inquiry [1]. It appears that the reason for this original finding is that the series is subject to a shift, corresponding to the introduction of imports in 1990:1. If this shift is not taken into account then the series appears to be non-stationary rather than stationary. If subsequent analysis is conducted on the assumption that the series is non-stationary, the conclusions reached are called into question.

Chapter 7

The effect of imports on producer prices

7.1 Introduction

The results of chapter 6 and this chapter suggest that producer prices have moved from a stationary data generating process to a non-stationary data generating process sometime after 1990:1. This implies that there has been an exogenous shock that has impacted on the data generating process increasing volatility and making producer decisions less reliable. The introduction of imports after 1990:1 is a prime example of an exogenous shock on the industry, moving the industry market equilibrium from one of autarchy to one exposed to the international trading environment. This chapter attempts to identify the factors which have influenced producer prices and attempts to quantify the effects of those factors in determining the level and changes to the level of producer prices. In this chapter we test producer prices for a structural break corresponding to an exogenous shock occurring in 1990:1 and then quantify factors determining the data generating process for producer prices using an autoregressive distributed lag (ADL) model. The results of the ADL model are quite surprising and generated considerable debate and controversy when first presented in a previous paper [79]. While the ADL model quantifies the effect of the various factors (including imports) affecting producer prices it does not identify the mechanism by which imports impact on producer prices. We suggest that a Bertrand bargaining game played between producers and processors is a possible mechanism by which imports suppress producer prices. The stylised outcome of a Bertrand game fits the observed results of the ADL model [1].

7.2 Testing for structural breaks

It is of primary interest to determine whether or not the data generating process (DGP) underlying changes in saleyard prices for baconers has changed due to the introduction of imports.

A test for the statistical significance of a possible break is the Chow test [21]. Denoting the residual sum of squares for the model fitted by OLS up to and including period $t-i$ by RSS_{t-i}, and the corresponding residual sum of squares for the model fitted up to and including period t by RSS^*_t, then the Chow test statistic is calculated as:

$$Chow = \frac{(RSS^*_t - RSS_{t-i})\,(t-k)}{RSS_{t-i}\,(t-(t-i))} \sim F_{t-(t-i),t-k} \tag{7.1}$$

Under the null hypothesis that there has been no structural change in the model between periods $t-i$ and t, this statistic has the F distribution with $t-(t-i)$ and $t-k$ degrees of freedom.

The nature of the Chow test is that it detects shifts in the variable coefficients (the parameters) which are not endogenous to the system. What is important to note is that the test for parameter constancy undertaken by the Chow test identifies periods of change in the exogenous variable which is not explained by shifts in the endogenous variables. Normal changes in the endogenous variables which affect the exogenous variable according to the underlying DGP are not identified as having significant impact on the constancy of the parameters.

In order to test the saleyard price for baconers for a structural break a model capturing how the variability in prices is explained by the variability in, for example, production, needs to be developed. If the Chow test introduced above indicates that a structural break has changed the values of the parameters in the model, then external factors (subsumed into the structural break) explain more of the variation in saleyard prices pre- and post-break than the underlying DGP.

[1] We are currently working on the calibration of an imperfectly competitive computable general equilibrium model of the Australian pig industry which incorporates Bertrand, Nash-Cournot, and Stackelberg bargaining between consumers, middlemen, and producers in the presence of variable returns to scale and transaction costs. This model is of the general type presented in [78] and will attempt to empirically validate the results of the ADL model.

Table 7.1: Regression Results for Structural Break

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	3.8526^{**}	0.16909	4.5383^{**}	0.082571
T	0.011490^{**}	0.0013435	0.0056846^{**}	0.0005583
$SBFQ$	0.094767	0.18466	−0.084407	0.14067
RPQ	0.91772	0.67397	2.3893^{**}	0.64751
$PPDQ$	−0.44234	0.43194	−0.22624	0.29382
Q_t^1	−0.095518	0.047182	−0.059136	0.030606
Q_t^2	−0.059235	0.051005	−0.061802	0.040057
Q_t^3	−0.048483	0.029541	−0.036976	0.025309
R^2	0.88698		0.77655	
$\text{LMF}_{(df)}$	$2.1946_{(4,11)}$		$6.1869^{**}_{(4,41)}$	
RSS	0.026604		0.15710	
$\text{Chow}_{(df)}$		$7.3577^{**}_{(30,45)}$		

We formulate a model of supply in price dependent form

$$y_t = \alpha_o + \alpha_1 T + \sum_{i=1}^{N} \beta_i x_{it} + \varepsilon_t \tag{7.2}$$

where the endogenous variable is the saleyard price for baconers (SPQ) and the exogenous variables being the saleyard price of cattle (SBFQ), the retail price of beef (RBFQ), the retail price of pork (RPQ) and the production of pigmeat (PPDQ) [2]. The model is estimated from 1984:2 to 1989:4 and then for the full sample period to 1997:2 with the variables in log-stationary form. The regression results are presented in Table 7.1[3] [4].

The Chow test for a structural break strongly rejects the hypothesis that there is not a structural break at 1990:1. It is interesting to note that there appears to be serial correlation for the model estimated over the full sample

[2] We do not include the wholesale price for pork legs as this series is incomplete and does not cover the 1990:1 structural break period. Regression estimates (not reported) indicate that the coefficient for the wholesale price is not significant and thus does not contribute to the DGP for producer price. This is borne out by the relatively low correlation coefficient of 0.67156 between wholesale and producer prices.

[3] The regression estimated only uses 3 seasonal dummies rather than 4. Johnston [56, p. 226] shows that running a regression with all the dummies produces a unit vector, equivalent to an intercept. The regression so specified will encounter severe multicollinearity.

[4] The Lagrange Multiplier F test for serial correlation is used in preference to the Durbin-Watson d statistic in this case.

Table 7.2: ADF tests for post break saleyard baconer prices

Residuals	Lag	AIC	Ljung-Box[p-value]	$\Delta^{d-1}y_{t-1}$	$t\,(df)$	Q_t^i	$(p \leq 0.05)$
Δ^2SPQ	1	43.1138	0.066575[.796]				
	2	42.1630	0.025593[.873]	-4.8407^{**}		$Q_t^1, Q_t^2, Q_t^3, Q_t^4$	
	3	43.8030	0.40587[.524]				
ΔSPQ	1	45.5539	0.17750[.674]				
	2	45.0285	0.22974[.632]	-1.7364			
	3	45.2039	0.6953×10^{-4}[.993]				

period. This indicates that perhaps an AR(1) DGP exists. In other words, there is an indication that the saleyard price for baconers is non-stationary over the full sample period. This backs up the conclusions of the Perron additive outlier test performed earlier, that the presence of a structural break will introduce a Type II error[5] in unit root tests. In order to confirm this the model was estimated again over the full sample period, but with the structural break dummy included. What was unexpected was that there is still evidence of serial correlation, when it was expected that the structural break dummy would have captured the dynamics of the regime change.

There is a possibility that was not explored in testing for seasonal integration with a structural break above, that although the saleyard price for baconers is $I\,(0)$ prior to the structural break, the introduction of a change in regime could have introduced non-stationarity, that is, the saleyard price for baconers is in fact

$$y_t \sim \begin{cases} I\,(0) & S = 0 \\ I\,(1) & S = 1 \end{cases} \tag{7.3}$$

The Perron additive outlier test only looks at the possibility of an $I\,(1)$ DGP versus an $I\,(0)$ DGP with structural break, not versus an $I\,(1)$ DGP with structural break. In order to confirm that saleyard prices for baconers is in fact $I\,(d)$ after the structural break the ADF test was carried out again on the data after 1989:4 and the results of this test are presented in Table 7.2.

The ADF test indicates that in fact saleyard prices for baconers is $I\,(1)$ after the structural break[6] and needs to be differenced once to obtain sta-

[5] That is, non-rejection of the null hypothesis of a unit root when in fact one does not exist.

[6] This opens up some interesting extensions to the analysis. The introduction of imports (the structural break) has changed the underlying DGP for saleyard prices. Prior to the break the DGP was stable with a constant mean and after the break the DGP appears to be unstable with a shifting mean. Non-stationarity is analogous to volatility in an ARCH/GARCH setting. There is a possibility that trade liberalisation has increased volatility, as experienced in other markets (for example the financial market), and this

Table 7.3: Regression Results for Structural Break with I(1) process

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	0.17267	0.15873	0.10700	0.064839
T	−0.0007894	0.0012613	−0.0004076	0.0004384
$SBFQ$	0.28256	0.17336	−0.013837	0.11046
RPQ	0.098781	0.63271	0.73333	0.50846
$PPDQ$	−0.37488	0.40549	-0.67959^{**}	0.23073
Q_t^1	-0.15267^{**}	0.044293	-0.16444^{**}	0.024033
Q_t^2	−0.090607	0.047882	−0.045120	0.031455
Q_t^3	−0.0045999	0.027732	0.024204	0.019874
R^2	0.78367		0.73671	
$\text{LMF}_{(df)}$	$0.26998_{(4,11)}$		$1.0364_{(4,41)}$	
RSS	0.023446		0.096871	
$\text{Chow}_{(df)}$		$4.6975^{**}_{(30,45)}$		

tionarity. The Chow test was re-run on the stationary saleyard price for baconers, with the sample period prior to the structural break being $I(0)$ (See Table 7.1) and then assumed to be $I(1)$ (See Table 7.3)

For the scenario where the pre-break DGP is $I(0)$ $Chow = 3.9618^{**}$ (highly significant structural break) and when the pre-break DGP is $I(1)$ the Chow test result is shown in Table 7.3. In either case the Chow test indicates that a structural break has caused the underlying DGP to change.

We can confirm this result by examining the coefficients of the supply model based on a rolling regression. The rolling OLS regression allows the coefficients of the regression to be recalculated with each additional observation. What this means this that by examining the plot of the coefficients over time, with their standard error bars, if the lagged coefficients differ significantly from zero then the coefficients have changed from the previous time period. We estimate the supply model above in log-differenced form to ensure that the variables are all stationary. We select a time window of 10 quarters, so the lagged coefficient of saleyard prices of baconers is compared with the regression of the previous 10 quarters. The plot of lagged saleyard prices for baconers is shown in Figure 7.1.

needs to be examined using ARCH/GARCH techniques. One of the possibilities is that the structural break has shocked the saleyard prices out of their stationary process and the period from 1990:1 to 1997:2 is a transition period as the prices move to a new, possibly stationary, equilibrium.

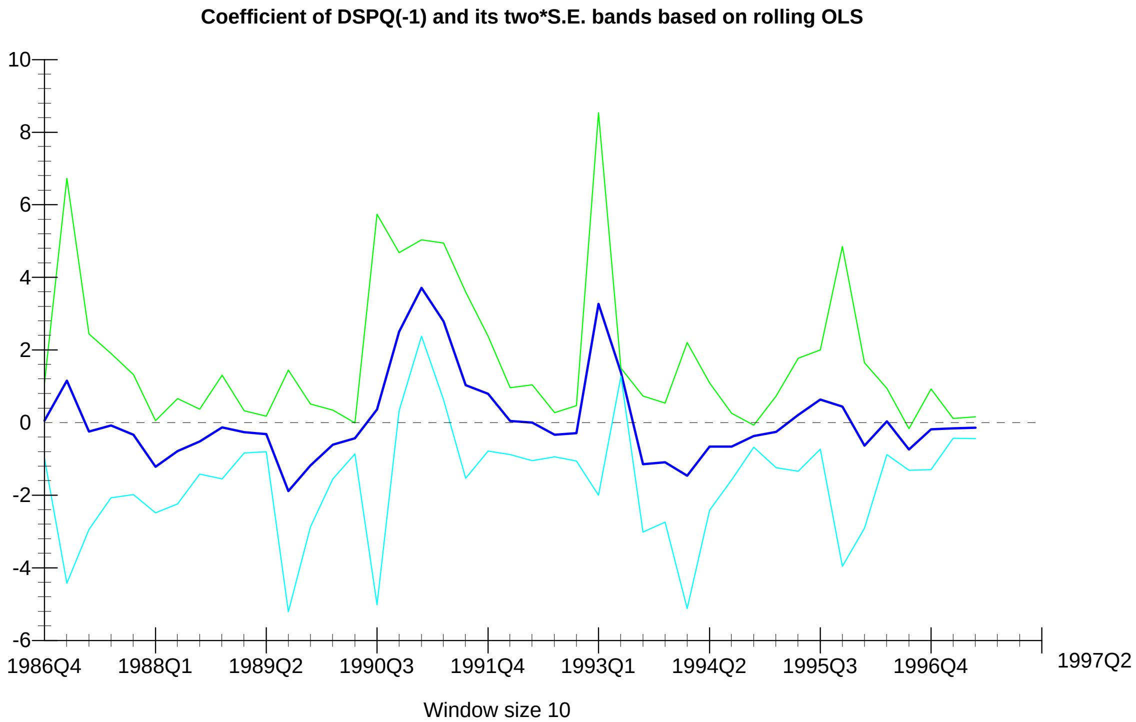


Figure 7.1: Plot of rolling regression for saleyard prices for baconers.

The results indicate that in 1990:4 the data generating process for saleyard prices for baconers shifted significantly from the estimate of the data generating process for the past 10 quarters. After 1990:4 there was no significant deviation from the new data generating process.

7.3 Modelling domestic producer prices

One of the questions we would like to answer is whether or not the introduction of imports have led to the lowering of producer prices. There is a general feeling among industry members that the introduction of imports has imposed a price cap on producer prices, as processors are now able to bargain down farmgate prices under the threat of importing competing product. This reduction in producer prices has not resulted, it is claimed, in a coincident reduction in retail prices, as retail oligopolies have managed to maintain their market power. The further relaxation of import restrictions in 1997:11, allowing processed pigmeat to be imported from Canada, has meant that retail oligopolies can import directly, rather than source their product from domestic processors. It is claimed that this will drive farmgate prices down even further.

Although this argument in intuitively appealing, and has some theoretical backing [15], due to time constraints we are unable to formally test this in an analytical framework[7].

We can, however, formulate an autoregressive distributed lag (ADL) model. This is an attempt to capture the data generating process and obtain coefficients that will indicate the sign and the magnitude of the relationship between the variables in the supply model. The advantage of the ADL model is that it is an encompassing model and the order of integration of the variables does not have to be explicitly defined, as the lagged endogenous and exogenous variables on the right hand side of the equation pick up any serial correlation.

The ADL model is of the form

$$\phi(L,p)\, y_t = \sum_{i=1}^{k} \beta_i(L,q_i)\, x_{it} + \delta' \mathbf{w}_t + u_t \tag{7.4}$$

where

$$\begin{aligned} \phi(L,p) &= 1 - \phi_1 L - \phi_2 L^2 - \ldots + \phi_p L^p \\ \beta_i(L,q_i) &= \beta_{i0} + \beta_{i1} L + \ldots + \beta_{iq_i} L^{q_i} \qquad i = 1, 2, \ldots, k \end{aligned} \tag{7.5}$$

[7] See [78] for a possible methodology to test this proposition.

where L is a lag operator such that $Ly_t = y_{t-1}$, k is the number of regressors, p is the number of lags, and $\mathbf{w}_t$ is a $s \times 1$ vector of deterministic variables (intercept, seasonal dummies etc.). The long-run coefficients are also computed as

$$\hat{\theta} = \frac{\hat{\beta}_i\left(1, \hat{q}_i\right)}{\hat{\phi}\left(1, \hat{p}\right)} \tag{7.6}$$

for the lagged exogenous and lagged endogenous variables, and

$$\hat{\psi} = \frac{\hat{\delta}\left(\hat{p}, \hat{q}_i\right)}{\hat{\phi}\left(1, \hat{p}\right)} \tag{7.7}$$

for the deterministic exogenous variables.

The model is regressed using a maximum number of lags and the SBC[8] is used to determine which lags to eliminate. A maximum number of 4 lags was chosen, as quarterly data is used, and the ADL procedure is computationally very expensive, needing to evaluate $(p+1)^k = (4+1)^6 = 15625$ different equations in order to obtain the optimal lag length.

The model is a supply model in price dependent form estimated from 1984:4 to 1997:2 in both logged and levels form, in an attempt to obtain meaningful parameter values. The results are presented in Tables 7.4 and 7.5. The long-run coefficients are also computed as

$$\hat{\theta} = \frac{\hat{\beta}_i\left(1, \hat{q}_i\right)}{\hat{\phi}\left(1, \hat{p}\right)} \tag{7.8}$$

In the logged form of the regression analysis the long-run coefficient of the import volume variable is negative, but not significantly different from zero[9]. In the levels form of the regression analysis the long-run coefficient of import volume is negative and is significantly less than zero. In both cases the test statistics for serial correlation and heteroscedasticity are non-significant. This indicates that performing the regression in logged form to eliminate heteroscedasticity is unnecessary and may in fact bias the coefficient test statistics towards non-rejection of the null hypothesis.

The long-run coefficient for import volumes is -0.2014×10^{-4}, which indicates that in this model, for every 1000 tonnes of imported pigmeat, domestic producer prices will fall by 20.14 ± 10.32 cents/kg. This compares with the effect of domestic production, where every 1000 tonnes extra production will

[8] SBC is used in preference to AIC in this case as SBC is more parsimonious with the lag length selection

[9] There is insufficient evidence to suggest that the coefficient of import volume is significantly different from zero $(p > 0.05)$.

Table 7.4: ADL model results - log form

Regressor	Regression estimates Coefficient	Standard Error	Long-run estimates Coefficient	Standard Error
α_0	4.7098	2.8584	4.7098	2.8584
LSBFQ_t	-0.21161	0.099498	0.023870	0.084104
LSBFQ_{t-1}	-0.036667	0.12468		
LSBFQ_{t-2}	-0.096176	0.13841		
LSBFQ_{t-3}	0.36833	0.11257		
LPPDQ_t	-0.26956	0.20764	-0.26956	0.20764
LRPQ_t	2.6022	0.46908	0.82962	0.14092
LRPQ_{t-1}	0.34620	0.68332		
LRPQ_{t-2}	-1.1398	0.60351		
LRPQ_{t-3}	-0.97903	0.47783		
LCAMPQ_t	0.016337	0.021381	0.016337	0.021381
LCAMVQ_t	-0.0060565	0.0098794	-0.0060565	0.0098794
Q_t^1	-0.10141	0.021860	-0.10141	0.021860
Q_t^2	-0.12909	0.021300	-0.12909	0.021300
Q_t^3	-0.028036	0.017807	-0.028036	0.017807
R^2	0.92513			

Table 7.5: ADL model results - levels form

Regressor	Regression estimates Coefficient	Standard Error	Long-run estimates Coefficient	Standard Error
α_0	36.0391	24.7770	63.5233	40.6510
SPQ_{t-1}	0.43266	0.17643		
SBFQ_t	-0.036586	.097411	-0.064488	0.16849
PPDQ_t	-0.1485×10^{-5}	0.6245×10^{-6}	$-0.2617 \times 10^{-5*}$	0.1225×10^{-5}
RPQ_t	0.59351	0.17143	0.23630*	0.099643
CAMPQ_t	-0.020738	0.039387	-0.036553	0.074096
CAMVQ_t	-0.3313×10^{-5}	0.4274×10^{-5}	$-0.2014 \times 10^{-4*}$	0.1032×10^{-4}
CAMVQ_{t-1}	-0.8113×10^{-5}	0.3816×10^{-5}		
Q_t^1	-25.9457	5.0456	-45.7324*	18.8681
Q_t^2	-20.2987	3.7501	-35.7788*	13.7523
Q_t^3	-2.7688	3.4956	-4.8803	5.7131
T	0.91654	0.39930	1.6155	0.88632
BREAK	8.9809	16.9161	15.8299	32.5080
R^2	0.92250			

only drop producer prices by 2.617 ± 1.225 cents/kg. These are partial coefficients, and the interaction of the other variables in the model will have ameliorating effects on the realised price. The R^2 is 92.25%, indicating that the model is a good fit of the data generating process. The R^2 of the model details how much of the variability in saleyard prices for baconers is explained by the independent variables in the model (import volumes and prices, retail pork prices, saleyard prices for cattle, and domestic pigmeat production).

This raises the question as to why imports have such a large effect on producer prices compared with domestic production. The equilibrium outcome of a simple Bertrand game played between importers and producers suggests that importers would be able to bargain down domestic prices to the same price as the imported product. Under Bertrand competition [61, pp. 387-389] sales of pigmeat by the domestic producer are given by

$$x_d(p_d, p_f) = \begin{cases} x(p_d) & \text{if } p_d < p_f \\ \frac{1}{2}x(p_d) & \text{if } p_d = p_f \\ 0 & \text{if } p_d > p_f \end{cases} \tag{7.9}$$

Since the processor is indifferent between supplier for a particular quality of pigmeat at a particular price, if the price offered by the domestic producer, p_d, is lower than that of the foreign producer, p_f, the domestic producer will capture all of the market and the foreign producer will sell no pigmeat $(x = x_d)$. If the prices are equivalent to each other, then the foreign producer and the domestic producer will each supply half of the pigmeat to the market $\left(x = \frac{1}{2}x_d + \frac{1}{2}x_f\right)$.

This simple game predicts that prices will fall to an equilibrium position equal to that of the lowest price offered. In a competitive market this means that prices will be set to equal cost of production. In a situation of cross subsidisation due to the jointness of production of higher price pork bellies and lower priced hinds, prices may, in fact, fall to the marginal cost minimum.

There is a very good quote by Don Burr, the CEO of PeopleExpress Airlines, which was taken over by American Airlines in a price-cutting war.

> All we had left was our cost structure, which at the time was a billion dollars a year less than American. You figure that at a billion dollars cheaper, you ought to be safe. We kept naively hoping that our billion-dollar cushion would give us enough room even if they underpriced us here and there. But all they need to take away from us was that marginal traffic above breakeven. You don't have to take away half the guys market. All you have to do is take away a few seats on every flight and the guys dead.[26, pp 125-126]

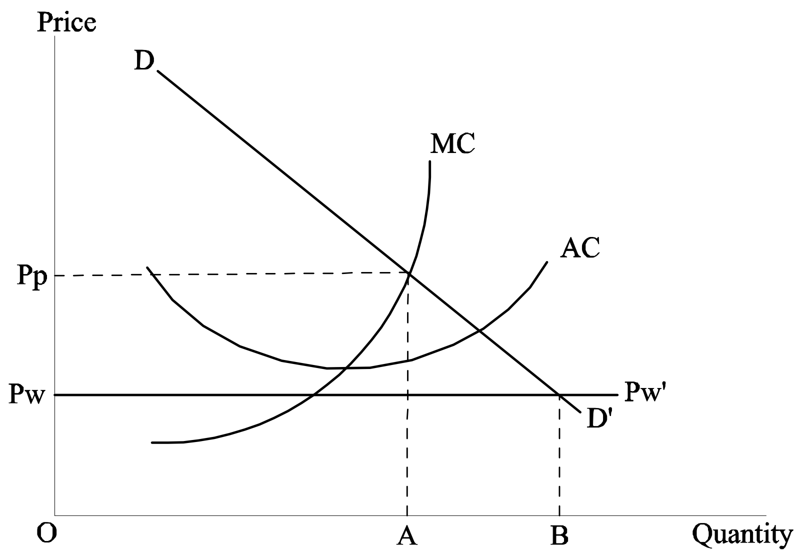


Figure 7.2: Long-run marginal and average cost curves

This, we think, is the mechanism by which imports are having such a large effect on the domestic market. That is, they take the margin above the breakeven point, which is quite small due to the competitiveness of the producers.

If we have a look at a partial equilibrium analysis (See Figure 7.2), the marginal cost curve (MC) cuts the demand curve (DD) at price P_p and quantity A. This is how much the domestic industry is supplying. If the industry is subjected to the world price, P_w, then consumption will increase to quantity B. However, since the world price is below the domestic industries' breakeven point, the intersection of the marginal cost and average cost curve (AC), the domestic producers will find it unprofitable to remain in the industry and all consumption will be supplied by the imported commodity.

The results in this section suggest that there has been a significant depression in saleyard prices for baconers over the period 1990:1 to 1997:2.

The question of whether or not prices have been capped due to the ability of processors to source product from overseas has not been addressed in this framework. In addition, there has been some argument by industry members that the ability of retailers to import processed pigmeat from Canada from 1997:11 has further exacerbated the depression in prices. The analysis conducted above only looked at the data generating process from 1984:4 to 1997:2, which has not included the post 1997:11 period.

The ADL model formulated in this section does not reveal the dynamic relationships which exist between prices and production, nor the relative importance of particular prices or volumes in determining the movement of other prices or volumes. In order to investigate these issues we need to move to a modelling framework which takes into account the dynamic relationships between variables. Such a model is presented in chapter 12.

7.4 Summary

This chapter has tested for the effect of structural breaks on the data generating process underlying saleyard prices for baconers. It is concluded that the introduction of imports in the first quarter of 1990 has affected saleyard prices, contrary to the conclusions of the Industry Commission Report [53]. Not only is there an effect on prices, but the introduction of imports has fundamentally changed the dynamics of the supply response. The ABARE submission to the Industry Commission Report on Pigs and Pigmeat [1, p. 36] suggested that partial equilibrium analysis indicated that the introduction of imports would cause a once-off price reduction in domestic pigmeat prices. The analysis in this section has shown that in fact the introduction of imports continues to have a lasting effect on domestic pigmeat prices as it has introduced non-stationarity into a previously stationary supply response process.

The more recent 1998 ABARE study [3] has indicated that the present decline in prices will continue in the short term, but:

> From mid-year prices are expected to recover in line with the seasonal pattern from July to December. [3, p. 11]

In light of the original ABARE study [1], which found evidence of non-stationarity over the whole time period in question (1984-1995), and this analysis which found evidence of non-stationarity over the time period after the introduction of imports (1990-1997), it is surprising that ABARE has made this new claim above (that prices will recover to the seasonal pattern). It is expected that a series will return to its long-run equilibrium *only* if it is stationary. Unless ABARE has now found evidence that the 1997:11 shock has introduced stationarity to the saleyard price for baconers it is unclear how they could have reached this conclusion.

The ABARE study seems to confirm the conclusions reached in this section:

> Since March 1994, production has moved away from the steady price trend and prices have again started to fluctuate over a wider and non-seasonal range. [3, p. 1]

In the framework of this section, it appears that the ABARE study is actually saying that prior to March 1994 prices were $I(0)$ (we argue that this was prior to 1990) and after 1994 prices were $I(1)$. Again, it is unclear how prices are supposed to return to a (randomly fluctuating) long-term trend, or even which trend that is. In addition, the ABARE study uses EMABA [31] to back up its conclusions. This is surprising. EMABA is a simultaneous equation model that assumes that the series are stationary, and yet ABARE's own original study [1] found evidence for non-stationarity.

In order to account for non-stationarity in a model that can be used for forecasting, we turn to extensions to simultaneous equation modelling. Chapter 12 of this report utilises vector autoregression techniques to develop an alternative to EMABA that examines the dynamic inter-relationships of prices and production in the Australian pig industry.

The ADL modelling approach presented in this chapter attempts to quantify the effect of imports on domestic producer prices. The results indicate that for every 1000 tonnes of imported pigmeat, domestic producer prices will fall by around 20.14 ± 10.32 cents/kg. This compares with the effect of domestic production, where every 1000 tonnes extra production will only drop producer prices by 2.617 ± 1.225 cents/kg. We hypothesise that the mechanism of the large effect of imports on producer prices is due to a Bertrand bargaining game played between producers and processors where the equilibrium outcome is that prices fall to the lowest offered price.

Chapter 8

The effect of imports on domestic production

8.1 Introduction

In an earlier report ABARE [3] suggested that increased production was the cause of depressed producer prices while discounting the effects of imports on domestic producer prices. The ABARE report was flawed as it only examined changes in prices and production over a short (2 year) period which included a period of high feed grain prices due to low yields under drought and ignored the pattern of production over the historical period prior to the introduction of imports:

> During the period from December 1995 to March 1997 the annualised average production of pigmeat decreased by 4.4 per cent per quarter... Production then recovered and continued to increase by an average of 1.3 per cent per quarter from September 1997 to March 1998.[3, p. 4]

The ABARE report goes on to say:

> For the first 8 months of the 1997-98 financial year Australian production of pigmeat increased to 222 000 tonnes. This represents an increase of 5 per cent compared with the corresponding period in the 1996-97 financial year.[3, p. 5]

Examination of the historical series (See Figure 5.5) indicates that domestic production after 1990 deviated from the long-term pattern and 1996 was an extreme low. The recovery from September 1997, from that extreme low, still did not appear to return to historical levels.

Media releases from the Minister for the Department of Primary Industries and Energy (DPIE) supported the contention that increased production had driven producer prices down:

> "Mr O'Keefe [Opposition spokesman on Primary Industry] ignores the fact that domestic demand for pigmeat has slipped badly while domestic production has gone up - in other words, domestic factors are influencing the industry's fortunes more than imports."[6]

But also added a new interpretation; that producer prices were being driven by oversupply of pigmeat:

> "RASAC [Rural Adjustment Scheme Advisory Council] has recognised that producers are facing extreme difficulty, but recommended against EC [Exceptional Circumstances] because the current downturn in prices is a market adjustment resulting mainly from an oversupply in the domestic pig market," Mr Anderson said.[7]

At first glance these two interpretations seem to be consistent with each other but equilibrium analysis indicates that this is not the case. A permanent increase in production is modelled in Figure 8.1 as a shift to the right in the supply curve from the initial equilibrium at point E to the new equilibrium at point B. If a decrease in production has occurred we expect that the shift would in fact be to the left. A temporary oversupply in production is actually a movement from equilibrium (at point E) to disequilibrium (at point A) where supply and demand no longer equate. How long the market takes to return to an equilibrium position is an empirical question. If the market takes a long time to return to equilibrium then persistent disequilibrium could be the cause of depressed (or wildly fluctuating) prices.

The other point raised in the Media release by the Minister for the Department of Primary Industries and Energy (DPIE) was that per capita consumption of pigmeat had declined, as a result of lower prices for beef and poultry meat - substitutes for pork.

The purpose of this chapter is to analyse whether a shift in production or a disequilibrium in market supply and demand are responsible for depressed producer prices. The chapter is organised as follows. Section 8.2 reviews some models of market disequilibrium. Section 8.3 looks at the hog cycle. Section 8.4 looks at consumption effects and the domestic supply of pork. Section 8.5 tests to see whether a shift in production has occurred. Having

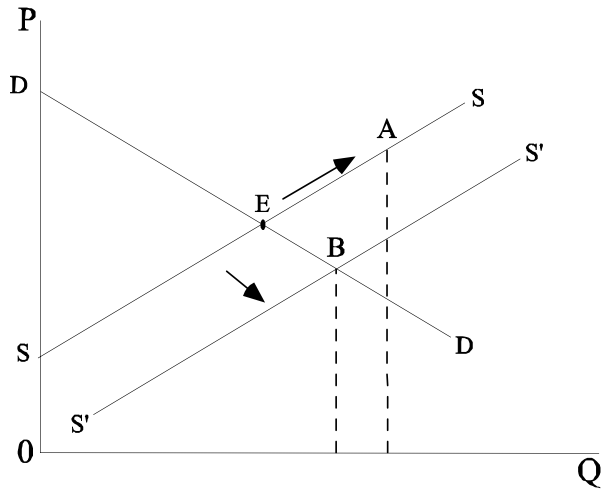


Figure 8.1: Increase in domestic pigmeat production and oversupply of domestic pigmeat

found that a shift in production has occurred, Section 8.6 formulates a model to determine the nature of that shift (whether to the right or to the left of the original equilibrium). Section 8.7 extends the model to incorporate a measure of market disequilibrium and see whether persistent disequilibrium is present in the market. Finally Section 8.8 provides the main conclusions of the analysis.

8.2 Changes in market equilibrium - structural breaks and cobweb models

Changes in the market equilibrium can manifest themselves in the form of a shift in the intercept or slope of the supply (or demand) curve or movements along the curve. Since the market equilibrium is not stationary over time, and observed prices and quantities are usually (dis)equilibrium prices and quantities, econometric models are used in an attempt to capture the long-run equilibrium relationship between factors affecting supply and demand.

In terms of estimating whether a shift in the demand or supply curve has taken place due to changes in the curve's underlying relationship, econometric modelling usually attempts to determine whether there has been a change in the data generating process (DGP) of the dependent or endogenous variable (price or quantity) that is not explained by changes in the independent, or exogenous variables in the model. If there have been changes in the endogenous variable not explained by normal changes in the exogenous variables then a shift in the relationship, or a structural break has occurred.

Movements along the demand or supply curve which are not matched by a similar movement in the other curve will lead to a situation where there is a divergence between what consumers are willing to purchase at a particular price and what producers are willing to supply at a particular price. This divergence, or disequilibrium, can occur when there are lagged reactions to dynamic changes in the market equilibrium. For example due to high elasticities of demand consumption patterns may change quite rapidly for pigmeat products, but changes in production need around 10 months (114 days gestation, 170 days until slaughter), to feed into the market place. Cobweb models attempt to explain the disequilibrium in markets due to the lagged nature of supply and demand. If producers expect to receive the same price for their produce in the next time period as they did in the current time period, or future prices are not perfectly predicted by producers, then over- and under-supply will occur. Prices will oscillate out of phase with production in an attempt to return to a market equilibrium.

The cobweb model has three possible outcomes:

1. Elasticities of demand and supply are equal - perpetual oscillation (See Figure 8.2(a)).

2. Elasticity of supply is greater than demand - un-stable market equilibrium (See Figure 8.2(b)).

3. Elasticity of demand is greater than supply - stable equilibrium (See Figure 8.2(c)).

The model outlined in Figure 8.2(a) shows that a temporary disturbance away from the market equilibrium by a decrease in supply to q_1 will increase price to p_1 (point A). The increase in price will cause an increase in production to q_2 (point B) , and a corresponding decrease in price to p_1 (point C), which will then decrease production to q_1 (point F). Since the elasticities of demand and supply are the same, a permanent oscillation will result. In the case where production is more elastic than demand (See Figure 8.2(b)) the oscillations will explode away from the initial disturbance point A. In the case where demand is more elastic than production (See Figure 8.2(c)) the oscillations will converge to the original equilibrium point again.

It is unclear from the literature whether pigmeat production follows a disequilibrium process like a cobweb model. The Bureau of Agricultural

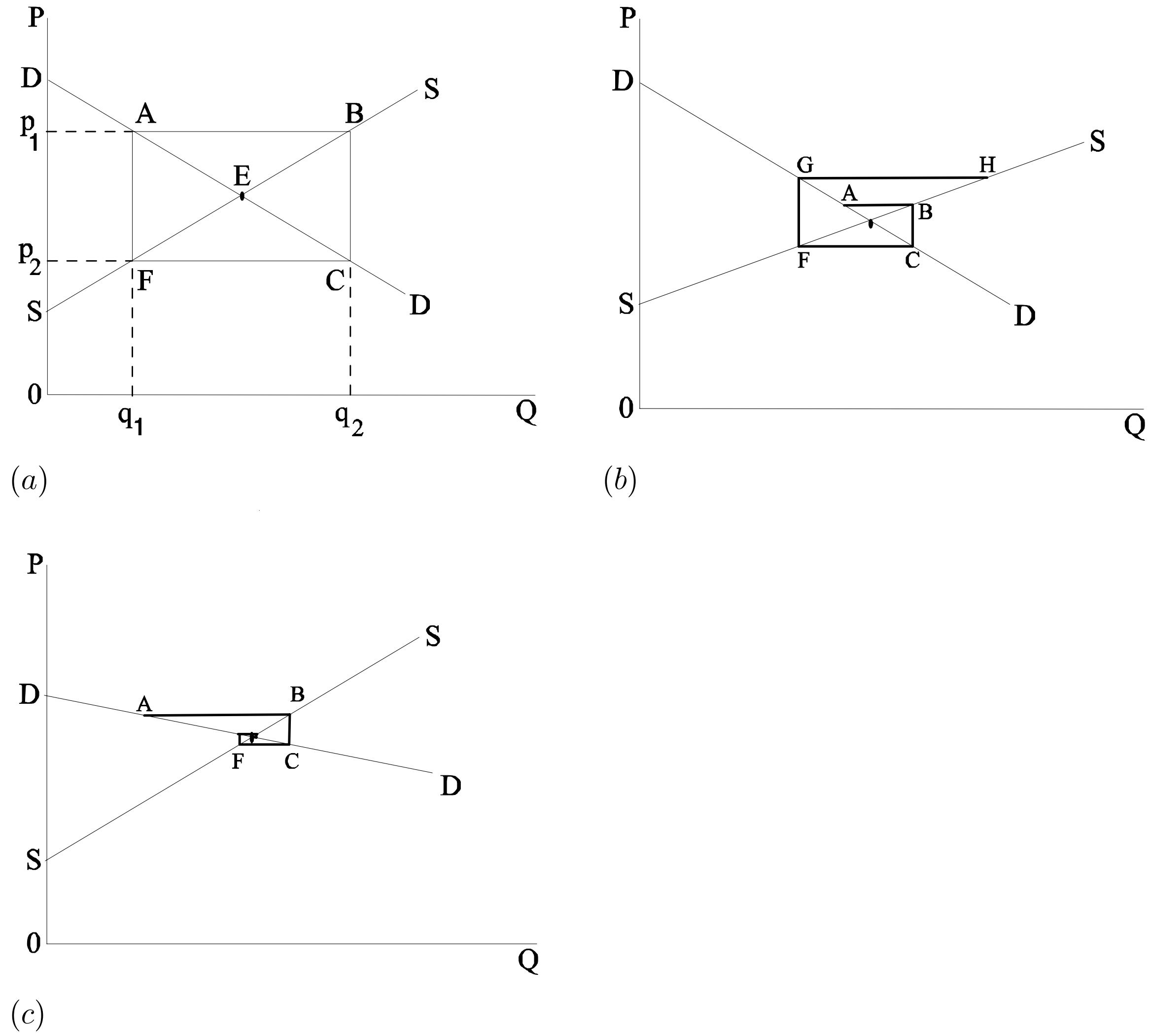


Figure 8.2: Cobweb models

Economics (BAE) - forerunner of ABARE - suggested that the market for pigs follows a four year cobweb cycle:

> When pig prices rise, and the increase appears to be of a permanent nature, existing producers add to their breeding herd or new producers enter the industry. Because of the relatively short time span involved in breeding pigs for slaughter, production of pigmeat increases sharply about 18 months to two years after the initial price rise. Consumption is unable to keep pace with the higher production and pig prices fall. With the lower prices, producers react by reducing their pig numbers or leaving the industry, and production falls sharply below the normal consumption level. The result is a rise in pig prices and the process repeats itself. [18][1]

While the BAE found evidence of a four year cycle in prices, confirmed by Griffith[46], Griffith did not, however, find evidence of a four year cycle in production. Griffith hypothesised that shifts in demand for pork, and shifts in the prices of substitutes, like beef, may be more plausible explanations of a cobweb effect in pigmeat production[2].

8.3 Hog cycles and spectral analysis

The analysis of the hog cycle conducted by Griffith [46] relied on spectral analysis to determine whether there was a four year cycle in hog prices. The interpretation of the results were subjective, and no hypothesis tests were conducted. The spectral analysis implied that there were frequency peaks at 3,4,6,8,12, and 48 months for producer prices. (See Figure 8.3). The largest peaks were at 4 and 12 months.

Applying the principle of parsimony in model lag length selection suggests that 4 and/or 12 months should be the optimal lag length to use. The results of the previous chapter suggest that when using quarterly data seasonal dummy variables should be sufficient to pick up the 12 month peak in frequency. The results of Griffith's paper suggest that production does not

[1] cited in [84, p. 67]

[2] The difference between the BAE [18] and Griffith [46] results tallies closely with the results in this paper and results from Purcell and Harrison [79]. The apparent persistent disequilibrium in prices corresponds to Walrasian instability whereas the quick return to equilibrium for production corresponds to Marshallian stability. I am grateful to Rodney Beard (School of Natural and Rural Systems Management, University of Queensland) for this observation. Further research is pending.

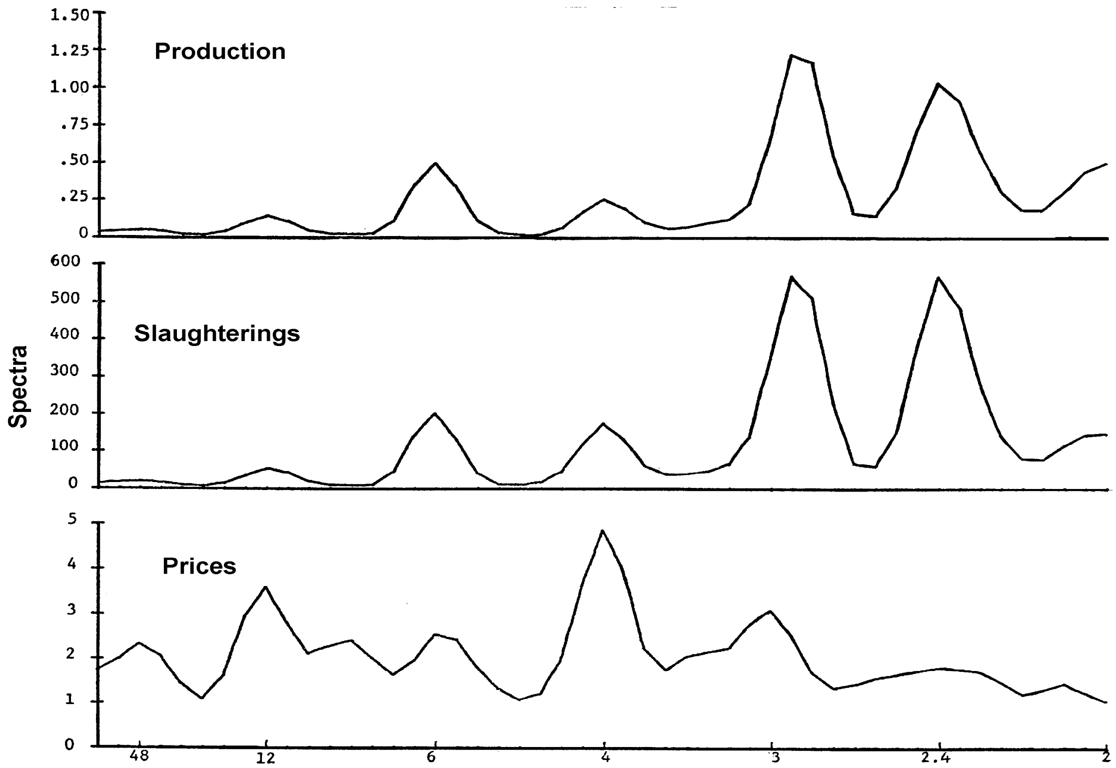


Figure 8.3: Spectral densitites for production, slaughtering, and producer prices. 1958:9 to 1975:12. Source: [46, Figure 2, p. 135]

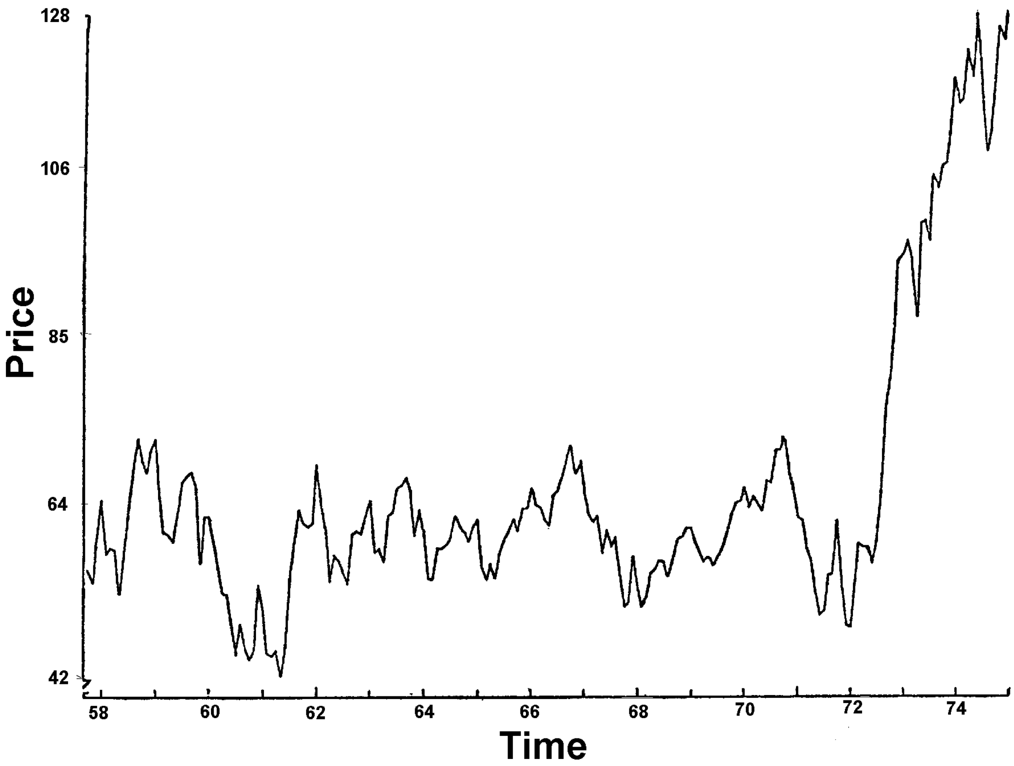


Figure 8.4: Homebush monthly average porker prices, September 1958 to December 1975 (c/kg). Source: [46, Figure 1, p. 132]

follow a 4 year cycle, and that the peaks in frequency occur at 3 and 2.4 months. This result is borne out by the results in this chapter which suggest that shocks in production dissipate within one quarter.

Even if it can be successfully argued that producer prices did follow a 4 year cycle between 1958:9 and 1975:12 there is no reason to suggest that a 4 year hog cycle is still in effect. The price series presented in Griffith's paper [46, Figure 1, p. 132] show a distinct structural break mid-1972 (See Figure 8.4) which suggests that Griffith's analysis needs to be carried out on the post-1972 data generating process to see if pig producer prices still follow a 4 year cycle.

Spectral analysis was carried out on the data for producer prices and production volumes (in stationary form). Monthly data from 1984:1 to 1998:6 was run through the PROC SPECTRA routine in SAS/ETS[82]. The results are shown in Figures 8.5 to 8.8.

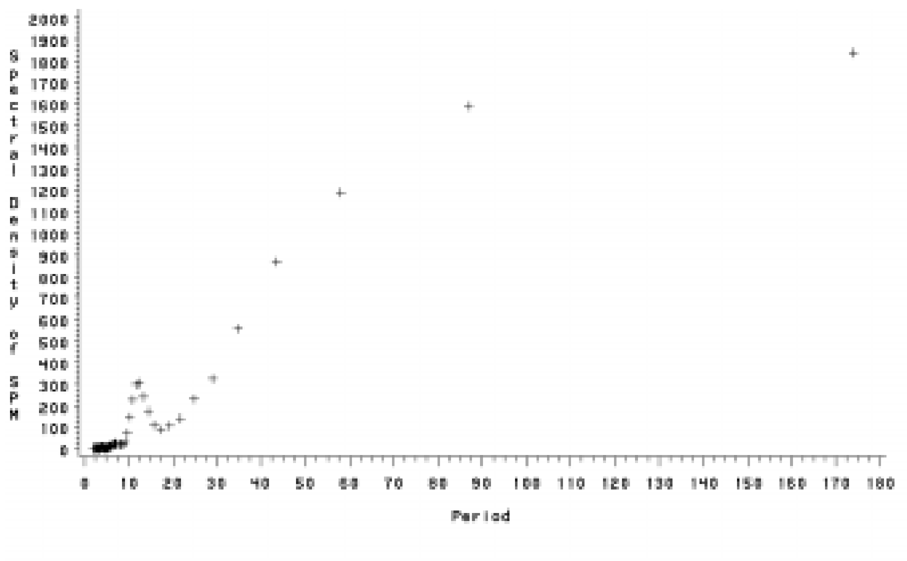


Figure 8.5: Spectral density for producer prices.

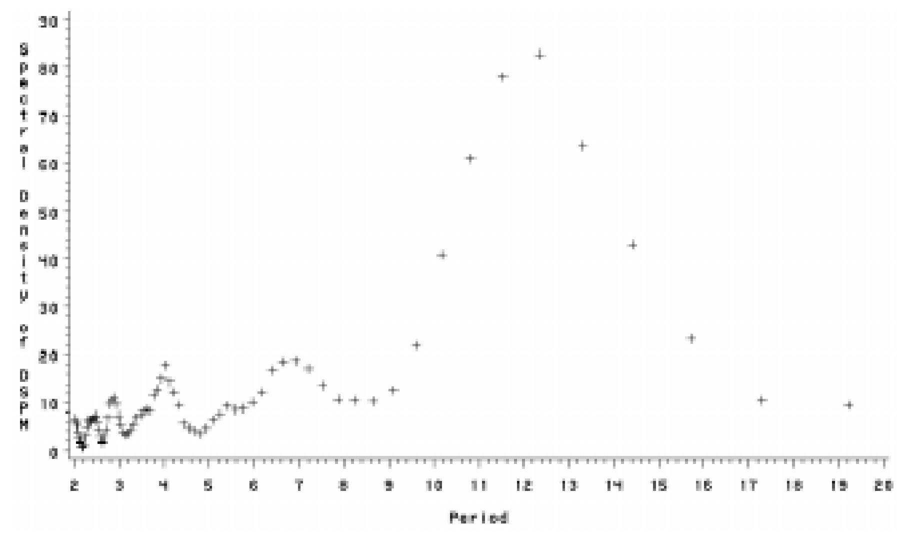


Figure 8.6: Spectral density for producer prices, 20 month period

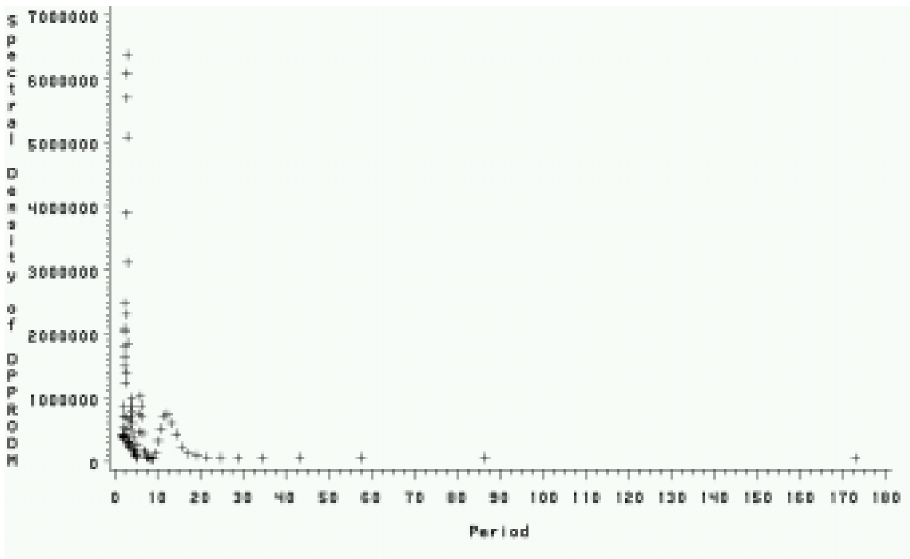


Figure 8.7: Spectral density for production volumes

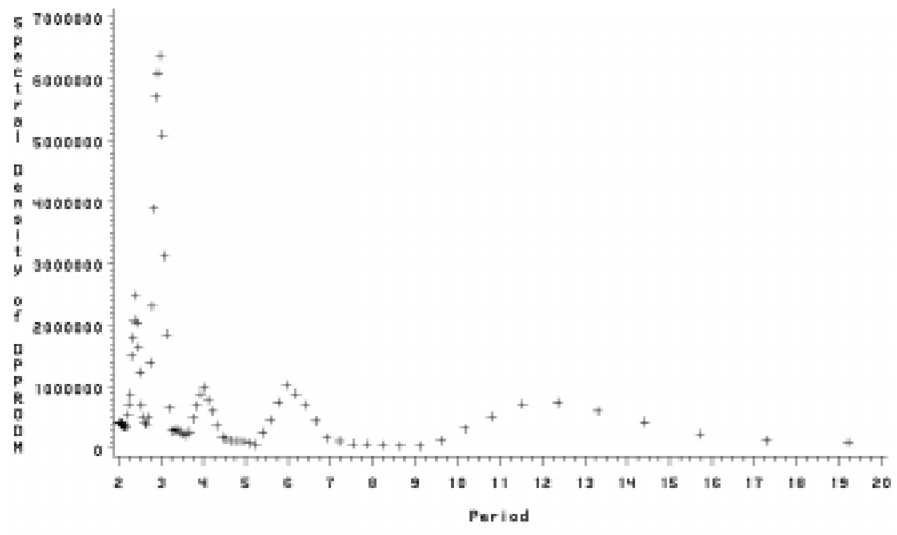


Figure 8.8: Spectral density for production volumes, 20 month period

The results indicate that there is no evidence of a 4 year cycle for producer prices, and in fact both producer prices and production volumes show no evidence of any periodicity greater than 12 months.

Producer prices show evidence of a strong 12 month cycle (See Figure 8.6), with lesser ones at 3,4, and 7 months. This result confirms the stylised facts of the industry, which show strong peaks in demand for leg ham over the Christmas period.

Production volumes show evidence of a strong 2-3 month cycle (See Figure 8.8) and lesser ones at 4,6 and 12 months.

The results tie in closely with Griffith's original work, in that cycles were detected at the exact same lower frequencies but the cycle at 48 months was not detected.

Why the 48 month cycle was not detected is a matter for speculation. One possible reason is that the structure of the industry has changed substantially since the 1950s and 1960s, with pig production moving away from being a sideline industry to the dairy industry and becoming more specialised. Producers are much more responsive to market signals now that their main enterprise is pig production and thus adjust prices and production quickly to changing demand and supply equilibria.

In Section 8.7 we attempt to determine what the magnitude of the likely disequilibrium process is and its persistence in the domestic market.

8.4 Consumption effects and domestic supply

The Media releases from the Minister for the Department of Primary Industries and Energy (DPIE) [6] [7] claimed that domestic demand for pigmeat had fallen from 20.2kg per capita in 1994-95 to 18.8 kg per capita in 1996-97, equating to a reduction in demand of 17,070 tonnes[7, p. 4]. This reduction in demand, with the implication that there was no concomitant decline in production, was claimed to have resulted in an oversupply of pigmeat in the domestic market and a resultant decline in producer prices as the market moved to a new equilibrium.

It is unclear what the source of this information was. Calculations seem to indicate that per capital consumption of pigmeat is derived from dividing pigmeat supply (domestic production plus imports[3]) by population. (See Figure 8.9).

[3] Supply is usually calculated as Production less Imports plus Exports. ABS statistics do not make a distinction between exports of wild boar meat and exports of domesticated pig meat. Industry sources indicate that exports of domesticated pig meat are minimal [?].

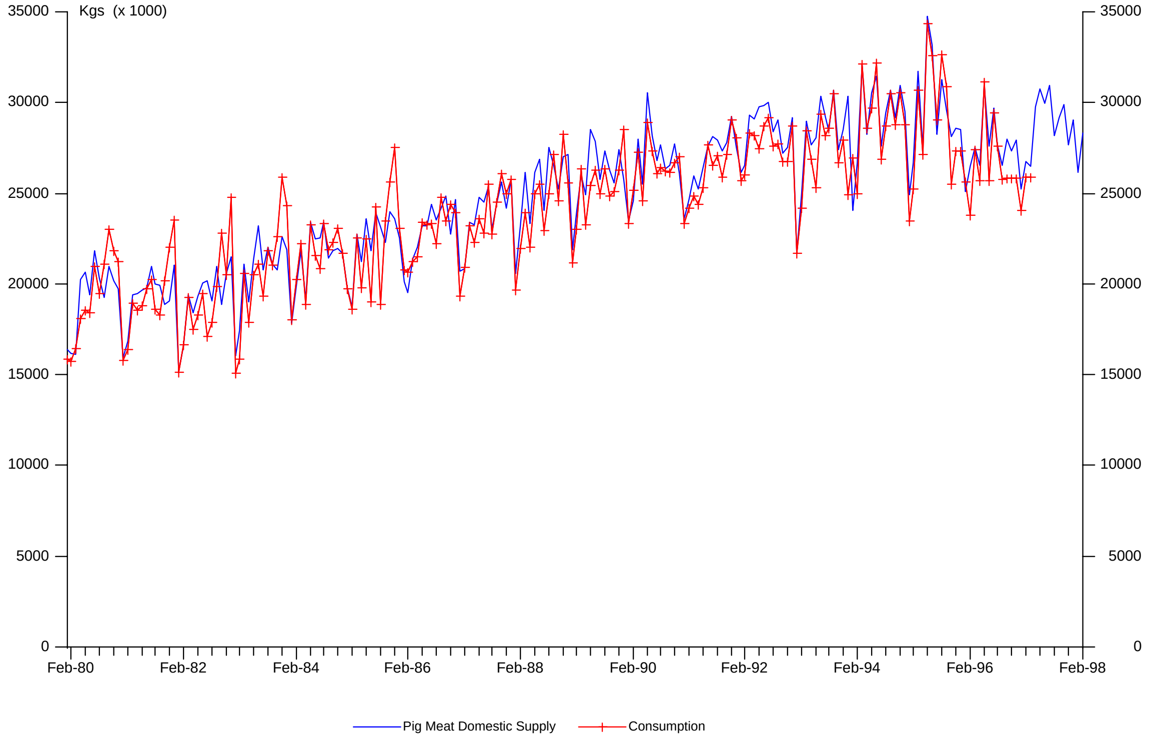


Figure 8.9: Domestic supply and consumption of pigmeat

Table 8.1: Correlation tests

Test	Statistic	p-value
$r_{Pearson}$	0.94685	0.0001
$r_{Spearman}$	0.94168	0.0001

This proposition needs to be tested, as this perceived excess supply could be accounted for by the differences in population series used to calculate total consumption in this paper compared with official ABS calculations[4].

Correlation coefficients were calculated to determine if consumption and domestic supply figures significantly different from each other (See Table 8.1).

The correlation coefficients indicate that there is a significant strong linear relationship between consumption and domestic supply.

If there is no statistical difference between supply and consumption data, then either the market is in equilibrium (i.e. changes in demand are tracked closely by changes in production) or ABS statistics are calculated on the assumption that the market is in equilibrium (i.e. consumption data is calculated from production data). Further, the observed increases in production could be due to supply increasing to meet increases in population. In either case the perceived drop in consumption can be accounted for by a concomitant drop in production, thereby eliminating any disequilibrium in the market. Thus the government claim of excess supply due to a decline in demand is not supported by the data.

8.5 Testing for shifts in production

The claim by ABARE [3] that the depression in producer price is due to an increase in domestic production needs to be tested in an analytical framework. In the time series of domestic production, a shift in the (static or long-run) supply curve will manifest itself as a change in the data generating process (DGP) of domestic production, or a structural break.

In order to test the domestic production of pigmeat for a structural break a model capturing how the variability in domestic production of pigmeat is explained by the variability in, for example, prices, needs to be developed. If the Chow test indicates that a structural break has changed the values of the parameters in the model, then external factors (subsumed into the structural break) explain more of the variation in domestic production of pigmeat pre- and post-break than the underlying DGP.

[4]Per capita consumption was multiplied by Estimated Resident Population [4, Table 3101.1] to determine total pigmeat consumption.

Table 8.2: Regression Results for Structural Break I

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	0.59116	0.56277	0.27915	0.34100
T	0.0015498	0.0018391	0.0001839	0.0005108
SPQ	−0.14773	0.14426	−0.057477	0.074647
$SBFQ$	0.12529	0.10267	0.13163	0.068429
RPQ	−0.065978	0.41251	−0.17019	0.37162
Q_t^1	-0.099893^{**}	0.016774	-0.068873^{**}	0.012341
Q_t^2	0.077663^{**}	0.023342	0.095894^{**}	0.014996
Q_t^3	0.013023	0.018234	0.0045888	0.013038
R^2	0.92485		0.84336	
$\text{LMF}_{(df)}$	$2.4693_{(4,11)}$		$2.1052_{(4,41)}$	
RSS	0.0088848		0.039912	
$\text{Chow}_{(df)}$		$5.2382^{**}_{(30,45)}$		

We formulate a model of supply in quantity dependent form

$$y_t = \alpha_o + \alpha_1 T + \sum_{i=1}^{N} \beta_i x_{it} + \varepsilon_t \tag{8.1}$$

where the endogenous variable is the production of pigmeat (PPDQ) and the exogenous variables being the saleyard price for baconers (SPQ), the saleyard price of cattle (SBFQ), and the retail price of pork (RPQ). The model is estimated from 1984:2 to 1989:4 and then for the full sample period to 1997:2 with the variables in log-stationary form. As noted in chapter 7 the saleyard price for baconers (SPQ) is $I(0)$ over the period 1984:2-1989:4 and $I(1)$ over the period 1990:1-1997:2. The regression is run with the saleyard price of baconers being both $I(0)$ and $I(1)$ and the results compared. The regression results for when the saleyard price of baconers is $I(0)$ are presented in Table 8.2 and for when the saleyard price of baconers is $I(1)$ are presented in 8.3 [5] [6] [7].

[5] The regression estimated only uses 3 seasonal dummies rather than 4. Johnston [56, p. 226] shows that running a regression with all the dummies produces a unit vector, equivalent to an intercept. The regression so specified will encounter severe multicollinearity.

[6] The Lagrange Multiplier F test for serial correlation is used in preference to the Durbin-Watson d statistic in this case.

[7] The statistics in the tables are presented with the superscripts * and **, indicating a significance level of 5% and 1% respectively.

Table 8.3: Regression Results for Structural Break II

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	0.047120	0.10139	0.040994	0.039025
T	-0.2630×10^{-3}	0.7884×10^{-3}	-0.2182×10^{-3}	0.2598×10^{-3}
SPQ	-0.14380	0.15555	-0.23783^{**}	0.080747
$SBFQ$	0.15328	0.10956	0.11264	0.063165
RPQ	-0.18981	0.38911	-0.086799	0.30739
Q_t^1	-0.10879^{**}	0.023657	-0.094724	0.014596
Q_t^2	0.074442^{*}	0.026832	0.073740	0.015533
Q_t^3	0.019771	0.016416	0.011460	0.011826
R^2	0.92393		0.86695	
$\text{LMF}_{(df)}$	$6.4974^{**}_{(4,11)}$		$4.4880^{**}_{(4,41)}$	
RSS	0.0089936		0.033902	
$\text{Chow}_{(df)}$		$4.1544^{**}_{(30,45)}$		

Table 8.4: Chow tests for structural break

	Post-Break	
Pre-Break	$I(0)$	$I(1)$
$I(0)$	$5.2382^{**}_{(30,45)}$	$4.2236^{**}_{(30,45)}$
$I(1)$	$5.1567^{**}_{(30,45)}$	$4.1544^{**}_{(30,45)}$

The Regression results for the structural break test under the situation of saleyard prices for baconers being $I(1)$ over the pre-break period are interesting. The Lagrange Multiplier F-test for the presence of serial correlation in the residuals strongly rejects the hypothesis of no serial correlation ($p < 0.01$) and yet the Ljung-Box Q-statistic does not reject the null hypothesis that the residuals are white noise (no serial correlation) ($p = 0.206$). The tests are conflicting, but the Lagrange Multiplier F-test is more robust than the Ljung-Box Q-statistic. The Lagrange Multiplier F-test confirms the finding that the saleyard prices of baconers in the period before 1990:1 were $I(0)$, that is, over-differencing of the variable leads to the re-introduction of non-stationarity.

The Chow tests are computed for all scenarios, that is, the saleyard price for baconers being either $I(0)$ or $I(1)$ in both the pre-break and post-break periods. The test statistics are presented in Table 8.4

The results show that, irrespective of whether the saleyard prices of baconers are stationary or non-stationary in the pre- or post-break period,

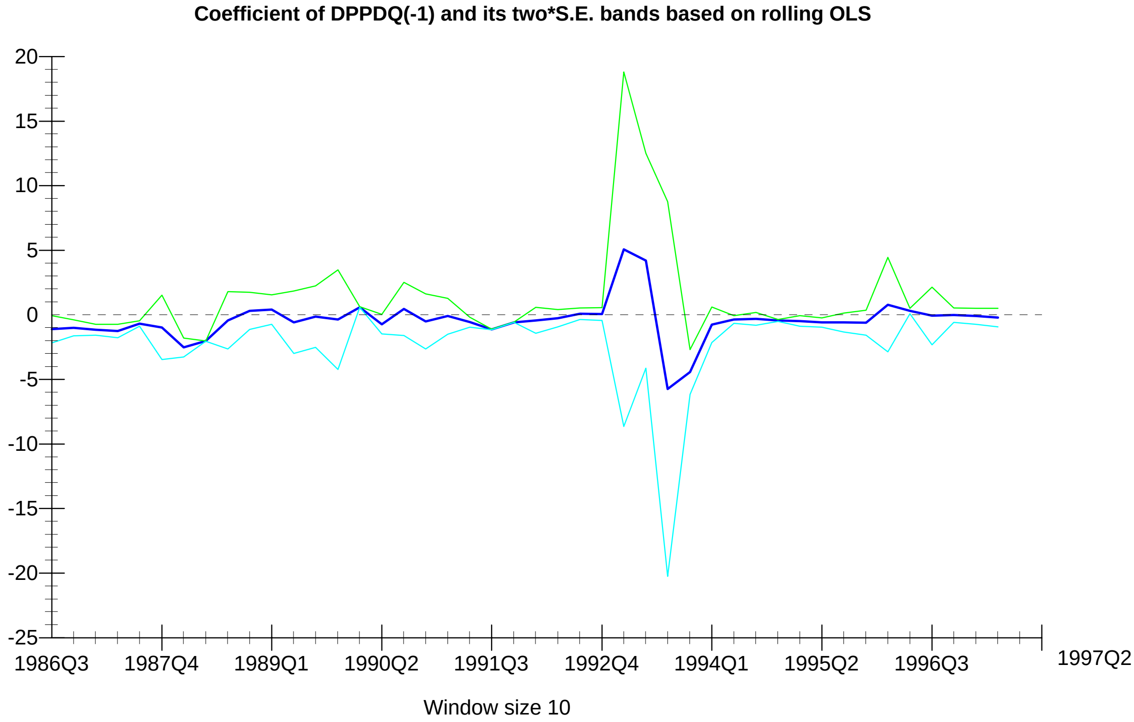


Figure 8.10: Plot of rolling regression for domestic production of pigmeat

domestic production of pigmeat has been affected by the structural break occurring in 1990:1, corresponding to the introduction of imports of pigmeat from Canada.

We can confirm this result by examining the coefficients of the supply model based on a rolling regression. The rolling OLS regression allows the coefficients of the regression to be recalculated with each additional observation. What this means is that by examining the plot of the coefficients over time, with their standard error bars, if the lagged coefficients differ significantly from zero then the coefficients have changed from the previous time period. We estimate the supply model above in log-differenced form to ensure that the variables are all stationary. We select a time window of 10 quarters, so the lagged coefficient of domestic production of pigmeat is compared with the regression of the previous 10 quarters. The plot of lagged domestic production of pigmeat is shown in Figure 8.10.

The results indicate that the data generating process for domestic production of pigmeat in 1990:1 shifted significantly from the estimate of the data generating process for the past 10 quarters. There was also a structural break occurring in 1988:2, 1991:3 and 1993:4 and a period of instability from 1994:3-1995:3. It is clear from this result that domestic production of pigmeat has been affected by external factors, that is, factors not modelled in the supply equation above, over a long period of time. ABARE reports [1, 3] have indicated that the pig industry has been undergoing structural change for a long period of time, and these results lend weight to their analysis. The introduction of imports is just another external factor impacting on the changing structure of the Australian pig industry.

8.6 Modelling domestic production

One of the questions we would like to answer is whether the introduction of imports have had an effect on domestic production of pigmeat. While the test for a structural break can indicate that the DGP underlying domestic production has changed after 1989:4 it does not indicate what the sign of that shift in supply has been. In order to determine the sign and magnitude of the shift in production we turn to an Autoregressive Distributed Lag (ADL) model which attempts to capture the whole data generating process underlying the dependent variable, such as domestic production of pigmeat.

The model is a supply model in quantity dependent form estimated from 1985:1 to 1997:2 and is in levels form in an attempt to obtain meaningful parameter values. The model regresses domestic production (PPDQ) against saleyard prices for baconers (SPQ), the saleyard price for cattle (SBFQ), retail price for pork (RPQ), import prices for Canadian pigmeat (CAMPQ) and import volumes for Canadian pigmeat (CAMVQ) along with the 1^{st} to 3^{rd} quarterly dummies and a structural break for 1990:1 onwards. A maximum number of 4 lags was chosen, as quarterly data is used. The results are conflicting, as the Information Criterion select different models [8].

[8] The AIC, R^2, and Hannan-Quinn Criterion [50] all select an ADL(4,4,4,4,4,3) model whereas the SBC selects an ADL(0,0,2,0,0,0) model.

The DHF tests indicate that the the variables are all $I(1)$, except for the saleyard price for baconers (SPQ) which was $I(0)$ before the structural break and $I(1)$ after the structural break and the import volumes and prices (CAMPQ, CAMVQ) which where $SI_4(0,1)$.

The ADL(4,4,4,4,4,3) model exhibts highly significant serial correlation which is not removed when the model is reparameterised in an ECM representation. As such the model is inappropriate to use as over-differencing has re-introduced serial correlation and fails to capture the AR(1) DGP.

In addition the ADL(0,0,2,0,0,0) model is not appropriate to use as it fails to capture the AR(1) DGP by selecting an AR(0) process.

Table 8.5: ADL(1,1,1,1,0,0) model results

Regressor	Regression estimates Coefficient	Standard Error	Long-run estimates Coefficient	Standard Error[p-value]
α_0	7070286	6574613	8608086	7973139[0.288]
$PPDQ_{t-1}$	0.17865	0.18737		
SPQ_t	−90588.6	37580.4	−99924.5	56170.8[0.084]
SPQ_{t-1}	8515.3	52912		
$SBFQ_t$	76913.3	28084.6	85611.1	26867.6[[0.003]
$SBFQ_{t-1}$	−6596.2	29989.6		
RPQ_t	8535.2	50378.7	28535.7	25816.9[0.277]
RPQ_{t-1}	14902.7	44484		
$CAMPQ_t$	−13742.3	10536.2	−16731.2	11824.3[0.166]
$CAMVQ_t$	−0.30757	1.0683	−0.37446	1.3209[0.778]
Q_t^1	−7120378	1222059	−8669073	2700222[0.003]
Q_t^2	5998.6	1602572	7303.3	1952246[0.997]
Q_t^3	−505020.8	945988.2	−614863.8	1127764[0.589]
T	338988.9	106590.9	412719.6	94694.4[0.000]
$BREAK$	4210495	4508510	5126285	5260080[0.336]
R^2	0.95548			

It was decided to estimate two ADL models, an ADL(1,1,1,1,0,0) model as the AR(1) process captures the $I(1)$ DGP [9] and the AR(0) process along with the quarterly dummies captures the $SI_4(0,1)$ DGP [10], and an ADL(1,1,1,1,4,4) model to see if the $SI_4(0,1)$ DGP could be captured by an AR(4) process. The end results are not substantially different - the structural break coefficient is still not significantly different from zero, and the ECMs are highly significant (The ECMs indicate that there is an extremely fast return to equilibrium following a shock to production). The long-run coefficients are different, but in the main they are of the same order of magnitude. The results are presented in Tables 8.5 and 8.6 [11].

The interpretation of the coefficients is not straight forward as the long

[9] In domestic production of pigmeat (PPDQ), saleyard prices for baconers (SPQ) and beef cattle (SBFQ), and the retail price of pork (RPQ).

[10] In import prices (CAMPQ) and import volumes (CAMVQ).

[11] The p-values for the long run coefficients are included with their respective standard errors. The p-values indicate the probability of falsely rejecting the null hypothesis ($H_0 : \beta = 0$) for that particular parameter. The p-values are interpreted such that if ($p < 0.1$) then the parameter in question is significantly greater or less than (depending on the sign of the parameter) zero. If ($p < 0.05$) then the parameter in question is significantly different from zero.

Table 8.6: ADL(1,1,1,1,4,4) model results

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	13600000	7873784	15100000	8722821[0.095]
$PPDQ_{t-1}$	0.10206	0.1883		
SPQ_t	−96645.2	41000.5	−108919.8	56946.3[0.066]
SPQ_{t-1}	−1157.7	59440.4		
$SBFQ_t$	43747.5	30575.8	21302.4	39771.7[0.597]
$SBFQ_{t-1}$	−24619.4	33177.5		
RPQ_t	55126	55349.7	63838	29112.5[0.037]
RPQ_{t-1}	2196.4	44974.3		
$CAMPQ_t$	−21679.7	19404	−1692.5	18784.3[0.929]
$CAMPQ_{t-1}$	8055.2	12675		
$CAMPQ_{t-2}$	7165.3	11121.9		
$CAMPQ_{t-3}$	−16959.3	12801.2		
$CAMPQ_{t-4}$	21898.8	8969.7		
$CAMVQ_t$	−2.1443	1.6165	−7.72426	3.8735[0.072]
$CAMVQ_{t-1}$	−1.3742	1.4755		
$CAMVQ_{t-2}$	0.23388	1.6099		
$CAMVQ_{t-3}$	−1.0918	1.397		
$CAMVQ_{t-4}$	−2.1270	1.6946		
Q_t^1	−7718923	1381852	−8596300	2598557[0.003]
Q_t^2	−511805.3	1751407	−569980	1884739[0.765]
Q_t^3	−114019.9	1062703	−126980	1179296[0.915]
T	271655.3	126815.8	302533.2	123475[0.021]
$BREAK$	3973068	6263695	4424670	6872021[0.525]
R^2	0.96852			

run coefficients are negative. The signs are the opposite as is expected from economic theory, for example, as producer price increases production is expected to increase, not decrease[12]. The reason for this is that domestic production is lagged and changes in market prices need around 2-3 quarters to impact on production decisions. The lagged nature of production means that current period production is affected by previous period prices, so that current period prices have a negative relationship with current period production due to the cobweb supply response.

In the ADL(1,1,1,1,0,0) model saleyard prices for baconers seem to follow an oscillatory pattern, indicative of a cobweb supply response. Every cent increase in the previous period's producer price adds around 8.5 tonnes (8515.3 kgs) to production while the overcompensation in supply response results in the current period's producer price decreasing production by around 90.6 tonnes (90588.6 kgs). Saleyard prices for cattle also follow a oscillatory pattern, with the previous period's cattle price decreasing domestic pigmeat production by around 6.6 tonnes (6596.2 kgs) for every one cent increase. Current period's cattle price increases domestic pigmeat production by around 77 tonnes (76913.3 kgs).

The both the short- and long-run coefficients of the ADL(1,1,1,1,0,0) model indicate that there is insufficient evidence from the sample data to conclude that the structural break value is significantly different from zero.

The ADL(1,1,1,1,4,4) model results are similar with differences being attributed to the extra lags for import volumes and prices capturing more of the DGP. The long-run coefficients indicate that the saleyard price for baconers has a significantly negative impact and a 1¢/kg increase in producer price decreases domestic production by around 110 tonnes (108919.8 kgs). Further, a 1¢/kg increase in retail pork prices increases domestic production by around 64 tonnes (63838 kgs). The volume of imports from Canada significantly decreases domestic production by around 7 kgs (7.2426 kgs) for every 1 kg imported. Again the sign of these coefficients appear to be contrary to established microeconomic theory due to the lagged and oscillating nature of the market equilibrium. Both the short- and long-run coefficients of the ADL(1,1,1,1,4,4) model indicate that there is insufficient evidence from the sample data to conclude that is structural break value is significantly different from zero.

Alternative ADL models were also considered and these results confirm the results obtained in the ADL(1,1,1,1,0,0) and ADL(1,1,1,1,4,4) models. The coefficients of the independent regressors (SPQ_{t-i}, SBFQ_{t-i}, RPQ_{t-i},

[12] ABARE [3, p. 4] also found a negative relationship between producer prices and domestic production of pigmeat.

CAMPQ_{t-i}, and CAMVQ_{t-i}) are all altered to a minor extent as the addition of lagged variables capture more of the DGP from the other variables. The signs of the long-run coefficients are robust to the different ADL models and the underlying conclusion of the models, that the structural break term is not significantly different from zero is not changed.

These results suggest that not only is the claim by ABARE, that there has been an increase in production, shown to be incorrect, but that the observed decline in domestic production in Figure 5.5 can be also attributed in part to import volumes.

While the ABARE claim of an increase in production can be explained by their comparison of production over a short time period, 1996:1-1998:1 [3, p. 4], their additional claim that there are other factors besides imports affecting producer profitability is thrown into doubt by the results in Tables 8.5 and 8.6. Any factors affecting domestic pigmeat production after 1990, besides import volumes and prices, are subsumed into the structural break dummy. The results indicate that the structural break term is not significantly different from zero, and thus factors other than import volumes and prices do not seem play an important role in determining the DGP for domestic pigmeat production.

The structural break term was dropped from the ADL models and the ADL models were re-estimated (See Tables 8.7 and 8.8).

The results are consistent with the previous models which had the structural break parameter included. In the new ADL(1,1,1,1,0,0) model every cent increase in the producer price drops domestic production by around 109 tonnes (108840.2 kgs) in the long-run while every cent increase in saleyard beef prices increases domestic production by around 87 tonnes (87277.7 kgs). In the new ADL(1,1,1,1,4,4) model every cent increase in the producer price drops domestic production by around 104 tonnes (103633.8 kgs) in the long-run while every cent increase in retail pork prices increases domestic production by around 63 tonnes (63469.1 kgs). Imports of pigmeat have a significant effect with every kg of imported product dropping domestic production by around 7 kgs (7.0417 kgs).

8.7 Oversupply in the domestic pigmeat market

The other aspect of the supply response we are interested in is whether there has been a persistent oversupply of pigmeat in the domestic market. This aspect can be examined by formulating an error correction model (ECM)

Table 8.7: ADL(1,1,1,1,0,0) model results, no structural break

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	6960677	6750149	9188094	8899785[0.309]
$PPDQ_{t-1}$	0.24242	0.17833		
SPQ_t	-80444.3	38167.4	-108840.2	54058.5[0.052]
SPQ_{t-1}	-2010.4	50322.9		
$SBFQ_t$	73195.2	26516.1	87277.7	28932.2[0.005]
$SBFQ_{t-1}$	-7075.7	29782.2		
RPQ_t	-13995.5	52807.9	27983.2	27300.5[0.313]
RPQ_{t-1}	35194.9	45872.7		
$CAMPQ_t$	-4049.3	3364.3	-5345.1	4125.7[0.204]
$CAMVQ_t$	0.0032532	1.0415	0.0042942	1.3745[0.998]
Q_t^1	-6846967	1194948	-9037996	2989888[0.005]
Q_t^2	771805.4	1559947	1018783	2219482[0.649]
Q_t^3	-426637.6	940828.9	-563161.7	1219141[0.647]
T	321501.5	104865.4	424382	102141.6[0.000]
R^2	0.94809			

using the long-run coefficients.

The error correction model addresses the issue of integrating short-run dynamics with the long-run equilibrium without losing long-run information. Rearranging the general ADL model (equations 7.4 and 7.5) we obtain the error correction model

$$\begin{aligned}\Delta y_t &= -\sum_{j=1}^{\hat{p}-1}\phi_j^*\Delta y_{t-j}-\sum_{i=1}^{k}\sum_{j=1}^{\hat{q}_i-1}\beta_{ij}^*\Delta x_{i,t-j}\\ &\quad -\phi\left(1,\hat{p}\right)ECM_{t-1}+\sum_{i=1}^{k}\beta_{i0}\Delta x_{it}+\delta'\Delta\mathbf{w}_t+u_t \qquad (8.2)\end{aligned}$$

where the error correction term is defined by

$$ECM_t = y_t-\sum_{i=1}^{k}\hat{\theta}_i x_{it}-\hat{\psi}'\mathbf{w}_t \qquad (8.3)$$

and the long run coefficients are defined by equations 7.6 and 7.7.

The ECM (equation 8.3) shows how much of the shock (or disequilibrium) in the previous period is dissipated in the current period. The larger the absolute value of the ECM the faster the return to the long-run equilibrium. For a stable model the ECM lies between zero and negative one

Table 8.8: ADL(1,1,1,1,4,4) model results, no structural break

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	1.56×10^7	7894232	1.79×10^7	8838396[0.054]
$PPDQ_{t-1}$	0.12753	0.18331		
SPQ_t	-79875.6	41572.3	-103633.8	52863.5[0.061]
SPQ_{t-1}	-10541.7	53703.8		
$SBFQ_t$	44790.3	29128.2	22309.7	40190[0.584]
$SBFQ_{t-1}$	-25325.8	32599.7		
RPQ_t	38219.4	55429.1	63469.1	27008.9[0.027]
RPQ_{t-1}	17155.5	45627.1		
$CAMPQ_t$	-9075.1	8066.7	10893.7	6955.5[0.129]
$CAMPQ_{t-1}$	4432.6	11609.6		
$CAMPQ_{t-2}$	4119.7	10674		
$CAMPQ_{t-3}$	-11679.2	11190		
$CAMPQ_{t-4}$	21706.4	8823		
$CAMVQ_t$	-2.2319	1.5937	-7.0417	3.9381[0.085]
$CAMVQ_{t-1}$	-0.85496	1.3595		
$CAMVQ_{t-2}$	-0.14931	1.4988		
$CAMVQ_{t-3}$	-0.81927	1.3702		
$CAMVQ_{t-4}$	-2.0882	1.6549		
Q_t^1	-7290253	1256661	-8355882	2599997[0.003]
Q_t^2	385197.7	1621262	441502.7	1910264[0.819]
Q_t^3	-43664.1	1048528	-50046.6	1200121[0.967]
T	238128	117679.5	272935.6	120530.6[0.032]
R^2	0.96439			

Table 8.9: ADL(1,1,1,1,0,0) model ECM

Regressor	Regression estimates Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	7070286	6574613[0.289]
ΔSPQ_t	-90588.6	37580.4[0.021]
$\Delta SBFQ_t$	76913.3	28084.6[0.009]
ΔRPQ_t	8535.2	50378.7[0.886]
$\Delta CAMPQ_t$	-13742.3	10536.2[0.200]
$\Delta CAMVQ_t$	-0.30757	1.0683[0.775]
ΔQ_t^1	-7120378	1222059[0.000]
ΔQ_t^2	5998.6	1602572[0.997]
ΔQ_t^3	-505020.8	945988.2[0.597]
ΔT	338988.9	106590.9[0.003]
$\Delta BREAK$	4210495	4508510[0.356]
ECM_{t-1}	-0.82135	0.18737[0.000]
R^2	0.91547	

($ECM \in [-1, 0)$) If the $ECM = 0$ then there is no return to the long-run equilibrium and any shock will be permanent. If the $ECM = -1$ then there is instantaneous return to the long-run equilibrium (100% within the same time period). For an unstable model the absolute value of the ECM is greater than 1 ($ECM \in [-\infty, -1)$).

The results of this model are presented in Tables 8.9 to 8.12. Irrespective of the particular model chosen the results show that the ECM is significant, indicating that oversupply does occur in the supply response of pigmeat to changes in prices and other factors. The coefficient of the ECM is quite large, ranging from around -0.82 to -0.90, depending on the ADL model chosen, indicating that there is a very rapid return to the equilibrium after a shock.

Plotting the impulse-response function for domestic production of pigmeat from the VAR model in chapter 12 shows how the impact of an exogenous shock to the dependent variable is spread between the variables of the system (See Figure 8.11). The results of the VAR model confirm the findings of the single equation ADL models estimated in this chapter. A one standard error shock to production in the current time period returns all but around 0.002 of production to the long-run equilibrium in the first time period after the shock. In subsequent periods the disequilibrium oscillates around the long-run equilibrium but never exceeds more than around 0.008 difference from the long-run equilibrium. The results are of similar magnitude for the

Table 8.10: ADL(1,1,1,1,4,4) model ECM

Regressor	Regression estimates	
	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	13600000	7873784[0.094]
ΔSPQ_t	-96645.2	41000.5[0.025]
$\Delta SBFQ_t$	43747.5	30575.8[0.162]
ΔRPQ_t	55126	55349.7[0.327]
$\Delta CAMPQ_t$	-21679.7	19404[0.272]
$\Delta CAMPQ_{t-1}$	-12104.8	7954.8[0.138]
$\Delta CAMPQ_{t-2}$	-4939.4	9959.8[0.623]
$\Delta CAMPQ_{t-3}$	-21898.8	8969.7[0.020]
$\Delta CAMVQ_t$	-2.1443	1.6165[0.194]
$\Delta CAMVQ_{t-1}$	2.9848	2.2008[0.185]
$\Delta CAMVQ_{t-2}$	3.2187	1.7183[0.070]
$\Delta CAMVQ_{t-3}$	2.1270	1.6946[0.219]
ΔQ_t^1	-7718923	1381852[0.000]
ΔQ_t^2	-511805.3	1751407[0.772]
ΔQ_t^3	-114019.9	1062703[0.915]
ΔT	271655.3	126815.8[0.040]
$\Delta BREAK$	3973068	6263695[0.530]
ECM_{t-1}	-0.89794	0.18830[0.000]
R^2	0.94024	

Table 8.11: ADL(1,1,1,1,0,0) model ECM, no structural break

Regressor	Regression estimates	
	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	6960677	6750149[0.309]
ΔSPQ_t	-80444.3	38167.4[0.042]
$\Delta SBFQ_t$	73195.2	26516.1[0.009]
ΔRPQ_t	-13995.5	52807.9[0.792]
$\Delta CAMPQ_t$	-4049.3	3364.3[0.236]
$\Delta CAMVQ_t$	0.0032532	1.0415[0.998]
ΔQ_t^1	-6846967	1194948[0.000]
ΔQ_t^2	771805.4	1559947[0.624]
ΔQ_t^3	-426637.6	940828.9[0.653]
ΔT	321501.5	104865.4[0.004]
ECM_{t-1}	-0.75758	0.17833[0.000]
R^2	0.91617	

Table 8.12: ADL(1,1,1,1,4,4) model, no structural break ECM

	Regression estimates	
Regressor	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	1.56×10^7	7894232[0.057]
ΔSPQ_t	-79875.6	41572.3[0.064]
$\Delta SBFQ_t$	44790.3	29128.2[0.134]
ΔRPQ_t	38219.4	55429.1[0.496]
$\Delta CAMPQ_t$	-9075.1	8066.7[0.269]
$\Delta CAMPQ_{t-1}$	-14146.9	7257[0.060]
$\Delta CAMPQ_{t-2}$	-10027.2	8149.5[0.228]
$\Delta CAMPQ_{t-3}$	-21706.4	8823[0.020]
$\Delta CAMVQ_t$	-2.2319	1.5937[0.171]
$\Delta CAMVQ_{t-1}$	3.0568	2.1753[0.170]
$\Delta CAMVQ_{t-2}$	2.9075	1.6449[0.087]
$\Delta CAMVQ_{t-3}$	2.0882	1.6549[0.216]
ΔQ_t^1	-7290253	1256661[0.000]
ΔQ_t^2	385197.7	1621262[0.814]
ΔQ_t^3	-43664.1	1048528[0.967]
ΔT	238128	117679.5[0.052]
ECM_{t-1}	-0.87247	0.18331[0.000]
R^2	0.94250	

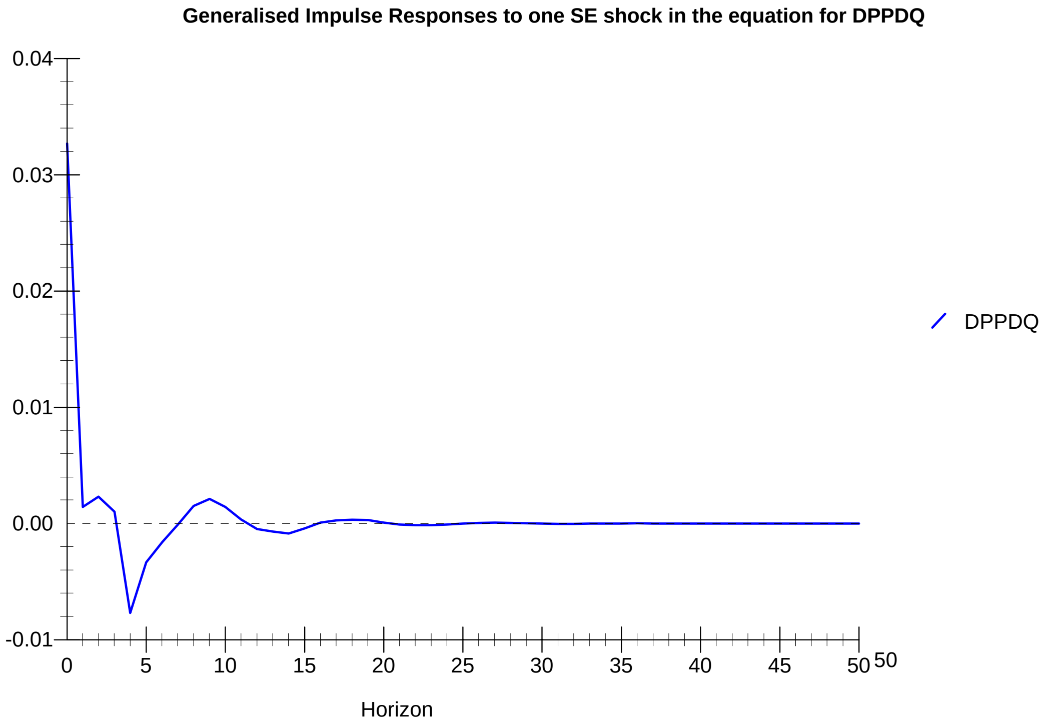


Figure 8.11: Generalised Impulse Response Function for production of pigmeat

other variables in the domestic production equation of the VAR model.

The results in this section indicate that any oversupply in pigmeat production is likely to be very short-lived and thus the claims by DPIE, that there is an oversupply in pigmeat production causing a depression in pigmeat prices, do not appear to be supported.

8.8 Summary

This chapter has examined the factors affecting domestic pigmeat production in Australia to determine whether there has been an increase in production, or a persistent oversupply in domestic pigmeat, which could have contributed to an acute depression in producer prices over the period 1990:1-1997:2, corresponding to the introduction of imports from Canada. We show that the increase in production, as claimed by ABARE [3], only refers to the period between 1995 and 1998, a time when production was in fact below historical patterns. Modelling work indicates that there has been a change in the underlying supply response of the domestic pig industry and that production is in fact significantly below historical patterns. Every cent increase in the producer price drops domestic production by around 100 tonnes while every cent increase in saleyard beef prices increases domestic production by between 60 and 90 tonnes. Imports of pigmeat have a significant effect with every kg of imported product dropping domestic production by around 7 kgs.

Combined with chapter 7, indicating that import volumes and prices have driven producer prices down, the implication is that imports are crowding out domestic production, import prices are driving producer prices down, and the concomitant depression in producer price has driven production down even further.

In terms of whether a persistent oversupply in production has been the cause of low producer prices, modelling work indicates that producers respond quickly to market signals and any oversupply in domestic pigmeat is cleared, to all intents and purposes, within one time period (3 months). This is confirms the spectral analysis results. Declines in pigmeat consumption have not resulted in an oversupply of pigmeat in the domestic market as production has followed changes in consumption.

Chapter 9

The effect of imports on wholesale prices

9.1 Introduction

The Productivity Inquiry into the pig and pigmeat industry issues paper [76] has stated that it is necessary to establish serious injury to the domestic industry producing "like" or "directly competitive" products to imports. In this chapter we attempt to address the issue of serious injury to "like" products. This analysis is severely hampered by lack of adequate data. The price series for "like" products would be the wholesale price for bone-out pork leg, but this data has not been available. The only industry-wide data that is available is the Sydney market wholesale price for pork leg square cut (bone-in) [77]. The argument for using this series is that the boning-out processing stage will add a constant mark-up price wedge and so the data generating process (DGP) for bone-out pork leg will be directly comparable with the DGP for bone-in pork leg. It is immediately obvious that this argument is tenuous. A similar logic would presuppose that there is a constant mark-up between producer and retail prices and that those DGPs would be the same. Figure 5.1 shows that the DGPs for producer and retail prices are totally different and are a function of the institutional structure of the industry at those particular stages. Nevertheless, it is desirable to determine whether imports have affected bone-in prices as this will give another indication of the mechanism by which imports suppress producer prices.

The data series is the Sydney market wholesale price for pork leg square cut (bone-in) and covers the period 1993:5 to 1998:8 (i.e. monthly data). This time series is extremely short, covering only 64 observations and thus it was desirable to use monthly data rather than quarterly data. The correlation

Table 9.1: Correlation Matrix for Monthly Dataset

	$SBFM$	$SPML$	SPM	RPM
$SBFM$	1.0000			
$SPML$	−0.47843	1.0000		
SPM	−0.34548	0.23070	1.0000	
RPM	−0.79839	0.36072	0.28473	1.0000
WPM	0.035140	−0.0025765	0.76759	0.074478
$PPRODM$	0.25905	−0.046147	−0.45787	−0.30956
$CANVM$	−0.54184	0.14054	0.16303	0.73021
$CANPM$	0.044536	0.052132	0.27198	0.18400
	WPM	$PPRODM$	$CANVM$	$CANPM$
WPM	1.0000			
$PPRODM$	−0.34159	1.0000		
$CANVM$	0.047898	−0.095784	1.0000	
$CANPM$	0.32454	−0.14886	0.14095	1.0000

matrix for the dataset in monthly format is presented in Table 9.1[1].

The correlation matrix shows that there is a reasonable relationship between wholesale prices and producer prices of 0.768 but all other variables show a low relationship with wholesale prices.

9.2 Testing for structural breaks

In order to test the domestic wholesale price of pigmeat for a structural break a model capturing how the variability in domestic wholesale price of pigmeat is explained by the variability in, for example, production, needs to be developed. If the Chow test indicates that a structural break has changed the values of the parameters in the model, then external factors (subsumed into the structural break) explain more of the variation in domestic wholesale price of pigmeat pre- and post-break than the underlying DGP.

We formulate a model of domestic wholesale price in the form

$$y_t = \alpha_o + \alpha_1 T + \sum_{i=1}^{N} \beta_i x_{it} + \varepsilon_t \tag{9.1}$$

[1] In order to estimate the relationship between wholesale prices and retail prices, which are only available in quarterly frequency, it was decided to disagregate the retail price series. Although this procedure is not statistically acceptable, it was felt that the retail series did not exhibit large enough variability to make a major difference to the relationship between retail and wholesale prices.

Table 9.2: Regression Results for Structural Break I

	Estimation Period			
	93:6 to 97:10		93:6 to 98:6	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	0.026855	0.19516 [0891]	0.010957	0.15465 [0.944]
T	-0.2098×10^{-4}	0.4080×10^{-4} [0.959]	0.6200×10^{-5}	0.3184×10^{-3} [0.985]
SPM	0.36772	0.23352 [0.125]	0.37864	0.19667 [0.061]
$SBFM$	−0.0094645	0.15431 [0.951]	−0.053927	0.12554 [0.670]
RPM	0.60416	1.1740 [0.610]	−0.098919	0.87683 [0.911]
$PPRODM$	0.11583	0.089271 [0.203]	0.12617	0.079324 [0.119]
$CANVM$	−0.0081015	0.0106702 [0.631]	−0.0098415	0.013664 [0.475]
$CANPM$	−0.024440	0.067811 [0.721]	−0.027320	0.059463 [0.648]
M_t^1	−0.092109	0.042525 [0.037]	−0.082444	0.032448 [0.015]
M_t^2	−0.069168	0.034323 [0.052]	−0.064310	0.028494 [0.029]
M_t^3	−0.037568	0.035776 [0.301]	−0.031205	0.028917 [0.287]
M_t^4	−0.023685	0.035990 [0.515]	−0.016820	0.03054 [0.585]
M_t^5	−0.046685	0.034925 [0.190]	−0.053548	0.028501 [0.067]
M_t^6	−0.0045870	0.030363 [0.881]	−0.0051284	0.025998 [0.845]
M_t^7	0.0018854	0.038095 [0.961]	0.011976	0.033966 [0.726]
M_t^8	0.0091313	0.031399 [0.773]	0.013112	0.028117 [0.643]
M_t^9	−0.010317	0.031568 [0.746]	−0.0065815	0.027971 [0.815]
M_t^{10}	−0.0062962	0.040041 [0.876]	0.0091143	0.032825 [0.783]
M_t^{11}	0.030943	0.032839 [0.353]	0.033247	0.027200 [0.228]
R^2	0.63043		0.64322	
$\text{LMF}_{(df)}$	$1.6660_{(12,22)}$		$1.8520_{(12,30)}$	
RSS	0.067387		0.071572	
$\text{Chow}_{(df)}$		$0.32605_{(8,42)}$		

where the endogenous variable is the wholesale price of pork (WPM) and the exogenous variables being the saleyard price for baconers (SPM), the saleyard price of cattle (SBFM), the retail price for pork (RPM), the domestic production of pigmeat (PPDM) (in tonnes) , the import volumes and prices for Canadian pigmeat (CANVM and CANPM respectively) and the 1^{st} to 11^{th} seasonal dummy. The model is estimated from 1993:5 to 1997:10 and then for the full sample period to 1998:8 with the variables in log-stationary form (See Table 9.2).

The results indicate that the data generating process for wholesale prices is not significantly changed after 1997:10, implying that the new import protocols for pigmeat have not had an impact on wholesale prices[2]. This result is confirmed by the VEC model results in chapter 14.

9.3 Modelling wholesale prices

While the results in the previous section indicate that there has not been any significant effect of the new import protocols on the data generating process underlying wholesale prices, one of the questions we would like to answer is whether imports per-se have had an effect on wholesale prices. We formulate an Autoregressive Distributed Lag (ADL) model which attempts to capture the whole data generating process underlying the formation of wholesale prices.

The model is a wholesale price model estimated from 1993:7 to 1998:6 and is in levels form in an attempt to obtain meaningful parameter values. The wholesale price (WPM) is regressed on the saleyard price for baconers (SPM), the retail price for pork (RPM), the saleyard price for cattle (SBFM), the production of pigmeat (PPRODM), import volumes of Canadian pigmeat (CANVM), import prices for Canadian pigmeat (CANPM) and the 1^{st} to 11^{th} seasonal dummy and a structural break term for post 1997:10 data. Different model lag lengths were chosen by the information criterion. Based on the diagnostic tests the more appropriate model was the one selected by the SBC. The ADL(1,0,0,0,0,0,0) model that was selected exhibited significant serial correlation[3]. The results are presented in Table 9.3 [4].

While model suggests that import volumes decrease wholesale prices by $9.375¢/kg$ for every 1000 tonnes imported, the standard error is very large indicating that no confidence can be attached to this estimate.

The results indicate that wholesale prices are not significantly influenced by any of the variables in the regression model, implying that the DGP

[2] There is a question of whether the use of quarterly data would change the results for the structural break test. Re-running the Chow test on quarterly data indicates that the data generating process has not significantly changed after 1997:4.

[3] The serial correlation could not be eliminated with the addition or reduction in lag length. It is possible that more than four lags are required to eliminate serial correlation. Given the number of variables in the model the search algorithm takes a prohibitive amount of computer time to regress $(4+1)^7 = 78125$ equations. Even increasing the lag length to just 5 lags requires 279936 equations to be estimated.

[4] The p-values for the long run coefficients are included with their respective standard errors. The p-values indicate the probability of falsely rejecting the null hypothesis ($H_0 : \beta = 0$) for that particular parameter. The p-values are interpreted such that if ($p < 0.1$) then the parameter in question is significantly greater or less than (depending on the sign of the parameter) zero. If ($p < 0.05$) then the parameter in question is significantly different from zero.

Table 9.3: ADL(1,0,0,0,0,0,0) model results

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	273.6175	209.6899	869.8918	666.8755 [0.200]
WPM_{t-1}	0.68546	0.13100		
SPM	0.16364	0.18954	0.52026	0.61109 [0.400]
RPM	0.071743	0.16996	0.22809	0.50617 [0.655]
$SBFM$	-0.23467	0.18707	-0.74606	0.70038 [0.293]
$PPRODM$	0.0019019	0.0013145	0.0060467	0.0053127 [0.262]
$CANVM$	-0.2949×10^{-5}	0.9971×10^{-5}	-0.9375×10^{-5}	0.3307×10^{-4} [0.778]
$CANPM$	0.059432	0.052124	0.18895	0.18920 [0.324]
T	-0.059943	0.39741	-1.9057	1.2193 [0.126]
S_t^1	-29.9812	9.4557	-95.3169	50.7717 [0.68]
S_t^2	-24.4973	9.4294	-77.8825	34.4276 [0.029]
S_t^3	-23.8765	10.3532	-75.9089	33.2697 [0.028]
S_t^4	-23.1094	12.6458	-73.4700	40.2610 [0.076]
S_t^5	-27.9320	12.2057	-88.8020	41.4422 [0.038]
S_t^6	-19.2355	12.2216	-61.1541	34.8041 [0.087]
S_t^7	-8.2750	11.0857	-26.3080	29.9651 [0.385]
S_t^8	-4.9227	9.6024	-15.6504	27.4158 [0.571]
S_t^9	-9.5537	8.9261	-30.3734	25.0772 [0.233]
S_t^{10}	-4.9605	9.8824	-15.7705	28.3304 [0.581]
S_t^{11}	9.0525	8.3967	28.7800	33.7407 [0.399]
$BREAK_{97:11}$	5.2440	9.0142	16.6718	31.0240 [0.594]
R^2	0.90989			

for wholesale prices depends on other factors. This result is unusual, as we expected that wholesale prices would have some relationship with either retail or producer prices, considering that there was a relationship found between retail prices and producer prices in chapter 10 and in the VEC models presented in chapters 13 and 14. One suggestion for this result is that wholesale prices, like retail prices, are influenced by changing prices of close substitutes more than prices further up and down the marketing chain. Unfortunately data is not available on wholesale prices other than that of the Sydney market wholesale price for pork leg square cut (bone-in) and this proposition cannot be tested at this stage.

Wholesale price data from Darling Downs Bacon (DDB) was kindly provided to us by KPMG Management Consulting, who had been asked by DDB to provide a submission to the Productivity Commission Inquiry on their behalf. We are able to construct a VEC model looking at price effects due to substitutability between products at the wholesale stage and estimate the effect of imports on DDB wholesale prices. As the data pertains to only DDB and not to the whole industry, and the results from the modelling exercise will form part of the DDB submission we only provide a synopsis of the results.

A comparable product manufactured by DDB to the pork leg square cut (bone-in) product is the Smoked Ham (bone-in). The results of the VEC model suggest that price changes in this product line are related to changes in Champagne Ham (bone-out), Processed Bacon, and Frozen Pork. Import volumes and prices do not seem to have an effect on this product line.

A product which is directly comparable with imports is the Champagne Ham (bone-out). This product line's prices are influenced significantly by both import volumes and prices, with every 1000 tonnes of imports dropping the price by $\$0.7039 \pm 0.3831/kg$ and every \$1.00 increase in import prices increasing the wholesale price by $5¢/kg$. In addition to the direct effects of imports, market conditions after the November 1997 import protocol changes have resulted in Champagne Ham prices dropping by $\$1.2722 \pm 0.32501/kg$.

Processed Shoulder Ham, a product which is also an as-like product to imports, is also significantly affected by imports, with import volumes depressing the price by $\$0.2692 \pm 0.1049/kg$ for every 1000 tonnes of imports and every \$1.00 increase in import prices decreasing the price by $2.8557 \pm 0.8358¢/kg$.

Other product lines, which are not as-like products to imports, do not show an effect of imports. Granger Causality tests indicate that import volumes and prices significantly cause changes in Processed Shoulder Ham prices.

9.4 Summary

This chapter has examined the effect of imports on wholesale prices. The results indicate that the Sydney market wholesale price for pork leg square cut (bone-in) has not been significantly affected by the introduction of imports after 1990 and the change in import protocols after November 1997. The modelling results indicate that retail and producer prices, and production volumes do not influence the data generating process underlying changes in the wholesale price series, indicating that other factors have more influence, such as prices of other product lines at the same processing level.

While the wholesale price for pork leg square cut (bone-in) is the only available price series that proxies wholesale prices on a national level this product is not directly comparable with imports, which are bone-out.

Using data obtained from Darling Downs Bacon (DDB) and pertaining only to their individual circumstances, we are able to show that prices for DDB product lines are significantly affected by changes in other products at the same processing stage. DDB product lines have been significantly affected by imports with as-like products, such as Champagne Ham (bone-out) and Processed Shoulder Ham registering declines in prices of $\$0.7039 \pm 0.3831/kg$ and $\$0.2692 \pm 0.1049/kg$ for every 1000 tonnes of imports respectively.

In addition, market conditions after the November 1997 import protocol changes have resulted in Champagne Ham prices dropping by $\$1.2722 \pm 0.32501/kg$.

Chapter 10

The effect of imports on retail prices

10.1 Introduction

The recent debate over the effect of imports of pigmeat from Canada on the prices and profitability of the Australian pig industry has centred around the issue of whether the decline in producer prices for pigmeat has been a result of imports or a result of either declining consumption of pigmeat as consumers substitute cheaper beef, lamb, and chicken for pigmeat or an increased production of pigmeat as producers attempt to maintain revenue.

While consumption of pigmeat has indeed been falling this has been matched by a corresponding decline in domestic supply [4], suggesting that any decline in producer price is not due to increased production. The other issue of pigmeat and other meat substitution is contingent on the assumption that changes in retail prices and changes in producer prices are linked. Figure 5.1 suggests that changes in producer prices are not matched by changes in retail prices. While producer prices have exhibited strong seasonality and have been affected by the introduction of imports, retail prices have continued to rise, in line with inflationary effects. Economic theory suggests that retailers prefer to maintain intertemporal and spatial price averaging to cater for consumer preferences. In the presence of market power changes in producer price may not necessarily be transferred to changes in retail price - especially when producer prices are falling.

In this chapter we identify the factors affecting the formation of retail prices. We initially test to see whether retail prices have been subjected to an exogenous shock after the period 1990:1 and then attempt to quantify the effect of imports on retail prices. If imports have not depressed retail prices the implication is that consumers are not reaping the benefits of trade liberalisation and that the declines in producer price are manifesting themselves in increased marketing margins for market intermediaries.

10.2 Testing for shifts in retail price

In order to test the domestic retail price of pigmeat for a structural break a model capturing how the variability in domestic retail price of pigmeat is explained by the variability in, for example, production, needs to be developed. If the Chow test indicates that a structural break has changed the values of the parameters in the model, then external factors (subsumed into the structural break) explain more of the variation in domestic retail price of pigmeat pre- and post-break than the underlying DGP.

We formulate a model of domestic retail price in the form

$$y_t = \alpha_o + \alpha_1 T + \sum_{i=1}^{N} \beta_i x_{it} + \varepsilon_t \qquad (10.1)$$

where the endogenous variable is the retail price of pork (RPQ) and the exogenous variables being the saleyard price for baconers (SPQ), the saleyard price of cattle (SBFQ), and the domestic production of pigmeat (PPDQ). The model is estimated from 1984:2 to 1989:4 and then for the full sample period to 1997:2 with the variables in log-stationary form. As noted in chapter 7 the saleyard price for baconers (SPQ) is $I(0)$ over the period 1984:2-1989:4 and $I(1)$ over the period 1990:1-1997:2. The regression is run with the saleyard price of baconers being both $I(0)$ and $I(1)$ and the results compared. The regression results for when the saleyard price of baconers is $I(0)$ are presented in Table 10.1 and for when the saleyard price of baconers is $I(1)$ are presented in Table 10.2 [1].

With the exception of the regression over the full estimation period in Table 10.1[2] the results indicate that none of the variables are significantly different from zero, a result borne out by the low R^2 ratios (which indicate the variability in retail prices of pork attributable to the variables in the model). This implies that the model is not a good specification of the underlying data generating process for retail prices of pork. Further, the regression over the

[1] The statistics in the tables are presented with the superscripts * and **, indicating a significance level of 5% and 1% respectively.

[2] The significance of the coefficient for saleyard prices for baconers for the full estimation period in Table 10.1 is tempered by the results of the unit root tests, which indicate that after 1990:1 the saleyard prices for baconers were in fact $I(1)$ rather than $I(0)$.

Table 10.1: Regression Results for Structural Break I

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	-0.46676	0.34418	-0.40690^{**}	0.12338
T	-0.0011765	0.0011372	$-0.6993 \times 10^{-3**}$	0.1762×10^{-3}
SPQ	0.11987	0.088034	0.097222^{**}	0.026348
$SBFQ$	0.022319	0.067076	0.020790	0.028320
$PPDQ$	-0.025805	0.16134	-0.027258	0.059521
Q_t^1	0.0024863	0.019231	-0.0026046	0.0064130
Q_t^2	-0.0078197	0.019139	-0.0058303	0.0082456
Q_t^3	0.0029461	0.011571	-0.0024603	0.0052120
R^2	0.45208		0.48941	
$\text{LMF}_{(df)}$	$1.7273_{(4,11)}$		$1.2191_{(4,41)}$	
RSS	0.0034750		0.0063925	
$\text{Chow}_{(df)}$		$1.2594_{(30,45)}$		

Table 10.2: Regression Results for Structural Break II

	Estimation Period			
	84:2 to 89:4		84:2 to 97:2	
Parameters	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_o	-0.0083821	0.067194	0.036292	0.018359
T	0.2383×10^{-3}	0.5173×10^{-3}	-0.1580×10^{-3}	0.1247×10^{-3}
SPQ	0.016424	0.10520	0.060249	0.041774
$SBFQ$	0.033140	0.076213	0.016501	0.031572
$PPDQ$	-0.082273	0.16866	-0.020377	0.072164
Q_t^1	-0.0075480	0.024099	-0.4937×10^{-3}	0.0098395
Q_t^2	-0.015249	0.021370	-0.012021	0.0090441
Q_t^3	-0.0031392	0.011289	-0.0089971	0.0056321
R^2	0.38535		0.36430	
$\text{LMF}_{(df)}$	$1.2577_{(4,11)}$		$1.4113_{(4,41)}$	
RSS	0.0038982		0.0079588	
$\text{Chow}_{(df)}$		$1.5625_{(30,45)}$		

Table 10.3: Chow tests for structural break

	Post-Break	
Pre-Break	$I(0)$	$I(1)$
$I(0)$	1.2594	1.9355
$I(1)$	0.9598	1.5625

full estimation period in Table 10.2 shows signs of significant heteroscedasticity, indicating that the estimators will not be efficient[3]. The Chow tests are computed for all scenarios, that is, the saleyard price for baconers being either $I(0)$ or $I(1)$ in both the pre-break and post-break periods. The test statistics are presented in Table 10.3

From the results of the Chow tests there is insufficient evidence to conclude that there has been a structural break for retail prices of pork at 1990:1.

10.3 Modelling domestic retail price

One of the questions we would like to answer is whether the introduction of imports have had an effect on domestic retail price of pigmeat. While the test for a structural break can indicate that the DGP underlying domestic retail price has changed after 1990:1 it does not indicate what the sign of that shift in supply has been. In order to determine the sign and magnitude of the shift in production we need to turn to other modelling techniques, such as Autoregressive Distributed Lag (ADL) models which attempt to capture the whole data generating process underlying the dependent variable, such as domestic retail price of pigmeat.

The model is a quarterly retail price model estimated from 1985:1 to 1997:2 and is in levels form in an attempt to obtain meaningful parameter values. The model regresses retail price for pork (RPQ) on the exogenous variables, the saleyard price for baconers (SPQ), the production of pigmeat (PPDQ, the saleyard price for cattle (SBFQ), the import volume and prices for Canadian pigmeat (CAMVQ and CAMPQ respectively) and the 1^{st} to 3^{rd} seasonal dummies and a structural break term for post 1989:4 data. The results are conflicting, as the Information Criterion select different models [4]. Alternative ADL models were also estimated without any gain in model

[3] Heteroscedasticity $\text{LMF}_{(1,51)} = 6.7465\,[0.012]$

[4] The AIC and R^2 both select an ADL(4,4,1,2,4,0) model whereas the SBC and Hannan-Quinn [50] select an ADL(2,0,1,2,0,0) model.

The ADL(4,4,1,2,4,0) model exhibits highly significant serial correlation and, as such, the model is inappropriate to use as over-differencing has re-introduced serial correlation and fails to capture the DGP.

Table 10.4: ADL(2,0,1,2,0,0) model results

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	-64.1820	17.7177	-130.0091	96.4567 [0.003]
RPQ_{t-1}	0.45597	0.13763		
RPQ_{t-2}	0.33700	0.12150		
$PPDQ_t$	0.3731×10^{-6}	0.5166×10^{-6}	0.1802×10^{-5}	0.2464×10^{-5} [0.470]
SPQ_t	0.40927	0.094322	3.1581	0.59334 [0.000]
SPQ_{t-1}	0.24455	0.14093		
$SBFQ_t$	0.096013	0.085601	0.095706	0.43723 [0.828]
$SBFQ_{t-1}$	0.17199	0.096840		
$SBFQ_{t-2}$	-0.24819	0.085467		
$CAMPQ_t$	-0.012926	0.029522	-0.062437	0.14098 [0.661]
$CAMVQ_t$	-0.1487×10^{-5}	0.3277×10^{-5}	-0.7182×10^{-5}	0.1586×10^{-5} [0.654]
Q_t^1	6.2395	2.0030	30.1379	25.9984 [0.254]
Q_t^2	1.4487	3.4566	6.9976	16.6457 [0.667]
Q_t^3	1.3403	2.6809	6.4738	12.5356 [0.609]
T	0.29958	0.29481	1.4470	1.3590 [0.294]
$BREAK$	1.6771	12.6675	8.1007	60.6393 [0.895]
R^2	0.99651			

fit or improvement in model diagnostics and it was decided to use the ADL model based on the SBC. The end results are not substantially different - the structural break coefficient is still not significantly different from zero, and the ECMs are highly significant ranging from -0.20 to -0.31 (The ECMs indicate that there is a moderately fast return to equilibrium following a shock to retail price for pork). The long-run coefficients are different, but in the main they are of the same order of magnitude. The results are presented in Table 10.4 [5].

Except for the intercept and saleyard prices for baconers no other variables in the model were significant and there is insufficient evidence to suggest that the structural break term is significantly different from zero, thus the structural break term was dropped from the ADL model and the model was re-estimated (See Table 10.5).

[5] The p-values for the long run coefficients are included with their respective standard errors. The p-values indicate the probability of falsely rejecting the null hypothesis ($H_0 : \beta = 0$) for that particular parameter. The p-values are interpreted such that if ($p < 0.1$) then the parameter in question is significantly greater or less than (depending on the sign of the parameter) zero. If ($p < 0.05$) then the parameter in question is significantly different from zero.

Table 10.5: ADL(2,0,1,2,0,0) model results, no structural break

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	-64.4147	17.3811	-314.1190	91.5265 [0.002]
RPQ_{t-1}	0.45914	0.13361		
RPQ_{t-2}	0.33579	0.11945		
$PPDQ_t$	0.3901×10^{-6}	0.4933×10^{-6}	0.1902×10^{-5}	0.2335×10^{-5} [0.421]
SPQ_t	0.41102	0.092072	3.1539	0.58896 [0.000]
SPQ_{t-1}	0.23572	0.12241		
$SBFQ_t$	0.092081	0.079149	0.086860	0.43056 [0.841]
$SBFQ_{t-1}$	0.17528	0.092268		
$SBFQ_{t-2}$	-0.24955	0.083645		
$CAMPQ_t$	-0.0092302	0.0094607	-0.045011	0.050992 [0.383]
$CAMVQ_t$	-0.1391×10^{-5}	0.3151×10^{-5}	-0.6784×10^{-5}	0.1549×10^{-4} [0.664]
Q_t^1	6.4916	4.5612	31.6565	23.3918 [0.185]
Q_t^2	1.4983	3.3877	7.3065	16.4067 [0.659]
Q_t^3	1.3532	2.6413	6.5989	12.4356 [0.599]
T	0.29563	0.28915	1.4417	1.3521 [0.294]
R^2	0.99651			

The results do not change substantially when the structural break term is dropped from the model, as expected (since its coefficient was not significant). The results of the models indicate that the retail price for pork DGP is a function of its own lagged values and the current and lagged values of producer prices (the saleyard price for baconers) but not pigmeat production, saleyard prices for cattle, or imports (both volume and price). The implication is that the introduction of imports has not had an effect on retail prices for pork and that the DGP for retail prices is dependent on other factors.

The non-significant variables were dropped[6] and the regression model re-estimated (see Table 10.6).

Since the retail price of pork seems to be dependent on factors other than imports or domestic production, and more likely dependent on close substitutes, the retail price of pork was regressed against the retail price of beef, chicken, and lamb. The ADL model was selected on the basis of the SBC, as this resulted in a more parsimonious model than the AIC or R^2 (see Table 10.7).

[6]The intercept and the varialbe RPQ_{t-2} were retained even though their coefficients were not significant as it was undesirable to restrict the intercept to pass through the origin and heteroscedasticity was present in the model without RPQ_{t-2}.

Table 10.6: ADL(2,0) model results

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	-9.7329	8.0838	-85.0864	74.7665 [0.261]
RPQ_{t-1}	0.78368	0.98020		
RPQ_{t-2}	0.10194	0.094267		
SPQ_t	0.44793	0.052580	3.9159	0.37992 [0.000]
R^2	0.99432			

Table 10.7: ADL(1,1,0,1,0) model results

	Regression estimates		Long-run estimates	
Regressor	Coefficient	Standard Error	Coefficient	Standard Error[p-value]
α_0	-84.9852	39.3117	-142.4275	54.6735 [0.013]
RPQ_{t-1}	0.40331	0.11514		
SPQ_t	0.17121	0.099879	0.64677	0.17906 [0.001]
SPQ_{t-1}	0.21472	0.11443		
$RPQL_t$	0.021692	0.043875	0.036354	0.075968 [0.635]
$RPQC_t$	-0.036284	0.14857	0.58286	0.15776 [0.001]
$RPQC_{t-1}$	0.38407	0.17250		
$RBFQ_t$	0.11844	0.037907	0.19849	0.041885 [0.000]
Q_t^1	-1.5915	3.2491	-2.6671	5.4145 [0.625]
Q_t^2	-6.7030	3.7718	-11.2336	6.5882 [0.096]
Q_t^3	-4.2267	3.0543	-7.0836	5.2588 [0.186]
T	1.3583	0.48864	2.2763	0.55786 [0.000]
R^2	0.99608			

The results of the ADL model suggest that the retail price for pork has a significant upward trend over time (every quarter adds an extra 2.2763 ± 0.55786 ¢/kg to the retail price of pork) and is dependent on the producer price (every \$1.00 increase in saleyard prices for baconers adds an extra $\$0.64677 \pm 0.17906$ /kg to the retail price of pork), the retail price for chicken (every \$1.00 increase in retail price for chicken adds an extra $\$0.58286 \pm 0.15776$ /kg to the retail price of pork), and the retail price for beef (every \$1.00 increase in retail price for beef adds an extra $\$0.19849 \pm 0.041885$ /kg to the retail price of pork). The retail price for lamb does not appear to be significant, implying that lamb is not a close substitute for pork.

10.4 Price transmission in the domestic pigmeat market

The apparent divergence between producer and retail prices in the presence of a marketing chain is a common facet in agricultural industries. There is evidence to suggest that changes in producer prices are not passed on fully to changes in retail price, especially in the situation where producer prices are in decline. Both Hahn and Duewer [48] and von Cramon-Taubadel [25] show that in the presence of market power reductions in producer prices are not reflected in reductions in retail prices but increases in producer prices are immediately reflected in increases in retail prices. In Section 10.3 the results suggest that a \$1.00 increase in producer price will result in a $\$0.64677 \pm 0.17906$/kg increase in retail price. However, this result is under the assumption of symmetrical price transmission - that is, a \$1.00 decrease in producer price will result in a $\$0.64677 \pm 0.17906$/kg decrease in retail price.

Asymmetric price transmission will result from situations where firms are facing different elasticities for their inputs and outputs. In situations where firms are able to exert market power, an increase in input price will be transferred rapidly to their output price but a decrease in input price will not be transferred as rapidly to their output price.

Hahn and Duewer [48] develop an endogenous switching model to capture the asymmetry of price transmission which they then optimise via a linear programming approach. However, von Cramon-Taubadel [25] takes an econometric approach using an error correction model (ECM) to capture the speed and degree of adjustment of retail prices to a change in producer prices.

The ECM in equation 8.3 implies symmetric price transmission, and asymmetric price transmission can be modelled if the ECM is decomposed into positive and negative price changes[44]

$$ECM_t = ECM_t^+ + ECM_t^-$$

where

$$\begin{aligned}\Delta A^+ &= \max(\Delta A, 0) \\ \Delta A^- &= \min(\Delta A, 0) \\ A &= (y_t, x_t)\end{aligned}$$

In testing a market for asymmetric price transmission particular attention needs to be paid to the frequency of the data [16],[24]. As the frequency of the data is reduced the asymmetric properties of price transmission will be obscured by the symmetry of the long-run equilibrium. Both [24] and [25] find that the data frequency needs to be higher than that required by market agents to complete transactions and that an appropriate frequency is weekly data. Even with weekly data von Cramon-Taubadel [25, Table 2] finds that the regression coefficients in the symmetric and asymmetric case are very similar although he does conclude that there is significant asymmetry in price transmission. Impulse-response functions indicate that equilibrium is restored within one quarter, indicating that a frequency lower than that will fail to pick up the asymmetric price transmission, at least for the northern German pork market.

In the Australian pig industry context, while weekly prices are available for producer prices, retail prices with a high frequency are difficult to come by. Official ABS statistics only detail quarterly retail prices, thus exploring the asymmetric nature of price transmission in the Australian pig industry is hampered by the inadequacies of the data. Data limitations constrain us to only analyse the case of symmetric price transmission as an indication of market power. If the price transmission between producer and retail prices is slow, the implication is, therefore, that market power is being exerted as competitive pressure to rapidly adjust price is missing.

The ECM representations of the ADL models are presented in Tables 10.8 to 10.11.

The results indicate that there is a slow-to-moderate speed of adjustment, ranging from -0.11 to -0.21, suggesting that a change in producer price is not immediately transferred to changes in retail price due to market power being exerted over the marketing chain. When substitutes are taken into consideration the speed of adjustment increases to around -0.60 (see Table 10.11), suggesting that the retail price for pork is sensitive to changes in retail prices for close substitutes.

Table 10.8: ADL(2,0,1,2,0,0) model ECM

	Regression estimates	
Regressor	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	-64.1820	17.7177 [0.001]
ΔRPQ_{t-1}	-0.33700	0.12150 [0.009]
$\Delta PPDQ_t$	0.3731×10^{-6}	0.5166×10^{-6} [0.475]
ΔSPQ_t	0.40927	0.094322 [0.000]
$\Delta SBFQ_t$	0.096013	0.085601 [0.269]
$\Delta SBFQ_{t-1}$	0.24819	0.085467 [0.006]
$\Delta CAMPQ_t$	-0.012926	0.029522 [0.664]
$\Delta CAMVQ_t$	-0.1487×10^{-5}	0.3277×10^{-5} [0.653]
ΔQ_t^1	6.2395	5.0030 [0.220]
ΔQ_t^2	1.4487	3.4566 [0.678]
ΔQ_t^3	1.3403	2.6809 [0.620]
ΔT	0.29958	0.29481 [0.316]
$\Delta BREAK$	1.6771	12.6675 [0.895]
ECM_{t-1}	-0.20703	0.054502 [0.001]
R^2	0.78580	

Table 10.9: ADL(2,0,1,2,0,0) model ECM, no structural break

	Regression estimates	
Regressor	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	-64.4147	17.3811 [0.001]
ΔRPQ_{t-1}	-0.33579	0.11945 [0.008]
$\Delta PPDQ_t$	0.3901×10^{-6}	0.4933×10^{-6} [0.434]
ΔSPQ_t	0.41102	0.092072 [0.000]
$\Delta SBFQ_t$	0.092081	0.079149 [0.252]
$\Delta SBFQ_{t-1}$	0.24955	0.083645 [0.005]
$\Delta CAMPQ_t$	-0.0092302	0.0094607 [0.336]
$\Delta CAMVQ_t$	-0.1391×10^{-5}	0.3151×10^{-5} [0.661]
ΔQ_t^1	6.4916	4.5612 [0.163]
ΔQ_t^2	1.4983	3.3877 [0.661]
ΔQ_t^3	1.3532	2.6413 [0.611]
ΔT	0.29563	0.28915 [0.313]
ECM_{t-1}	-0.20506	0.051694 [0.000]
R^2	0.78569	

Table 10.10: ADL(2,0) model ECM

	Regression estimates	
Regressor	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	-9.7329	8.0838 [0.234]
ΔRPQ_{t-1}	-0.10194	0094267 [0.285]
ΔSPQ_t	0.44793	0.052580 [0.000]
ECM_{t-1}	-0.11439	0.014880 [0.000]
R^2	0.62439	

Table 10.11: ADL(1,1,0,1,0) model ECM

	Regression estimates	
Regressor	Coefficient	Standard Error[p-value]
$\Delta\alpha_0$	-84.9852	39.3117 [0.037]
ΔSPQ_t	0.17121	0.099879 [0.094]
$\Delta RPQL_t$	0.021692	0.043875 [0.624]
$\Delta RPQC_t$	-0.036284	0.14857 [0.808]
$\Delta RBFQ_t$	0.11844	0.037907 [0.003]
ΔQ_t^1	-1.5915	3.2491 [0.627]
ΔQ_t^2	-6.7030	3.7718 [0.083]
ΔQ_t^3	-4.2267	3.0543 [0.174]
ΔT	1.3583	0.48864 [0.008]
ECM_{t-1}	-0.59669	0.11514 [0.000]
R^2	0.75902	

10.5 Summary

The results of this chapter indicate that retail prices have not been subjected to an exogenous shock after 1990:1 and that the introduction of imports did not have an effect, and specifically a negative effect, on retail prices. This implies that the assumed benefits of trade liberalisation, resulting from a reduction in consumer price and a concomitant expansion of the production possibility frontier, have not occurred. The question is therefore whether market intermediaries such as processors, wholesalers or retailers have benefited through increased marketing margins at the expense of producers and consumers. The result of the error correction models looking at price transmission between producer and retail prices suggest that the speed of adjustment of retail prices to changes in producer prices is very slow, indicating that market power in terms of intertemporal price averaging exists. When close substitutes, such as beef, chicken, and lamb are taken into consideration it seems that retail prices of pork are sensitive to changes in those retail prices, specifically changes in retail beef prices. The speed of adjustment of the retail price of pork is particularly fast when retail prices of beef are taken into consideration. This implies that pork is competitive with beef at the retail level, indicating horizontal competition exists but not vertical.

Chapter 11

Modelling supply and demand relationships

11.1 Introduction

Supply and demand relationships in a particular market can be modelled in two ways. A bivariate framework attempts to explain the relationship between a dependent and independent (endogenous and exogenous)variable or an endogenous and a set of exogenous variables. This framework is adequate if the exogenous variables are exactly that: they are not influenced by any other variables considered in the particular equation. If exogenous variables are actually endogenous through some sort of feedback mechanism; for example, prices are dependent on production, but production is also dependent on prices, then a single equation system is inadequate to capture the inter-relationships and the dynamics of the system.

In this case it is preferable to move to a multivariate framework with a set of simultaneously determined equations which accurately capture the feedback loops inherent in the system.

Traditionally simultaneous equation modelling (SEM) was used to determine multivariate relationships between equations. Applications of the SEMs were focused on the building of large and complicated models of economies, in some cases containing several thousand endogenous variables, which were used for forecasting and policy analysis. These models did not perform well and there was widespread criticism of structural econometric modelling using SEMs [57], [60], [83]. With the imposition of zero restrictions on parameters in order to achieve identification, there was a danger that models would be formulated that included some variables and deleted others purely to satisfy the identification of each equation even if the economic justification for such a formulation was weak [19].

Sims [83] viewed the restrictions imposed on SEMs as "incredible" and without theoretical justification. He suggested an alternative procedure of vector autoregressive modelling where everything depends on everything else.

The vector autoregression (VAR) approach is "atheoretic" by nature and allows the empirics to reveal the dynamics that govern the underlying relationship between variables unaffected by preconceived theory. The two principle assumptions of the Cowles Commission methodology - namely the dichotomisation of the variables into endogenous and exogenous and the zero restrictions imposed on the parameters - are abandoned in VAR modelling [19], [22].

VAR modelling assumes that the variables under consideration are $I(0)$, stationary, and in the presence of non-stationary variables the VAR model can be transformed into a Vector Error Correction (VEC) model. A VEC model allows the short-run dynamics lost in transforming $I(1)$ variables to $I(0)$ to be recaptured. The VEC model incorporates the concept of cointegration, where there exists a linear combination of two non-stationary variables which is in fact stationary.

In this section we outline the theory behind cointegration and causality in a bivariate framework before moving onto modelling the relationships between variables in a multivariate framework.

11.2 Co-integration analysis of non-stationary series

Banerjee , Dolado, Galbraith and Hendry [14] discuss a notion of equilibrium where variables joined in a theoretical economic relationship should not diverge in the long run and are stochastically bounded in any short-run divergence. In economics there is a need to integrate short-run dynamics with long-run equilibrium to obtain meaningful results. While the analysis of short-run dynamics is often done by differencing to eliminate trends in the variables, this procedure, however, loses information about long-run relationships. Regressions involving the levels of non-stationary variables will yield spurious results unless there exists a co-integrating relationship between the variables.

If there are two time series x_t and y_t and a graph of them shows the variables drifting apart, in other words, the difference between x_t and y_t does not seem to be stationary, then it is possible that they may not be integrated of the same order. If, on the other hand, the variables seem to be floating in time together, they may be integrated of the same order and this suggests that a linear combination of x_t and y_t might be stationary or integrated order zero, I(0) [19].

Definition 2 *If $y_t \sim I(1)$ and $x_t \sim I(1)$ then y_t and x_t are said to be co-integrated if there exists a co-integrating vector $[\beta_0, \beta_1]$ such that $(\beta_0 y_t - \beta_1 x_t) \sim I(0)$ [37].*

More generally if $\mathbf{x}_t = \left[\begin{smallmatrix} x_t \\ y_t \end{smallmatrix}\right] \sim I(d)$ and $\boldsymbol{\alpha} \neq 0$ (a co-integrating matrix) then $\mathbf{x}_t \sim CI(d, b)$ if $\boldsymbol{\alpha}'\mathbf{x}_t \sim I(d-b)$, $d \geq b > 0$ [74]. if $\mathbf{x}_t$ has $n > 2$ components and there are exactly r linearly independent co-integrating vectors with $r \leq n-1$ then $\boldsymbol{\alpha}$ will be an $n \times r$ matrix with r being the *co-integrating rank* [14, p 145].

To test for cointegration, the order of integration must first be established for each variable. If there are only two variables in the long run relation, both have to be of the same order of integration for cointegration to occur. If there are more than two variables the order of integration of the dependent variable cannot be higher than the order of integration of any of the explanatory variables [74]. Moreover, there must be either none or at least two explanatory variables integrated to an identical order higher than the order of integration of the dependent variable [19]. For the variables under consideration, saleyard prices, retail prices, and production, these are all $I(1)$ over the period 1990:1 to 1997:2.

11.3 Cause-and-effect relationships using Granger Causality

Granger Causality determines the direction of the relationship, if any, between two stationary variables. A variable W_t is said to GRANGER CAUSE a variable Z_t, ($W_t \Rightarrow Z_t$), if the prediction of the value of Z_t based on its own history, or lagged variables, can be improved by using the history, or lagged variables, of W_t [41]. In addition, the Granger tests also indicate bi-directional causality or feedback effects ($w \Leftrightarrow z$) and indirect causality is implied through a process of transitivity where, if $w \Rightarrow z$ and $z \Rightarrow v$, then $w \rightarrow v$.

In a stationary bivariate model:

$$z_t = \alpha_0 + \sum_{i=1}^{n} \gamma_i z_{t-i} + \sum_{j=1}^{k} \beta_j w_{t-j} + \varepsilon_t \tag{11.1}$$

Table 11.1: Bivariate Granger Causality tests

Bi-directional Granger Causality	
$RBFQ \Leftrightarrow PPDQ$	$SPQL \Leftrightarrow PPDQ$
$RPQ \Leftrightarrow PPDQ$	$SPQ \Leftrightarrow RPQC$
$RPQC \Leftrightarrow PPDQ$	$SPQ \Leftrightarrow RPQL$
$RPQL \Leftrightarrow PPDQ$	$SPQL \Leftrightarrow RPQL$
$SPQ \Leftrightarrow PPDQ$	$SPQL \Leftrightarrow SPQ$
Uni-directional Granger Causality	
$CAMPQ \Rightarrow PPDQ$	$SBFQ \Rightarrow RPQ$
$SPQ \Rightarrow CAMPQ$	$SPQ \Rightarrow RPQ$
$SBFQ \Rightarrow CAMVQ$	$SPQL \Rightarrow RPQ$
$PPDQ \Rightarrow SBFQ$	$RPQC \Rightarrow RPQL$
$WPQP \Rightarrow PPDQ$	$SBFQ \Rightarrow SPQL$
$RPQ \Rightarrow RBFQ$	$SBFQ \Rightarrow WPQP$
$RPQC \Rightarrow RBFQ$	$RPQL \Rightarrow RPQ$
$SPQ \Rightarrow RBFQ$	$RPQ \Rightarrow RPQC$

the past values of w_t Granger cause z_t if the Lagrange Multiplier F-test[1] (LMF) for the past w_t values are jointly significant.

If the two variables in the bivariate model are integrated of the same or higher order, and a cointegrating vector exists, then an ECM should be included in the Granger Causality test.

While the Granger bivariate causality tests indicate the direction of causality between two variables, to gain insights on the degree of strength of causal interactions between variables, it is necessary to use a multivariate framework.

Bivariate Granger causality tests $(n, k = 2)$ were carried out between the stationary variables in the dataset. The significant results are presented in Table 11.1. The results suggest that import prices do have an effect on prices and production in the Australian pig industry through a direct effect on production and a transitive effect on prices through production.

[1]The Lagrange Multiplier F statistic is more robust than the F-test and LMχ^2 test when there are non-linearities and logged data [19, pp 87-95].

11.4 Incorporating cointegration between variables using Error Correction Models

The concept of co-integration as expounded by Engle and Granger [37], which uses an Error Correction Mechanism (ECM) to incorporate past periods' disequilibrium, addresses the issue of integrating short-run dynamics with long-run equilibrium without losing long-run information.

If the variables are CI(1,1) and have the co-integrating vector $[\beta_0, -\beta_1]$, so that the deviations of y_t from its long run path y_t^* are I(0), a model in first differences incorporating an error correction mechanism (ECM) can be developed.

An ECM is of the form

$$\Delta y_t = \gamma \Delta x_t + \gamma \left(\beta_0 y_{t-1} - \beta_1 x_{t-1} \right) + \mu_t \tag{11.2}$$

If the presence of co-integration is established, the dependent variable is replaced by the appropriate linear combination of the variables which we expect to be stationary and the appropriate ECM [19].

This becomes more complicated when we move to the multivariate setting. Estimation of single-equation ECM models do not provide sufficient information about the underlying DGP compared with ECMs derived from systems of equations, especially in cases where weak exogeneity does not hold. Weak exogeneity will not hold when the ECM terms occur in more than one equation of the system, that is, they will be present in other marginal distributions and will need to be estimated jointly to maximise efficiency [14, p 261]. The Johansen procedure [54] enables the number of co-integrating vectors to be determined in a maximum likelihood approach. For example, if the long run relationship is of the form

$$v_t = \beta_0 y_t - \alpha_0 - \alpha_1 T - \sum_{i=1}^{m} \beta_i x_{it} \tag{11.3}$$

and the cointegrating vector is $\left[\hat{\beta}_0, -\hat{\alpha}_0, -\hat{\beta}_1, ..., -\hat{\beta}_m \right]$ then the multivariate ECM is of the form

$$\Delta x_t = \gamma_{11} \Delta y_t + \alpha_{11} T + \gamma_{12} \left(\hat{\beta}_{10} x_{t-1} - \hat{\alpha}_{10} - \sum_{i=1}^{m} \hat{\beta}_{1i} y_{t-1} \right) + \varepsilon_{1t} \tag{11.4}$$

$$\Delta y_t = \gamma_{21} \Delta x_t + \alpha_{21} T + \gamma_{22} \left(\hat{\beta}_{20} y_{t-1} - \hat{\alpha}_{20} - \sum_{i=1}^{m} \hat{\beta}_{2i} x_{t-1} \right) + \varepsilon_{2t} \tag{11.5}$$

11.5 Formation of a VAR model

The VAR model, in matrix format, can be shown as:

$$Z_t = \alpha_0 + \sum_{i=0}^{k} \beta_i Z_{t-i} + \varepsilon_t \tag{11.6}$$

where ε_t is a vector of white noise errors such that $\varepsilon_t \varepsilon_t' = I$ and I is an identity matrix implying that the errors are contemporaneously correlated and intertemporally uncorrelated [58]. Under these specifications the system can be consistently estimated using OLS [57]. However, because these estimates are difficult to interpret, through a process called invertibility, the finite order VAR process can be inverted into a infinite order Moving Average (MA) process [42], [74] which is easier to interpret. A matrix polynomial B(L) can be obtained from:

$$z(t) = A^{-1}(L)\, U(t) = B(L)\, U(t) \tag{11.7}$$

Where the matrix polynomial B(L) defines the impulse response matrix and its coefficients measure the dynamic response of endogenous variables $z(t)$ consequent upon a unit change in innovations emanating from a specified endogenous variable [17], [58].

However, the correlation of innovations across the equations confuses the diagnosis of distinct movement patterns displayed by the system. In the conventional methodology the issue of contemporaneous correlation among innovations (errors) is often suppressed by arbitrary restrictions that constrain the correlation between two variables to be unidirectional. In the VAR framework, since all variables are considered to be endogenous, and because contemporary right-hand variables are omitted at the estimation stage, any contemporaneous correlation shows up as a correlation between the current innovations in the variables [40].

To get around the problems of contemporaneous errors the variance-covariance matrix of residuals needs to be transformed by a diagonal matrix to obtain orthogonal innovations thus getting statistically acceptable results with the error terms no longer contemporaneously correlated. The technique of Choleski factorisation [36] uses orthogonalisation of the innovations to overcome the problem of contemporaneous errors. The triangularised innovation matrix traces out in a recursive Wold causal chain the shock movements [85] and the VAR system after Choleski factorisation can be shown as:

$$z(t) = B(L)\, V(t) \tag{11.8}$$

where $V(t)$ is generated through the Choleski factorisation technique [58].

The idea behind making the error terms orthogonal to each other is to enable the equations of the VAR model to be used separately for simulations or policy analysis of the impact of a known random shock on the system [19]. This is known as the impulse-response mechanism. The impulse-response mechanism indicates how the impact of an exogenous shock to the dependent variable is spread between the variables of the system.

One of the problems of orthogonalising the variance-covariance matrix of residuals is that the results are critical on the ordering of the variables within the VAR model. A new technique which has been developed to remove the problem of the dependence of the impulse responses on the ordering of variables is the Generalised Impulse Response Function [72]. We present both the orthogonalised and generalised impulse response functions in the results below.

Not only does the transformed matrix enable statistically acceptable results to be obtained from the impulse-response matrix but it also enables Forecast Error Variance Decomposition (FEVD) analysis associated with each endogenous variable to be done. FEVD analysis is used for forecasting and policy analysis simulations and indicates how the strength of the shock affects different variables and how much of the shock is explained by each of the variables [19], [58].

The total innovations generated by an endogenous variable on itself and other variables in the system can be regarded as proportional to the FEV. These FEVs describe fundamental economic forces, orthogonal by construct, that cause the endogenous variables $z(t)$ in the system to shift over time [58], [63]. The variance decomposition divides the FEV of a given variable according to the causal strength of the innovation effects of the variable on itself and other variables in the system. An optimal forecast is obtained when the highest amount of innovations by the variable is accounted for by itself. The magnitude of the FEV provides an estimate of the Granger causal strength of the innovating variable on the other variables in the VAR system [58], [83].

One of the problems with the orthogonalisation of the error terms is that this makes the results dependent on the ordering of the variables within the system of equations. The Generalised FEVD allows order-independent decompositions of effects to be calculated. The draw-back (or advantage!) to this procedure is that it allows feedback mechanisms to impact on the variables under consideration. The orthogonalised FEVDs partition the effect of a particular variable on the variable under consideration - for example we might conclude that for saleyard prices for baconers the forecast error variance is decomposed into 60% caused by saleyard prices of baconers, 20% caused by saleyard prices for cattle, 10% by domestic production of pigmeat, 5% by retail prices of pork, 2.5% by import prices and 2.5% by import volumes. This gives a total of 100%. In other words, the orthogonalised FEVDs are partial coefficients. In contrast, the generalised FEVDs allow feedback amongst the variables in the system to occur, meaning that the percentage effects of each variable will be much higher, and not sum to 100%. This is a more realistic analysis, as observed values are a combination of the partial effects and the feedback effects.

11.6 Summary

This chapter has reviewed the theoretical background to modelling in a simultaneous equation framework taking into consideration the dynamic and stochastic nature of the relationship between supply and demand. By extending the atheoretical nature of autoregressive distributed lag models to a multivariate framework, and allowing for cointegration between variables we are able to adequately capture both the short and long run inter-relationships between economic variables.

Granger causality tests were carried out and suggest that import prices do have a causal effect on domestic production of pigmeat, further there seems to be bi-directional causality between retail and producer prices for meat, suggesting scope for further modelling of the close substitution between meats.

Chapter 12

A VAR model of the Australian pig industry

12.1 Introduction

In this chapter we take into consideration the simultaneous framework between demand and supply and allow for feedback effects between prices and production. The end realisation of prices and production will depend on the interactions between short-run and long-run effects. We first test for the presence of cointegration between prices and production in a multivariate framework before building a VAR model of the Australian pig industry to examine the relationships between prices and production.

12.2 Testing for multivariate cointegration

The variables under consideration, saleyard prices for cattle and baconers, their respective retail prices, and production of pigmeat, are all $I(1)$ from the period 1990:1 to 1997:2. We take this as the relevant period of time to develop a suitable model to be used for forecasting purposes. In addition to these non-stationary variables, import volume and price of pigmeat from Canada, which are $I(0)$ can be incorporated as additional deterministic regressors in the Vector Error Correction Model. We can test the $I(1)$ variables for the presence of cointegration before using them in a VEC model framework.

The Johansen procedure [54] is quite easy to implement in practice, due to the wide availability of automated modules within statistical software. After specifying the $I(1)$ and $I(0)$ variables (for example, seasonal dummies) to include in the Johansen procedure and whether or not to include an intercept or trend, the Likelihood Ratio test for the Maximal Eigenvalue and Trace of

Table 12.1: Johansen Multivariate Cointegration Test

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r = 0$	$r = 1$	26.9082	31.0000	54.2655	58.9300
$r \leq 1$	$r = 2$	21.3207	24.3500	27.3572	39.3300
$r \leq 2$	$r = 3$	5.2857	18.3300	6.0365	23.8300
$r \leq 3$	$r = 4$	0.75081	11.5400	0.75081	11.5400

the Stochastic Matrix for the number of cointegrating relations is carried out (See Table 12.1).

The test determines the number of cointegrating relations that exist between the logs of the $I(1)$ variables SPQ, SBFQ, RPQ, and PPDQ with the $I(0)$ variables SCAMPQ, SCAMVQ and the 1^{st} to 3^{rd} seasonal dummies along with an intercept and time trend in a VAR(2) framework. The results show that there are no cointegrating vectors in a multivariate framework. This is in contrast to the ABARE [1] study which found evidence of cointegration between beef and pigmeat prices. There are two points here. The first point is that the ABARE cointegration analysis was conducted in a bivariate framework, rather than a multivariate framework. The power of the Johansen multivariate cointegration test is generally greater than that of the Engle-Granger bivariate cointegration test. Further, the arbitrary dichotomisation of variables into exogenous and endogenous variables under the Engle-Granger approach assumes the presence of only one cointegrating vector, rather than the possibility of multiple cointegrating vectors that can be identified under the Johansen procedure.

The second point is that the ABARE analysis was conducted over the whole time period (both pre- and post-shock). Saleyard prices for baconers over the pre-shock period have been found to be stationary, $I(0)$, and therefore it was inappropriate to conduct cointegration tests on variables which were integrated of a different order.

The third, and most important point, is that the variables have been log-transformed. Re-specifying the variables in their levels state results in two cointegrating vectors being identified. We explore the resulting VEC model in chapter 13.

In this case, even though the variables are non-stationary, there are no short-run dynamics, which are lost in the transformation to stationary series, that can be recaptured in an Error-Correction framework. In this case a simple VAR with stationary variables is sufficient to capture the dynamics of the system.

12.3 VAR model results

The VAR model regresses the variables DSPQ, DSBFQ, DRBFQ, DRPQ, DPPDQ, SCAMVQ, SCAMPQ[1], with a constant, time trend and seasonal dummies (Q_t^1, Q_t^2, Q_t^3) over the post trade liberalisation period, from 1990:1 to 1997:2, with forecasts to 1998:1. The lag length of the VAR needs to be determined, the AIC can be used to choose the appropriate lag length. Due to data constraints a VAR(3) model was the maximum possible. Reducing the lag length sequentially showed that the AIC was at a minimum with a VAR order of 2 lags, therefore a VAR(2) model was chosen as the more appropriate model to be estimated. Since the coefficients of the VAR model, in logged differenced form, are not directly interpretable, only the impulse-response functions and the forecast error variance decompositions are reported.

12.3.1 Impulse-Response functions

The impulse response functions trace out the effects of a shock to a particular variable on itself and the other variables over time. They are presented in Figures 12.1 and 12.2. The impulse response functions indicate how the changes in the respective variables adjust over time (in quarters) to a single shock to a particular variable. Since the variables are stationary, that is, in logged differenced form, the impulse response functions show how the *changes* in the variables adjust to a stable equilibrium, rather than the *levels* of the variables themselves. The results indicate that regardless of which variable is shocked, import volumes, and to a lesser extent import prices, are the least stable, taking between 2 and 4 years (8-12 horizon periods, or quarters) in the case of import volumes to return to a stable equilibrium. The other variables seem to be quite stable in response to a shock, returning quickly to the equilibrium. This result holds in either case of using the orthogonalised impulse response functions, or the generalised impulse response functions.

This indicates that the model, in differenced stationary form, is quite robust to shocks and can be used for forecasting and policy simulations.

12.3.2 Variance Decomposition

The decomposition of the forecast error variance into its various components for each variable is set out in Figure 12.3. The forecast error variance decomposition (FEVD) shows how the variability in the particular variable is partitioned amongst the other variables in the VAR model.

[1]Where D refers to the first difference Δ of the log-transformed variable and S refers to the seasonal difference Δ_4 of the log-transformed variable.

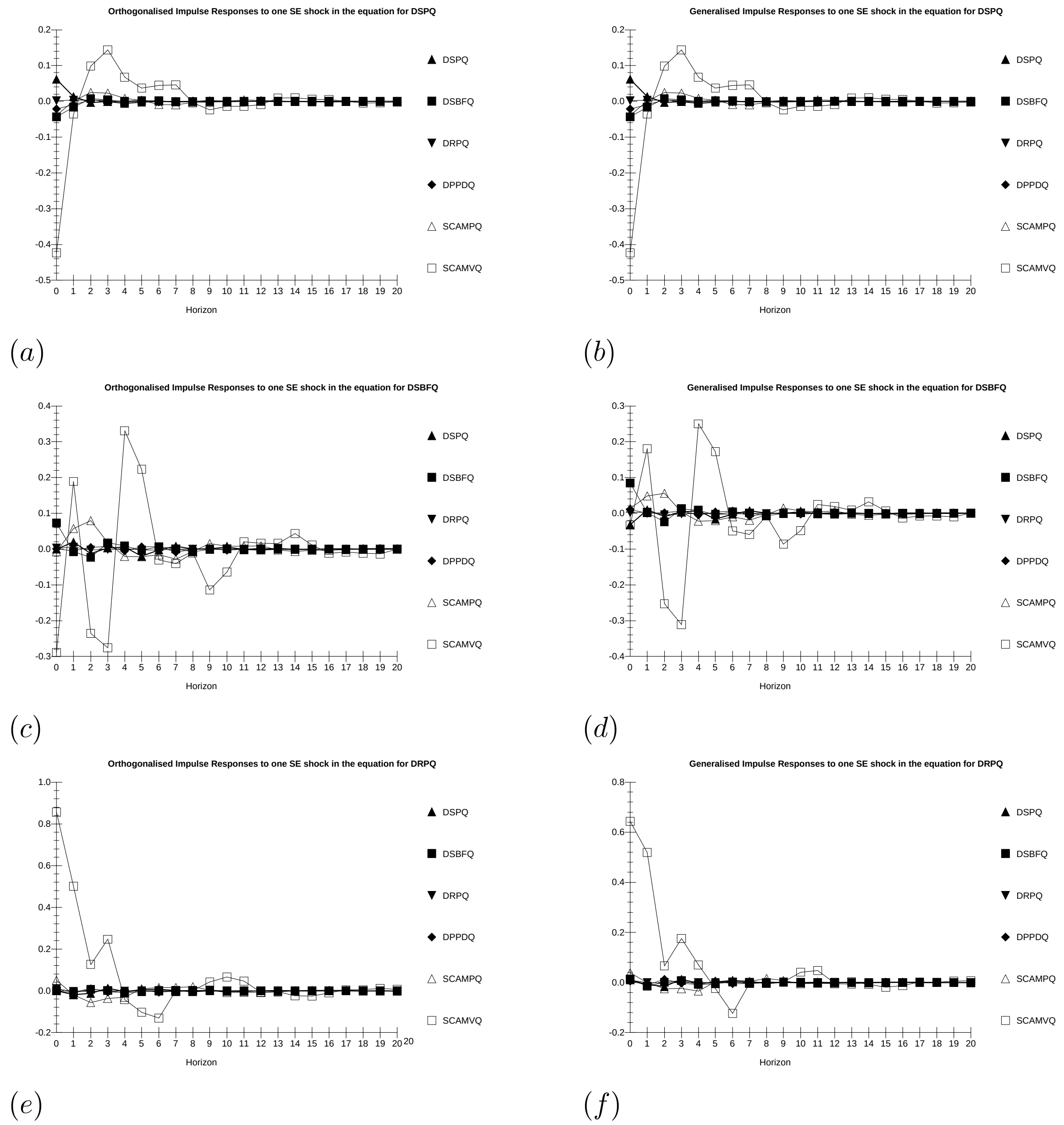
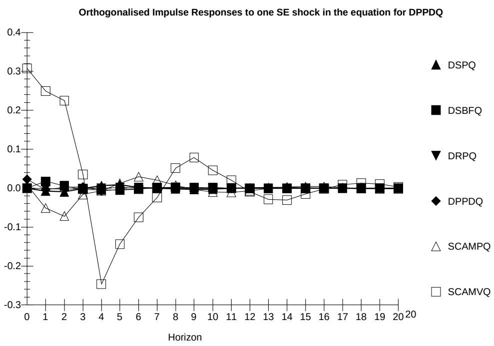
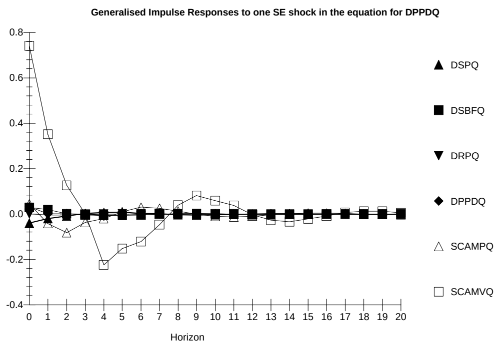


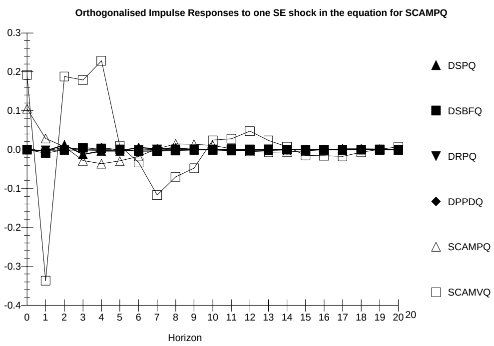
Figure 12.1: Orthogonalised and Generalised Impulse-Response functions for producer and retail prices



(a)



(b)



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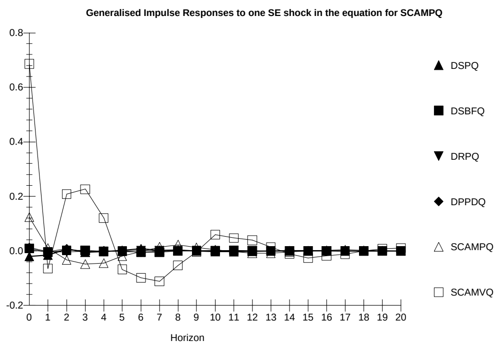
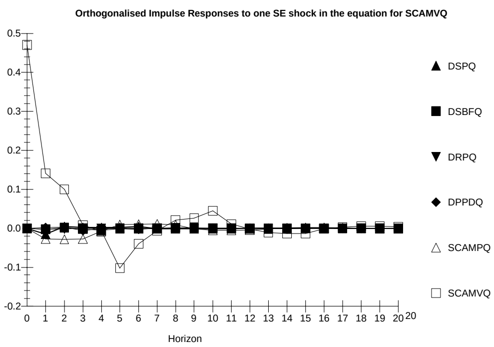
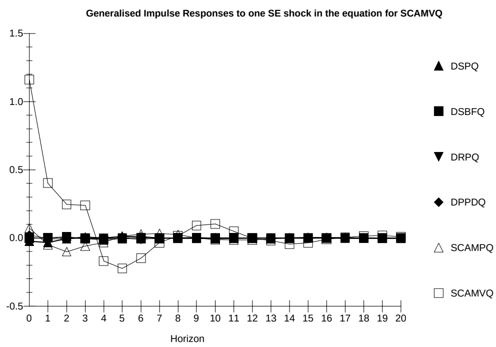


(d)



(e)



(f)

Figure 12.2: Orthogonalised and Generalised Impulse-Response functions for domestic production and imports

Since the VAR model is formulated in log-differenced form, in order to induce stationarity, the interpretation of the FEVDs are slightly different. No longer do the FEVDs indicate how the variability in a particular variable is partitioned amongst the other variables in the VAR, but they indicate how the variability in the first-differences in a particular variable is partitioned amongst the other first-differenced variables in the VAR. When we talk about the variability of a particular variable being attributed to another variable we are actually referring to the changes in that particular variable.

The orthogonalisation of the variance-covariance matrix of the residuals imposes an order-specific outcome of the forecast error variance decomposition. Taking, for example, Figure 12.3(a), the variance decomposition for the changes in saleyard prices for baconers we can see that 16% of the variability in the changes of saleyard prices for baconers is caused by changes in the saleyard price of cattle, 11% by changes in the retail price of pork, 5% by the changes in import prices for pigmeat, and 4% each for the changes in domestic production of pigmeat and import volumes of pigmeat. As this particular variance decomposition is the one we are most interested in from a policy perspective in this report, it seems that our results confirm the initial ABARE and NSW Government reports conclusions - that imports have had only a minimal effect on saleyard prices for baconers. However, when we re-ran the analysis with a different order - DSPQ, SCAMPQ, SCAMVQ, DRPQ, DPPDQ, DSBFQ - the results are quite striking (See Figure 12.4). By placing import prices and volumes higher up in the ordering, they play a greater role in determining the decomposition of variance. For saleyard prices for baconers, Figure 12.4(a), changes in import volumes now comprise around 25% of the variance of the change in saleyard prices for baconers whereas changes in the saleyard prices for cattle now only contribute around 2% of the variance of the change in saleyard prices for baconers.

The results show that it is not sufficient to look at the orthogonalised forecast error variance decompositions without further examination of the appropriate ordering of variables. The generalised forecast error variance decompositions are more appropriate to interpret as they are order independent - even though they have the drawback of feedback mechanisms impacting on the overall contribution of the variables to the variance decomposition.

The generalised forecast error variance decompositions are presented in Figure 12.5. These indicate that in the long run, apart from the variability explained by past values of itself:

1. 35% of the variability in changes in saleyard price for baconers is explained by changes in production of pigmeat, 30% by changes in import volumes, 20% by changes in saleyard price of cattle, and 10% each by

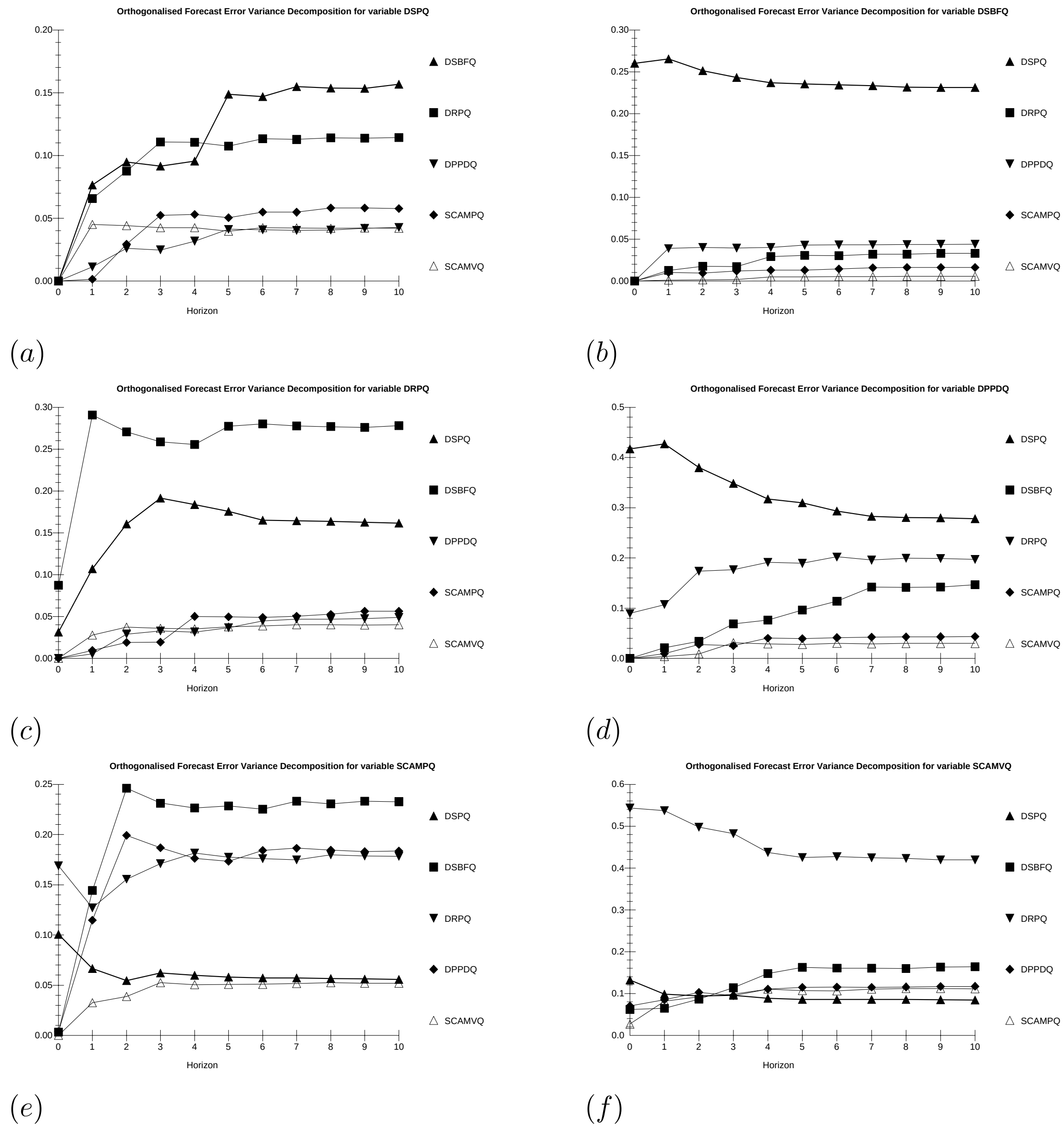


Figure 12.3: Orthogonalised Forecast Error Variance Decompositions

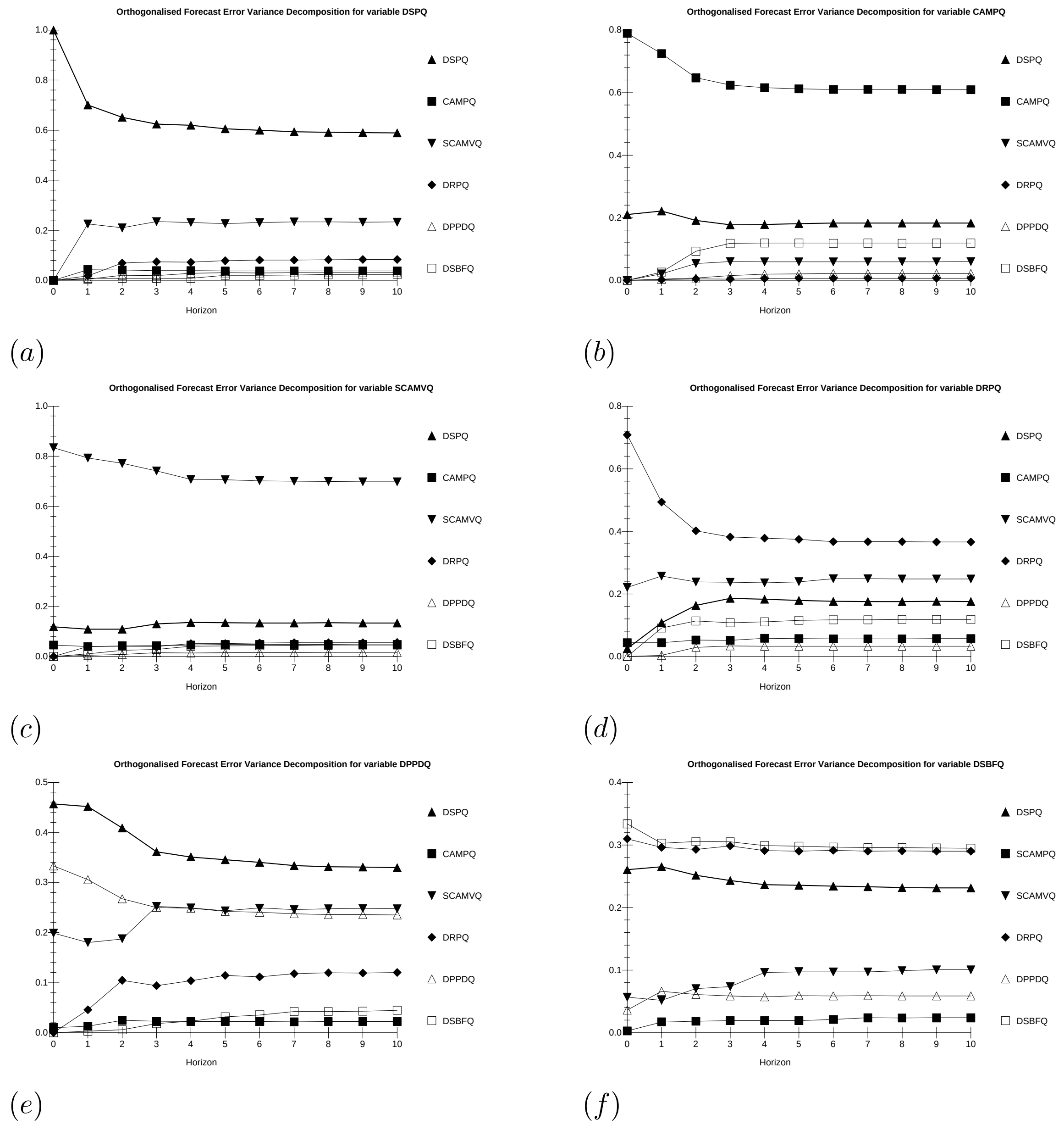


Figure 12.4: Revised Orthogonalised Forecast Error Variance Decompositions

changes in retail price of pork and import price of pigmeat.

2. 25% of the variability in changes in saleyard price for cattle is explained by the changes in saleyard price of baconers, 10% by changes in production of pigmeat, and around 5% each by changes in the retail price of pork, and changes in import price and volume of pigmeat.

3. 40% of the variability in changes in retail price of pork is explained by changes in import volumes of pigmeat, around 20% by changes in production of pigmeat, and around 15% by changes in saleyard price of cattle and baconers along with changes in import prices of pigmeat.

4. 35% of the variability in changes in pigmeat production is explained by changes in import volumes of pigmeat, 30% by changes in saleyard prices for baconers, 20% by changes in retail price of pork, and around 15% by changes in saleyard prices of cattle and import prices of pigmeat.

5. 45% of the variability in changes in import price of pigmeat is explained by changes in import volumes, 25% by changes in production of pigmeat, 15 % by changes in saleyard price of cattle, and around 10% by changes in saleyard price for baconers and retail price of pork.

6. 35% of the variability in changes in import volumes of pigmeat is explained by changes in production of pigmeat and retail prices of pork, 30% by changes in import prices of pigmeat, and 10% and 15% by changes in saleyard prices for baconers and cattle respectively

The results in this chapter were presented in a previous report [79]. The publication of the variance decompositions above generated a great deal of comment and unfortunately the nature of the decompositions were misinterpreted by the majority of critics. Taking one illustrative example, the FEVDs show that 40% of the variability in changes in retail price is explained by changes in import volumes. This was misinterpreted as suggesting that imports led to a 40% decline in retail prices. Similarly, it was suggested that imports led to a 30% decline in saleyard prices for baconers. It is a mistake to infer an *absolute* change in prices from the FEVDs. Rather, the FEVDs show a *relative* change in price. The graph of retail prices in Figure 5.3 show that retail prices are not subject to large variability. What the FEVDs do is indicate what, if there is any change (no matter how large the absolute value of that change is), the respective contributions of each of the variables in the VAR model is to that particular change. Both the regression coefficients and the FEVDs need to be taken into consideration together in order to get an idea of the dynamic interactions between the variables in the econometric model chosen.

12.3.3 Multivariate Granger Causality

Multivariate Granger Causality was carried out to test for the rejection of the null hypothesis of non-causality of the specified variables on the rest of the VAR model. Since there are a large number of combinations of variables that can be tested for Granger Causality, only the more relevant ones to this inquiry are reported in Table 12.2. The results indicate that all the variables, except for saleyard price of baconers and retail price of pork, Granger Cause the other variables in the VAR model. However, when saleyard price of baconers and retail price of pork are taken together, they jointly Granger Cause the other variables in the VAR model, but saleyard price for baconers and production of pigmeat together seem to have a cancelling out effect and do not Granger Cause the other variables in the VAR model.

The results are noteworthy, as they imply that import price and volume do Granger Cause the other variables in the VAR model. This is in contrast to the NSW Government submission to the Industry Commission Inquiry [45] which found that import volumes had no causal effect on saleyard prices in NSW, but did have a causal effect on retail prices. One possible explanation for this is the lack of incorporation of seasonal effects in the Granger Causality analysis carried out by the NSW Government submission. The results of this report suggest that seasonal effects do play an important part in the data generating process for saleyard prices for baconers, but do not play an important role in the DGP for retail prices. Because seasonal effects do not play a role in retail prices' DGP the Granger Causality effects are significant, whereas the confounding of the seasonal effects in the DGP for saleyard prices may weaken the Granger Causality effects if seasonality is not taken into consideration. Further, bivariate Granger Causality tests, as undertaken by the NSW Government submission, do not take into consideration multivariate effects, which may highlight relationships not modelled in a bivariate framework.

12.3.4 Forecasts

There is a question of how well the VAR model as specified predicts future changes in the variables. Figure 12.6 sets out the actual and forecasted values for those variables for which data exists for the post sample period. That is, the model from 1990:1 to 1997:2 is used to predict values out to 1998:1. The results indicate that the VAR model is well specified as it tracks changes in

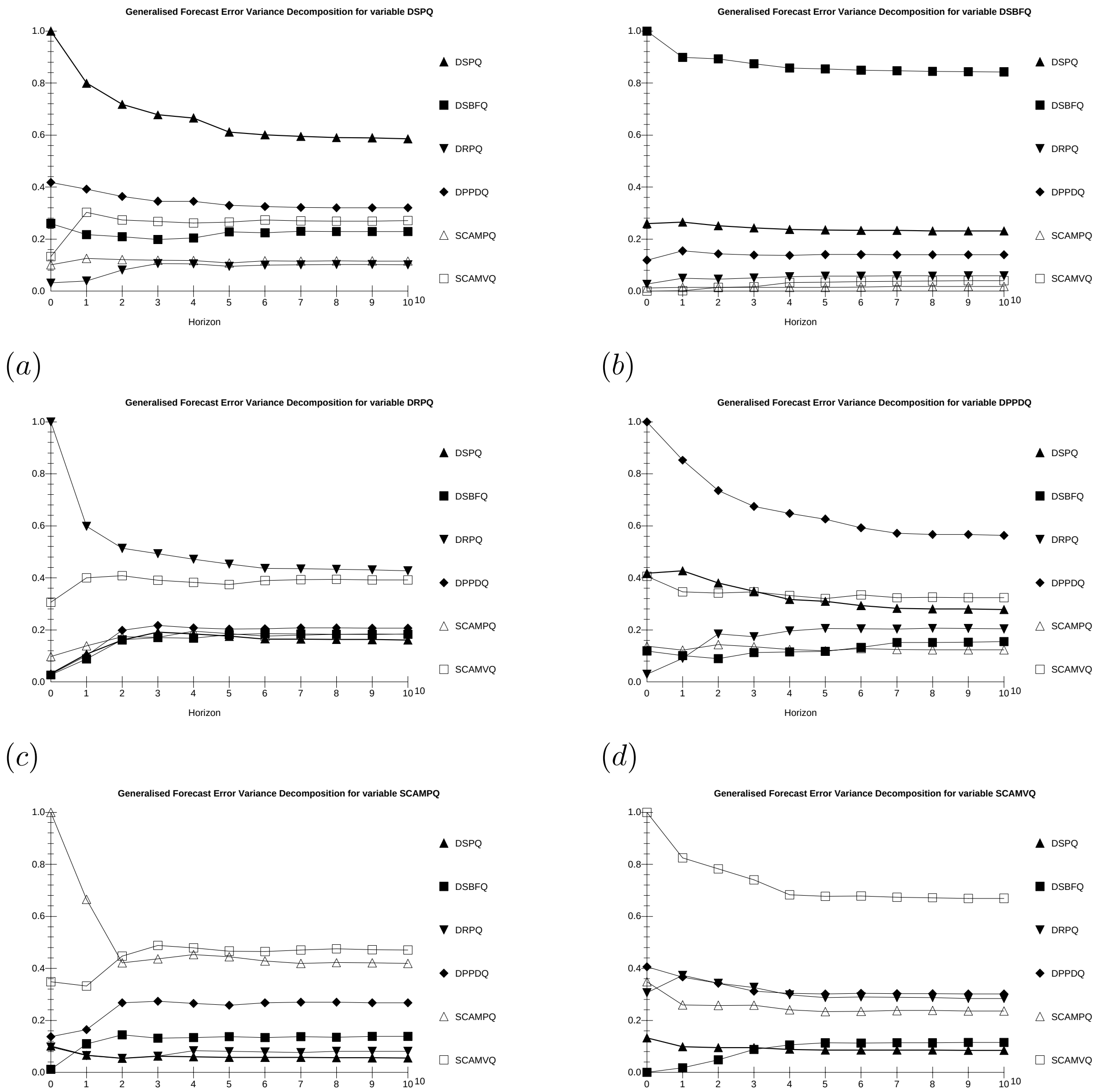


Figure 12.5: Generalised Forecast Error Variance Decompositions

Table 12.2: Multivariate Granger Causality tests - test of block non-causality

Variable	LR χ^2_{10}	Variable	LR χ^2_{16}
DSPQ	17.9891	DSPQ & DSBFQ	38.2392**
DSBFQ	31.9953**	DSPQ & DRPQ	35.4057**
DRPQ	14.2767	DSPQ & DPPDQ	23.3975
DPPDQ	24.0335**	DSPQ & SCAMPQ	43.7891**
SCAMPQ	45.0037**	DSPQ & SCAMVQ	32.0552**
SCAMVQ	26.0017**		

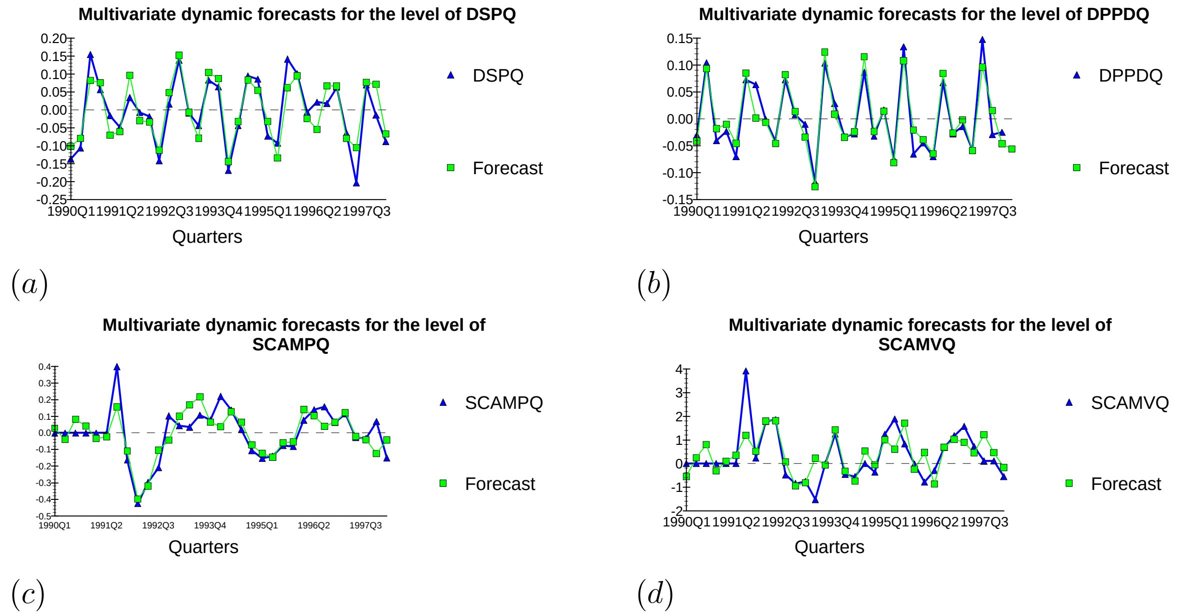


Figure 12.6: Multivariate dynamic forecasts

the levels of the variables reasonably well. If the VAR model was used to forecast saleyard prices for baconers and production of pigmeat the results imply that the forecasts would not be too far off actual values, at least in the short-run. There are some discrepancies with the forecasts for import volumes and prices, and the VAR model does not seem to track the changes in these two variables well. The results above imply that changes in import volumes and prices are determined outside the VAR system (a reasonable conclusion given that the Canadian pigmeat export sector is not modelled). Since a VAR model assumes that all the variables are endogenously determined there is scope for further extensions of the VAR model to exogeneity modelling.

12.3.5 Summary

The results imply that the VAR model itself is robust to shocks and returns to an equilibrium quickly, except for import volumes and prices. It is suspected that the lack of robustness for the import volumes and prices, and the corresponding low levels of forecast error variance explained by the other variables in the VAR model, is due to imports being exogenously determined, rather than being an integral part of the VAR system. The generally accepted small country assumption - that Australia faces a perfectly elastic foreign supply curve as it is a price taker on world markets - is a possible explanation for this exogeneity.

Except for import volumes and prices it seems that the VAR model is a good forecaster of variation in saleyard price for baconers and production of pigmeat. The VAR model shows the relative importance of each variable in the determination of changes to other variables. The results indicate that 35% of the variability in the saleyard price for baconers is determined by pigmeat production and 25% by the saleyard price of cattle. This supports the conclusions of previous studies, including the two ABARE reports [1], [3]. In addition, import volumes seem to play a major role in determining variability in the saleyard price for baconers and retail prices for pork - contributing 30% and 40% respectively . This result supports industry claims of an effect of imports in depressing prices. The variables in the VAR model do not seem to have a major role in determining variability in the saleyard price for cattle - with around 90% of the variability in the saleyard prices for cattle being explained by itself, this is to be expected, as economic theory suggests that the saleyard price for cattle would be determined by its own supply and demand relationships, not modelled in this VAR framework. The variability in production of pigmeat seem to be affected by both saleyard prices for baconers (30%) and import volumes of pigmeat (35%), again supporting industry claims of an effect of imports on the domestic supply curve.

Multivariate Granger Causality tests support the contention that import volumes and prices have an effect on the dynamics of the VAR model. The tests also support the generally accepted view that saleyard cattle prices and production have an effect on variables within the VAR model, including saleyard prices for baconers and retail prices for pork. A possible explanation for the differing results between the NSW Government submission to the Industry Commission Inquiry [45] is the use of bivariate rather than multivariate Granger Causality tests, and the failure to incorporate seasonality effects into the model structure.

Chapter 13

Modelling the Australian pig industry in a VEC and State-Space framework

13.1 Introduction

In this chapter we extend the VAR model of the Australian pig industry by lifting the restriction of log-stationarity in the variables in the model. We test for multivariate cointegration before specifying a Vector Error Correction (VEC) model in levels form. We examine the impulse-response functions of both the error correction terms and the variables themselves to get an appreciation of the stability of the model before undertaking dynamic forecasts to test the predictive power of the model.

Having estimated a VEC model of the Australian pig industry we turn to a state-space representation of the model, allowing for the coefficients of the model to vary through time. This enables changes like structural breaks to be explicitly incorporated into the modelling framework and allow dynamic forecasts to predict better.

13.2 Testing for multivariate cointegration

The Johansen maximum-likelihood test for cointegration is carried out on a VAR(2) with unrestricted intercepts and trends with the $I(1)$ variables being SPQ, SBFQ, RPQ, PPDQ and the $I(0)$ variables being CAMVQ and CAMPQ along with the 1^{st} to 3^{rd} seasonal dummies. The time frame is 1984:3 to 1997:2. The results indicate that the hypothesis of two cointegrating vectors is not rejected (See Table 13.1 and 13.2). The likelihood ratio

Table 13.1: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$\text{LR}_{Crit,0.05}$	Trace	$\text{LR}_{Crit,0.05}$
$r = 0$	$r = 1$	32.0006	31.0000	58.9300	55.0100
$r \leq 1$	$r = 2$	24.5079	24.3500	39.3300	36.2800
$r \leq 2$	$r = 3$	6.5702	18.3300	23.8300	21.2300
$r \leq 3$	$r = 4$	0.86690	11.5400	11.5400	9.7500

Table 13.2: Cointegrating vectors

CI vector	SPQ	$SBFQ$	RPQ	$PPDQ$
β_1	0.26541×10^{-2}	-0.014617	-0.3579×10^{-3}	0.9749×10^{-7}
β_2	0.026606	-0.54977×10^{-2}	-0.78578×10^{-2}	0.5483×10^{-7}
$\tilde{\beta}_1$	-1.0000	5.5075	0.13486	-0.3673×10^{-4}
$\tilde{\beta}_2$	-1.0000	0.20663	0.29534	-0.2061×10^{-5}

$$\text{CI matrix} = [\beta_1, \beta_2]$$
$$\text{Normalised CI matrix} = \left[\tilde{\beta}_1, \tilde{\beta}_2\right]$$

test for the trace of the stochastic matrix suggests that only one cointegrating vector exists, but both the SBC and HQC (not reported) confirm the result of the likelihood ratio test for the maximal eigenvalue of the stochastic matrix.

13.3 VEC model results

We estimate a VEC(2,2) model[1] which is presented in Tables 13.3 and 13.4.

The results to a large extent confirm the results of the individual ADL models presented in the previous chapters. Changes in the saleyard price for baconers is significantly affected by import volumes. For every 1000 tonnes of imports of pigmeat from Canada the saleyard price for baconers drops by $10.78 \pm 4.697¢/kg$ this is within the range of values estimated from the ADL model for pig producer prices.

One of the criticisms leveled at the results of our previous report [79] was that we failed to take into consideration the effect of exports on the data generating process and in by doing so we may have biased the results. This is true. The reason for this omission is that adequate export data does not exist that shows the division of exports into farmed and feral pigmeat. We re-estimated the VEC model (results not reported) incorporating export

[1] That is, 2 lags with 2 ECMs.

Table 13.3: VEC representation for pig industry

	ΔSPQ_t		ΔRPQ_t	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	-78.0800	51.0063 [0.134]	-74.8367	33.3079 [0.030]
ΔSPQ_t	0.18479	0.23148 [0.430]	0.061371	0.15116 [0.687]
ΔRPQ_t	0.078242	0.21438 [0.717]	-0.30998	0.1400 [0.033]
$\Delta SBFQ_t$	0.17626	0.14339 [0.226]	0.33953	0.093636 [0.001]
$\Delta PPDQ_t$	-0.6644×10^{-6}	0.8671×10^{-6} [0.448]	-0.6689×10^{-6}	0.5663×10^{-6} [0.245]
$CAMVQ_t$	-0.1078×10^{-4}	0.4697×10^{-5} [0.027]	-0.5324×10^{-5}	0.3067×10^{-5} [0.090]
$CAMPQ_t$	0.012735	0.019841 [0.525]	-0.0032767	0.012956 [0.802]
T	-0.67795	0.46852 [0.156]	-0.20531	0.30595 [0.506]
Q_t^1	-25.0232	4.8735 [0.000]	-6.4576	3.1825 [0.049]
Q_t^2	-14.3638	8.7211 [0.108]	-2.5518	5.6950 [0.657]
Q_t^3	8.0844	6.9339 [0.251]	7.7729	4.5279 [0.094]
ECM_{t-1}^1	-0.063532	0.026097 [0.020]	-0.0056527	0.017042 [0.742]
ECM_{t-1}^2	0.11316	0.26161 [0.668]	-0.62527	0.17083 [0.001]
R^2	0.75276		0.67481	

Table 13.4: VEC representation for pig industry

	$\Delta SBFQ_t$		$\Delta PPDQ_t$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	-141.5357	61.4323 [0.027]	3.23×10^7	1.07×10^7 [0.005]
ΔSPQ_t	-0.54372	0.27880 [0.058]	-88179.5	48708.5 [0.078]
ΔRPQ_t	-0.092445	0.25820 [0.722]	-41399.8	45110.8 [0.364]
$\Delta SBFQ_t$	0.12427	0.17270 [0.476]	-66516.5	30172.6 [0.033]
$\Delta PPDQ_t$	-0.8044×10^{-6}	0.1044×10^{-5} [0.446]	-0.022389	0.18247 [0.903]
$CAMVQ_t$	-0.4863×10^{-5}	0.5657×10^{-5} [0.395]	1.8933	0.98825 [0.063]
$CAMPQ_t$	0.026511	0.023896 [0.274]	-4105.2	4174.9 [0.332]
T	-1.3565	0.56429 [0.021]	239310.1	98586.4 [0.020]
Q_t^1	-2.0305	5.8697 [0.731]	-5411762	1025500 [0.000]
Q_t^2	7.0393	10.5037 [0.507]	1317273	1835099 [0.477]
Q_t^3	7.5987	8.3512 [0.368]	-983720.7	1459044 [0.504]
ECM_{t-1}^1	-0.057727	0.031431 [0.074]	20120.4	5191.4 [0.001]
ECM_{t-1}^2	-0.48608	0.31508 [0.131]	-13670.4	55047.6 [0.805]
R^2	0.33165		0.88703	

volumes and unit values. The results indicate that saleyard prices for baconers are depressed by $13.74 \pm 9.285¢/kg$ for every 1000 tonnes of imports. This is comparative with the $10.78 \pm 4.697¢/kg$ result estimated in the VEC model in this chapter, and the $13.42 \pm 6.094¢/kg$ result for the VEC model incorporating wholesale prices in chapter 14. The p-value for the import volume coefficient in the VEC model incorporating exports is 0.157, indicating that the probability of a Type I error for a one tailed test is 7.85%, just outside the critical value of 5%. Since the value of the coefficient is almost the same as that of the coefficient in the wholesale prices VEC model ($13.42 \pm 6.094¢/kg$), the implication is that including export volumes and values adds to the variability of the model, rather than change the value of the coefficient. The coefficients of the export volume and value variables are not significant (p=0.797,0.740 respectively) indicating that deleting them from the model will not change the results.

The saleyard price for beef cattle exhibits a significant downward trend (each quarter sees the price for cattle drop by around $1.36 \pm 0.56¢/kg$) and every \$1.00 increase in the saleyard price for baconers drops the saleyard price for cattle by around $\$0.54 \pm 0.28/kg$.

The retail price for pork is significantly influenced by the saleyard price for cattle where every \$1.00 increase in cattle prices shows around a $\$0.34 \pm 0.09/kg$ increase in the retail price for pork. This implies that retailers conduct spatial price averaging, as the increase in cattle prices will flow onto increases in retail prices for beef, leading to a substitution of consumer demand out of beef and into pork. The retail price is also influenced by import volumes; every 1000 tonnes of imports of pigmeat from Canada results in a drop in retail price of around $5.324 \pm 3.067¢/kg$. Again, the asymmetric response of retail prices compared with producer prices suggests that market power on the part of retailers exists.

The production of pigmeat exhibits a significant upward trend, every quarter sees production increase by around an additional 239 ± 99 tonnes. The increase in the saleyard price for baconers has a depressing effect on production, each $1¢/kg$ increase in the saleyard price for baconers reduces production by around 88 ± 49 tonnes. As with the ADL model for production the negative relationship is an indication of the cobweb cycle impacting on producer decisions. The increase in the saleyard price for cattle likewise has a depressing effect, each $1¢/kg$ increase in the saleyard price for cattle reduces production by around 67 ± 30 tonnes. Increases in imports of pigmeat from Canada increases production by $1.9 \pm 0.99kg$ for every kg imported. As with the ADL model for production the negative relationships are an indication of the cobweb cycle impacting on producer decisions.

The impulse response functions and forecast error variance decomposi-

Table 13.5: Generalised Forecast Error Variance Decompositions after 20 quaters

Variation in	SPQ	SBFQ	RPQ	PPDQ
SPQ	0.83706	0.12622	0.33740	0.034570
SBFQ	0.032258	0.67039	0.027423	0.53111
RPQ	0.79840	0.043593	0.43864	0.0004003
PPDQ	0.10145	0.62745	0.028979	0.56867

tions are shown in Figures 13.1 to 13.4

The impulse response functions of the error correction terms in the VEC model show a slow return to equilibrium, taking around 2 years (8 quarters) to return to equilibrium after a shock to a particular variable (See Figures 13.1(a-d)). For the system as a whole these ECMs seem to counterbalance each other and a system wide shock returns to equilibrium in just over 1 year (5 quarters) (See Figure 13.1(e)).

The impulse response functions for the variables in the VEC model (Figures 13.2 and 13.3) indicate that a shock to the system causes a permanent effect. The variables do not return to their original equilibrium after a shock, as predicted by ABARE [1, 3] in their EMABA simulations. The non-stationarity component of the variables means that a shock has a permanent effect resulting in the variables moving to a new equilibrium.

The forecast error variance decompositions are shown in Figure 13.4. The relative importance of each variable to the variation in the variable under investigation in the long run (5 years) is presented in Table 13.5.

Multivariate dynamic forecasts for the VEC model are carried out (See Figure 13.5). The forecasts indicate that although the model is a good fit of in-sample data the forecasts fail to predict movements in producer prices and production (See Table 13.6). The failure to predict movements in saleyard prices for cattle (See Figure 13.5(b)) is understandable, given that the data generating process for cattle prices would be exogenous to the VEC model, but the failure to predict movements in producer prices and production for pigmeat needs some explanation. Given that the model predicts movements in retail prices reasonably well, one possible explanation is that the introduction of new import protocols in November 1997 has again changed the data-generating process of the Australian pig industry. The actual producer prices for pigs in 1998:2 is 162.67¢/kg compared with the forecast value of 206.024¢/kg. In order to see whether the model can predict future variations in variables, and to take into account the possibility that a structural break in 1997:4 has changed the DGP, the VEC was re-estimated using data from 1984:3 to 1995:4 and forecasted ahead to 1998:2 (See Figure 13.6). The

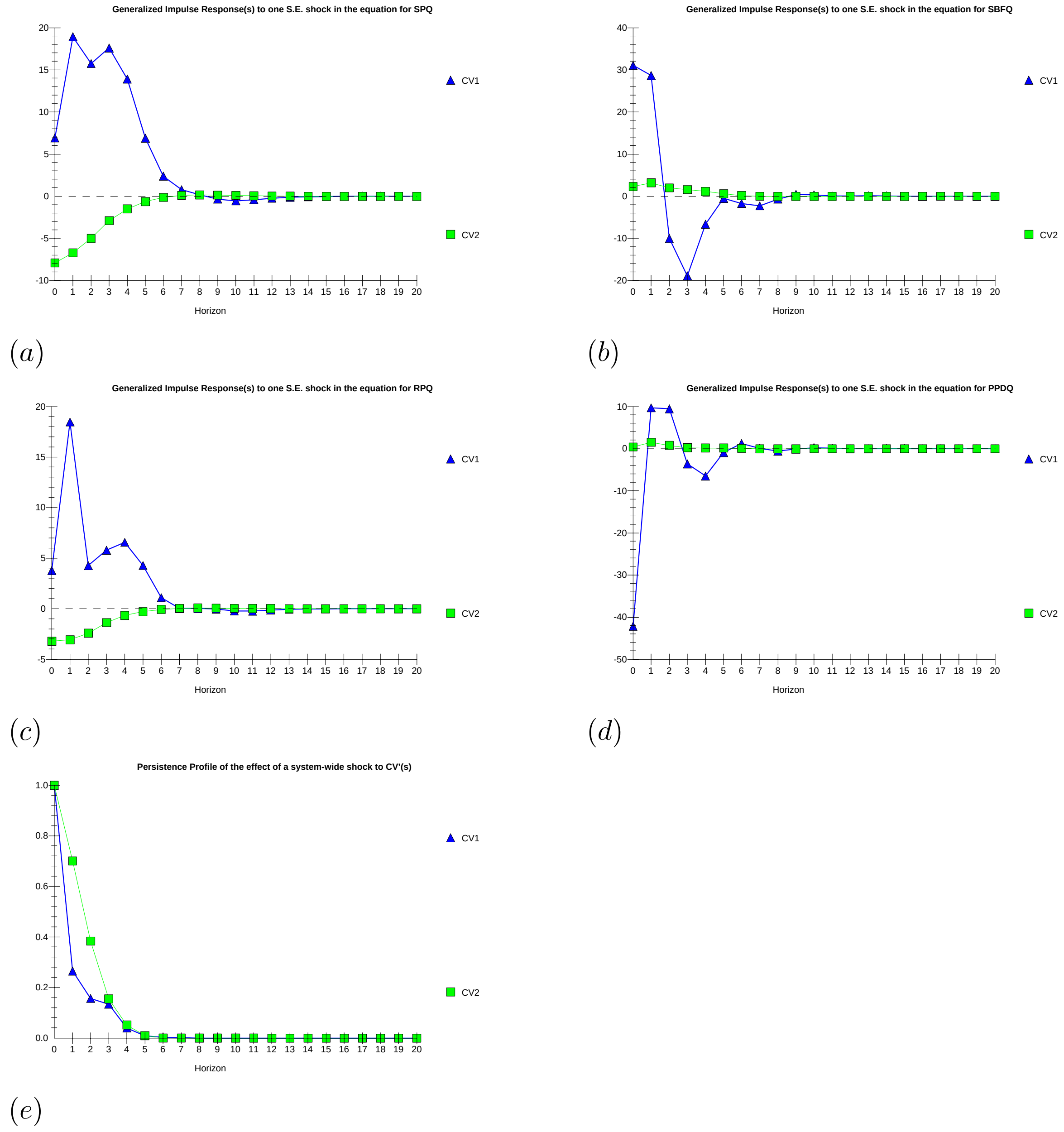
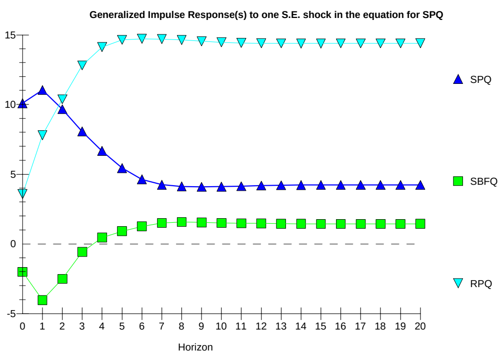
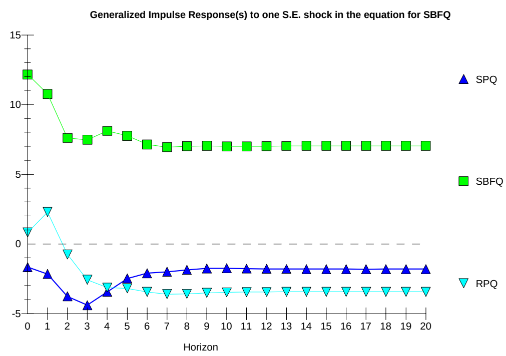


Figure 13.1: Impluse-Responses and Persistence Profile for Cointegrating Vectors



(a)



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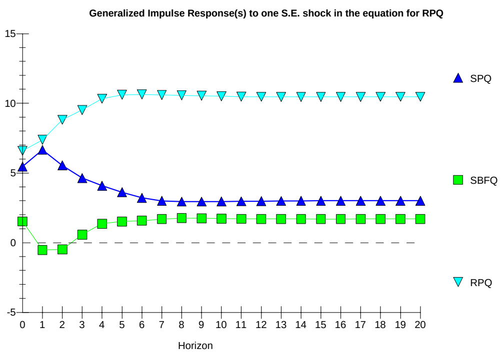

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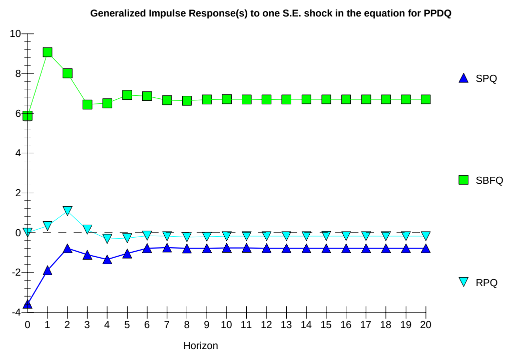


(d)

Figure 13.2: Generalised Impulse-Response Functions

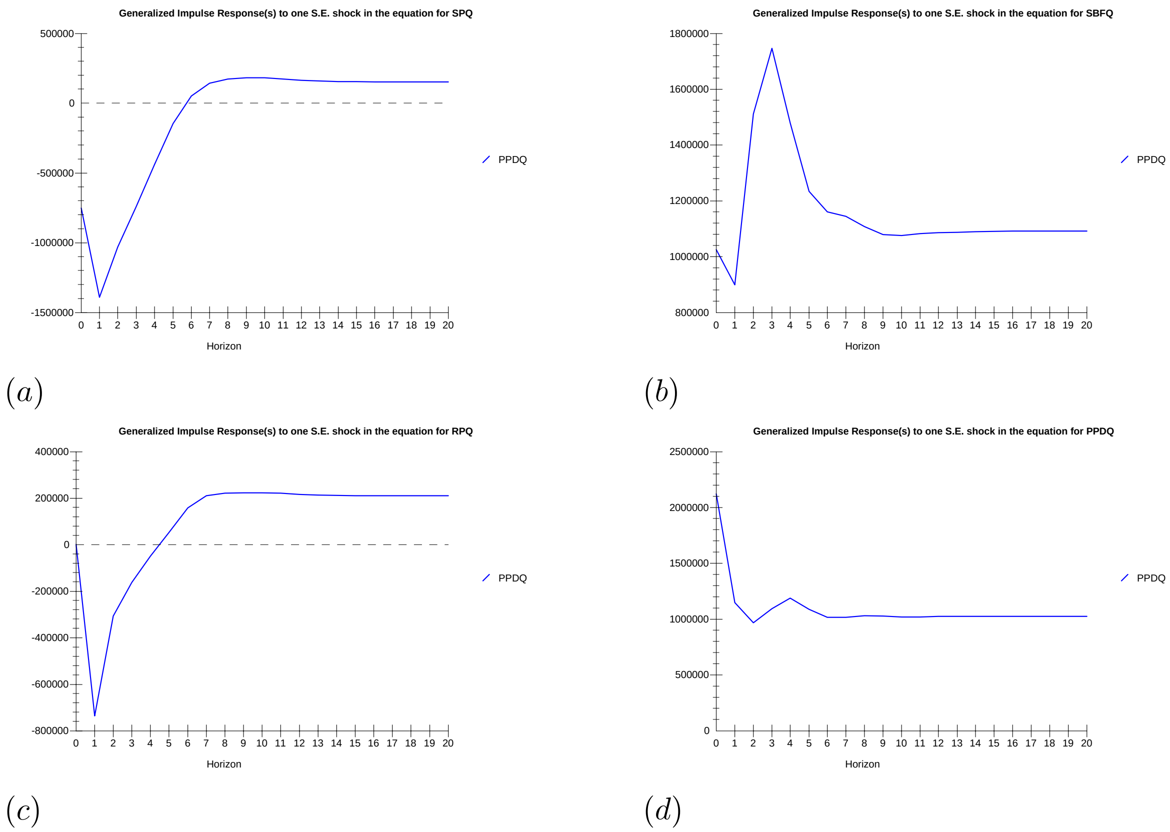


Figure 13.3: Generalised Impulse-Response Functions for production of pig-meat

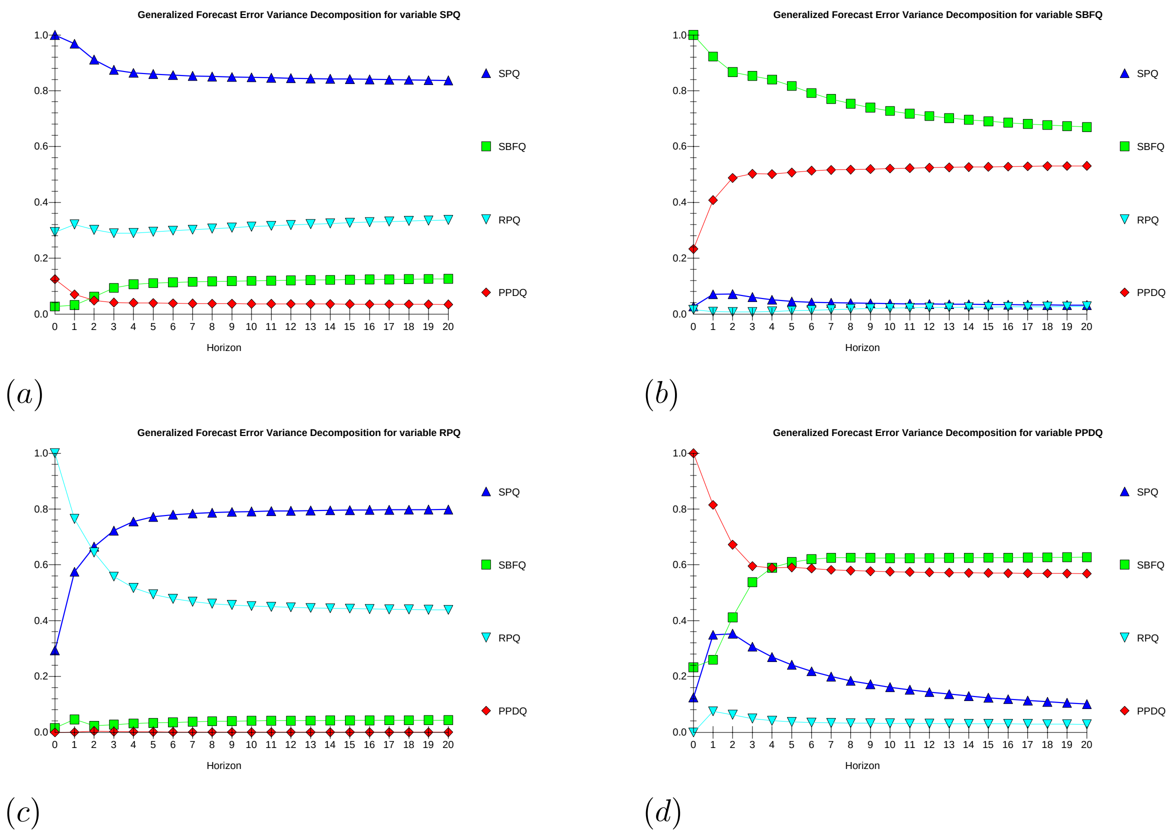
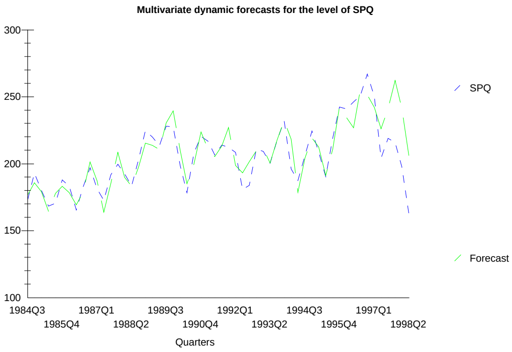


Figure 13.4: Generalised Forecast Error Variance Decompositions



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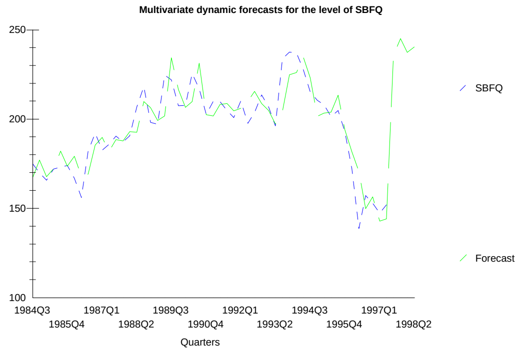

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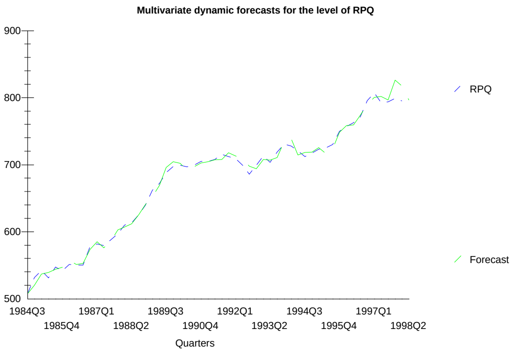

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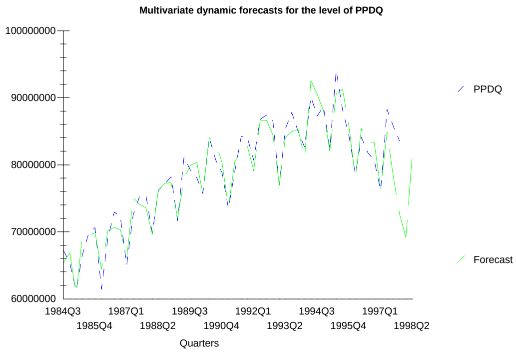


(d)

Figure 13.5: VEC model multivariate dynamic forecasts

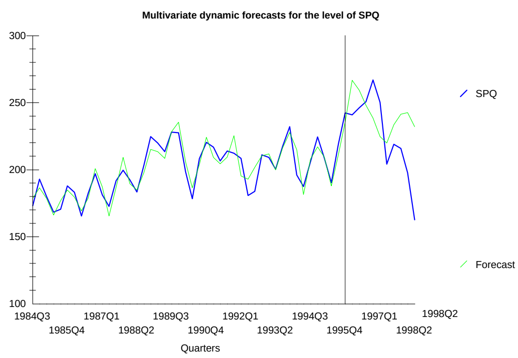
results indicate that the model predicts reasonably well up to around 4 quarters ahead but then breaks down after that. This is the general experience of forecasting models. The forecasts suggest that although the model's predictive ability starts to break down after a year, the forecasts for the VEC model (Figure 13.5) should predict reasonably well 2 to 3 quarters ahead. This implies that there could be a regime change which has impacted on the data-generating process and the fall in producer prices could well be due to the change in import protocol after November 1997.

13.4 A state space model of the Australian pig industry

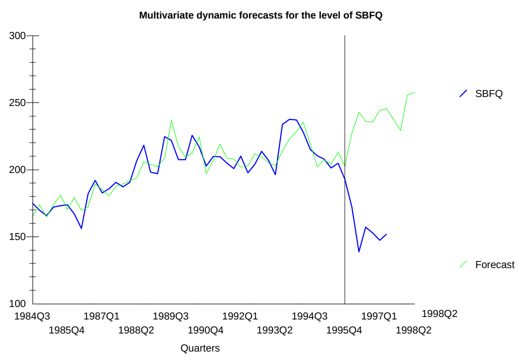
In the previous section we estimated a VEC representation of the Australian pig industry and conducted multivariate dynamic forecasts in an attempt to analyse the post November 1997 relaxation of the import protocols. While

Table 13.6: Multivariate dynamic forecasts Mean Square Errors

	In-sample	Forecast
SPQ	72.4497	1604.6
SBFQ	105.2458	
RPQ	31.3456	424.3182
PPDQ	3.21×10^{12}	8.82×10^{12}



(A)



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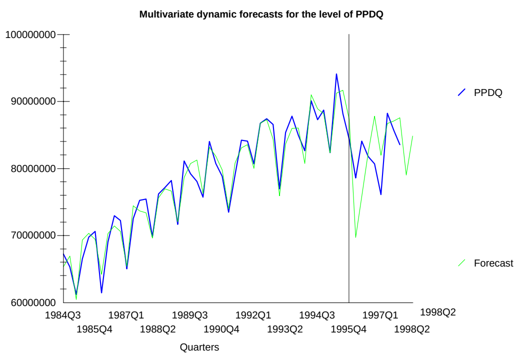

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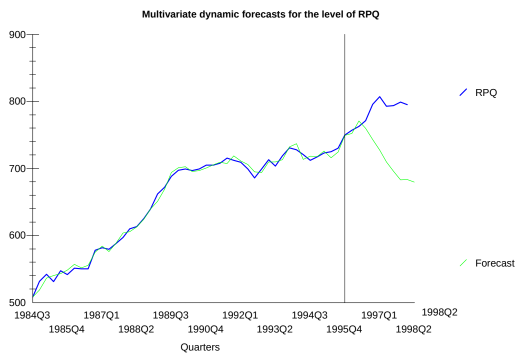


(D)

Figure 13.6: Multivariate dynamic forecasts for 1996:1 to 1998:2

the VEC model fitted the in-sample data very well it failed to predict adequately the fall in producer prices in 1998. While this may have been due to change in import protocols, the breakdown in predictive ability after around one year calls into question whether the failure to predict changes in variables is due to the change in import protocol, or the mis-specification of the VEC model. In this chapter we attempt to address this issue by developing a state-space model. A state-space model allows unobservable variables (the state variables) like structural breaks to be incorporated and estimated along with the observable model. The state-space model uses the Kalman filter to estimate VAR models with changing coefficients. The advantage of this is that coefficients which are changing due to (unobservable) structural breaks can be accurately estimated.

The state space representation of a dynamic system is given by

$$\xi_{t+1} = \mathbf{F}\xi_t + \mathbf{v}_{t+1} \tag{13.1}$$

$$\mathbf{y}_t = \mathbf{A}'\mathbf{x}_t + \mathbf{H}'\xi_t + \mathbf{w}_t \tag{13.2}$$

where $\mathbf{y}_t$, a $(n \times 1)$ vector of variables observed at time t, ξ_t is a (possibly unobserved) $(r \times 1)$ state vector, $\mathbf{F}$, $\mathbf{A}'$, and $\mathbf{H}'$ are $(r \times r)$, $(n \times k)$, and $(n \times r)$ matrices of parameters respectively, and $\mathbf{x}_t$ is a $(k \times 1)$ vector of exogenous variables [49, pp.372-373]. Equation 13.1 is the state equation and equation 13.2 is the observation equation. $\mathbf{v}_t$ and $\mathbf{w}_t$ are a $(r \times 1)$ and $(n \times 1)$ vector of white noise terms respectively with

$$E\left(\mathbf{v}_t\mathbf{v}_\tau'\right) = \begin{cases} \mathbf{Q} & \text{for } t = \tau \\ 0 & \text{otherwise} \end{cases}$$

$$E\left(\mathbf{w}_t\mathbf{w}_\tau'\right) = \begin{cases} \mathbf{R} & \text{for } t = \tau \\ 0 & \text{otherwise} \end{cases}$$

$$E\left(\mathbf{v}_t\mathbf{w}_\tau'\right) = 0 \quad \text{for all } t \text{ and } \tau$$

Given information about $(\mathbf{y}_t, \mathbf{x}_t)$ we can estimate $\mathbf{F}$, $\mathbf{A}'$, $\mathbf{H}'$, $\mathbf{Q}$ and $\mathbf{R}$ and make inferences about the state vector ξ_t using the Kalman filter algorithm.

The state space model was estimated for the VAR model of producer prices (SPQ), retail prices (RPQ), production (PPDQ), saleyard prices for cattle (SBFQ), import volumes (CANVQ) and import prices (CANPQ), all in stationary form (i.e. SPQ, RPQ, PPDQ, SBFQ were $I(1)$ and CANVQ and CANPQ were $SI_4(0,1)$). The model was estimated over the period 1984:1 to 1997:3 and forecast ahead 10 quarters. The results are presented in graphical format in Figures 13.7 to 13.12.

The results indicate that the Kalman filter failed to pick up the fall in producer price in 1998 (see Figure 13.7), thus the structural break that occured

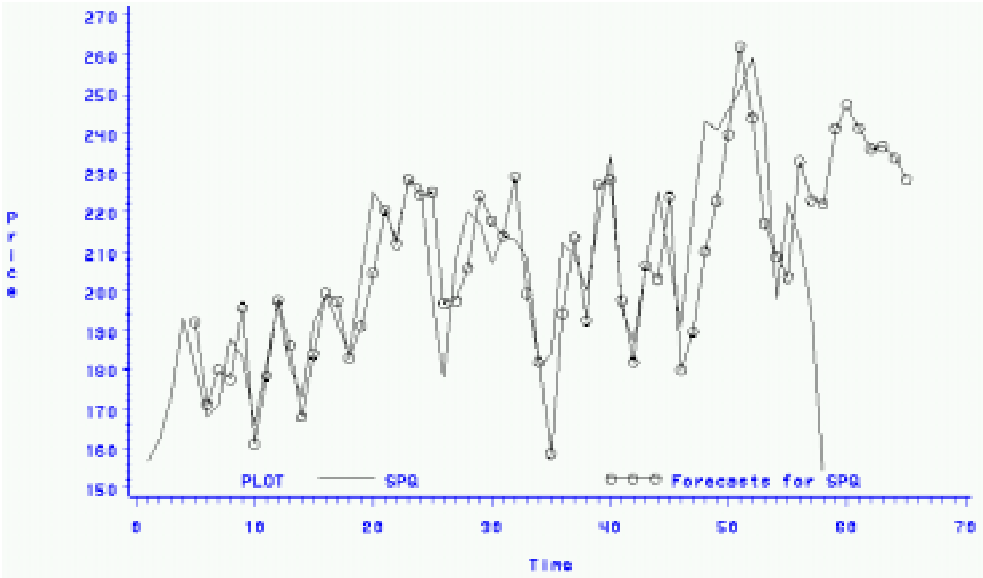


Figure 13.7: Actual and forecast values for producer prices

after November 1997 has changed the data generating process for producer prices, implying that the change in import protocols have had an effect on the market equilibrium. The model also failed to pick up the changes in production and the retail price, although the time series is too short to guage whether the difference between the actual and forecasted values are significant. Saleyard prices for cattle seem to be forecasted reasonably well, again it is difficult to tell what the long term forecast is like given the shortness of the out of sample data set. Import volumes and prices are predicted accurately by the Kalman filter.

13.5 Summary

The results of this chapter confirm the results of the individual ADL model equations. It appears that for every 1000 tonnes of imports the producer price drops by around $10.78 \pm 4.697¢/kg$ while for every \$1.00 increase in the producer price cattle prices drop by around $\$0.54 \pm 0.28/kg$. Cattle prices affect pork retail prices with a \$1.00 increase resulting in a $\$0.34 \pm 0.09/kg$ increase in the retail price for pork and every 1000 tonnes of imports resulting in a drop of around $5.324 \pm 3.067¢/kg$ for the retail price for pork.

The results of this chapter imply that retailers conduct spatial price averaging between meats and the asymmetric response of retail prices compared

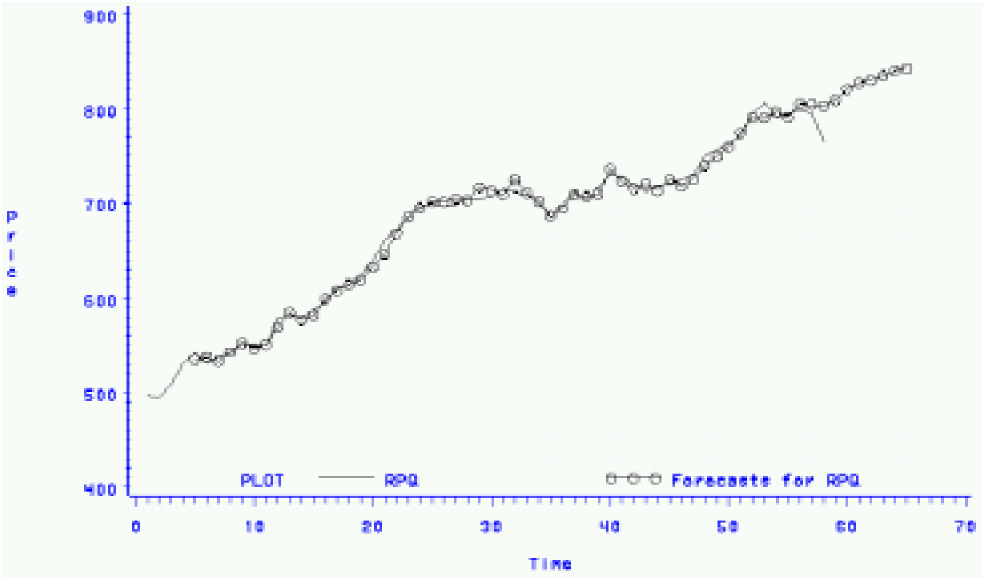


Figure 13.8: Actual and forecast values for retail prices

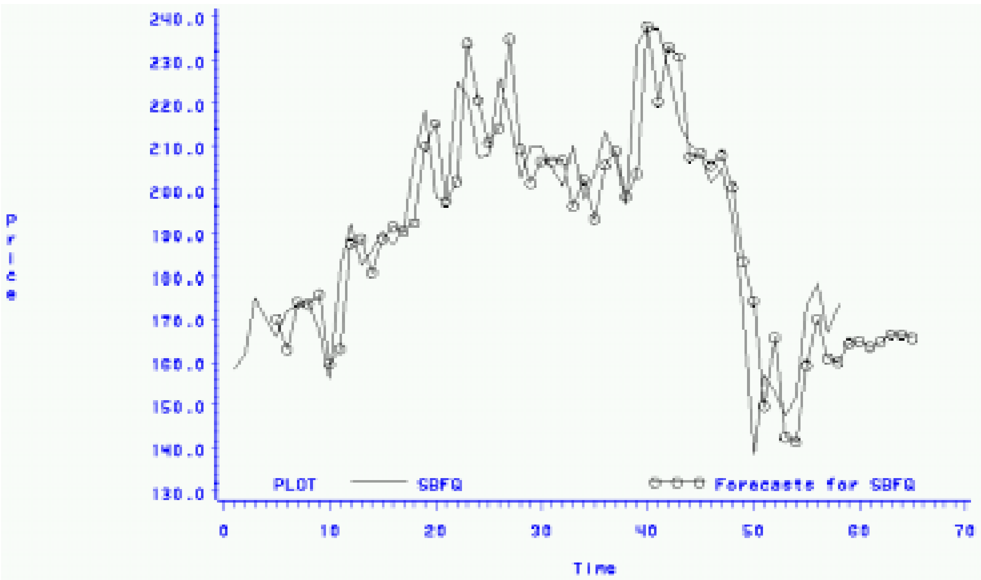


Figure 13.9: Actual and forecast values for cattle prices

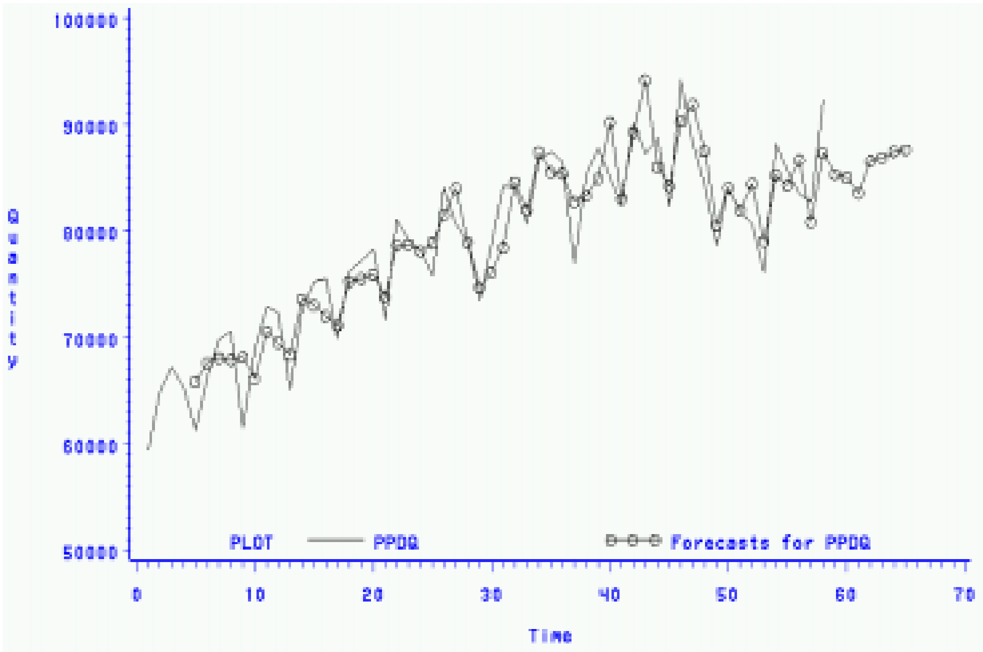


Figure 13.10: Actual and forecast values for production

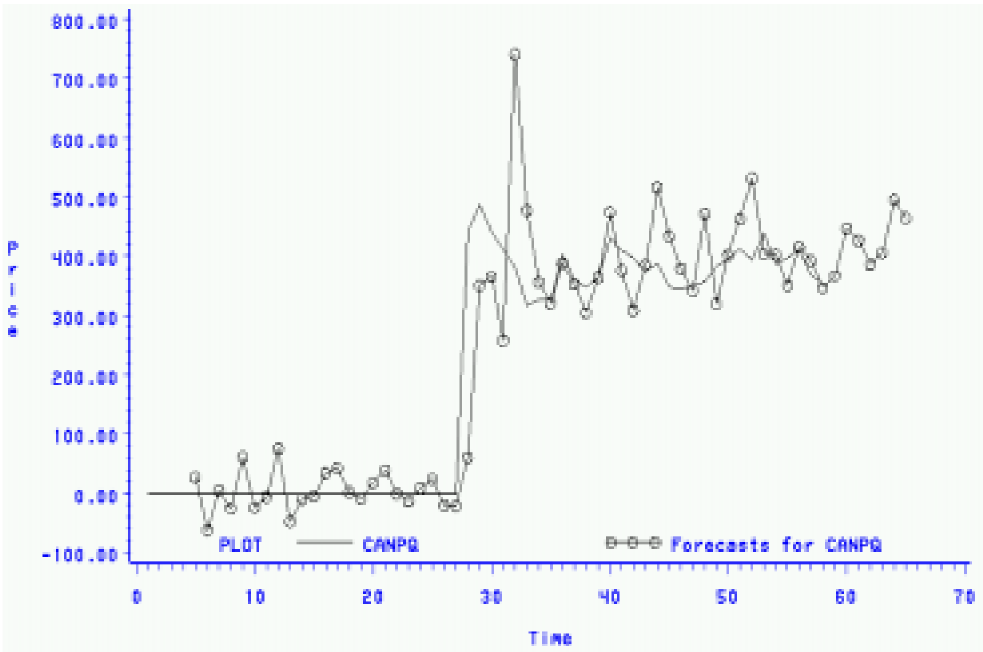


Figure 13.11: Actual and forecast values for import prices

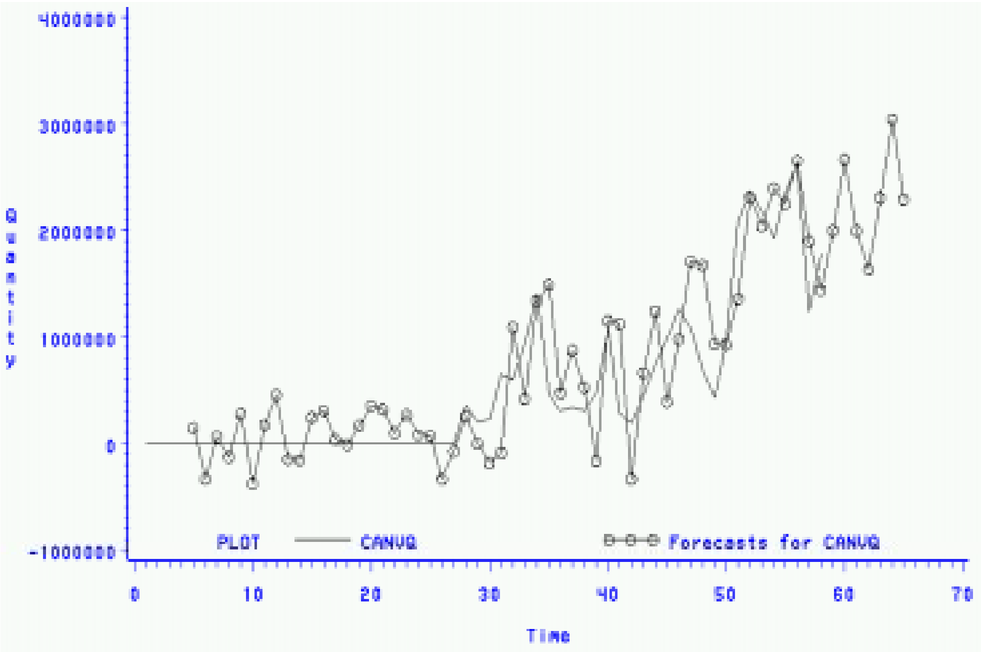


Figure 13.12: Actual and forecast values for import volumes

with producer prices suggests that market power on the part of retailers.

Looking at production effects; each $1¢/kg$ increase in producer price reduces production by around 88 ± 49 tonnes compared with an $1¢/kg$ increase in the cattle prices reducing production by around 67 ± 30 tonnes. Imports increase production by $1.9 \pm 0.99kg$ for every kg imported. As with the ADL model for production the negative relationship is an indication of the cobweb cycle impacting on producer decisions.

Turning to the impulse response functions, the functions suggest that the short-run deviations away from the long-run equilibriums persist in the system for up to 2 years but a system wide shock will have counterbalancing effects, reducing the time the deviations persist to just over 1 year.

Significantly, shocks to the variables themselves results in a permanent shift away from their long-run equilibriums to a new equilibrium. This is a feature of systems which are non-stationary, as explained in section 6.5. This result confirms the contention that unless non-stationarity is taken into consideration when developing models, the models will predict a return to the long-run equilibrium when in fact the variables will not. The results of the EMABA simulations are therefore suspect.

Multivariate dynamic forecasts are carried out which fit in-sample data very well but fail to predict the fall in producer price in 1998. Even though econometric models are notoriously poor forecasters, especially as the forecast period increases, it is uncertain whether the failure to predict the 1998 fall in producer price is due to the model or due to the change in import protocols in November 1997.

State-space modelling using a Kalman filter suggests that the multivariate forecasts in the VEC model were based on a good model specification, as the Kalman filter also failed to pick up the change in the data generating process after November 1997. The results of the space-state model suggest that the change in import protocol has had a negative effect on producer prices and that the decline in producer prices is not only due to actual imports but also due to the influence of the threat of unimpeded imports on the Bertrand bargaining game between producers and processors.

Chapter 14

A VEC model of producer-to-retail marketing margin

14.1 Introduction

Hahn [47] suggests that there exists simultaneous equation bias between retail and producer price formation, a problem that von Cramon-Taubadel [25] skirts around by testing for weak exogeneity between prices. The formation of a Vector Error Correction (VEC) model solves this problem, by explicitly taking into consideration the simultaneous nature of price formation. In this chapter we formulate a Vector Error Correction of the producer-retail price margin in an attempt to explore the nature of the divergence between the two prices. We take the results of chapter 10, that the retail price of pork is not significantly influenced by production or imports but it is influenced by producer prices, and formulate a VEC between the two prices.

14.2 Testing for multivariate cointegration

Prior to the formation of a VEC model to examine producer-to-retail marketing margins the number of cointegrating vectors in the model needs to be identified. The Johansen maximum-likelihood test for cointegration is carried out on a VAR(2) with unrestricted intercepts and no trends and the results indicate that the hypothesis of one cointegrating vector is not rejected (See Table 14.1).

Table 14.1: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r = 0$	$r = 1$	34.1972	14.88	37.2611	17.86
$r \leq 1$	$r = 2$	3.0639	8.07	3.0639	8.07

CI vector $(RPQ, SPQ) : \beta = \{-0.00346, 0.014581\}$
Normalised CI vector $(RPQ, SPQ) : \tilde{\beta} = \{-1.00, 4.2141\}$

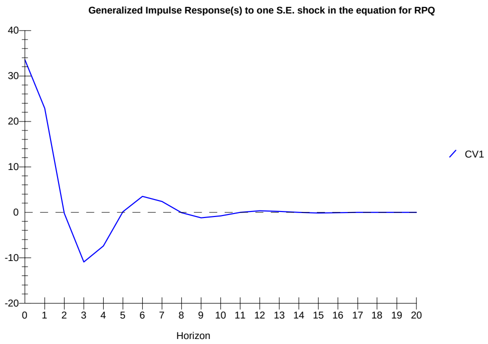
Table 14.2: VEC representation of price transmission

	ΔRPQ		ΔSPQ	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	−2.6635	5.2109 [0.612]	35.7038	8.9612 [0.000]
ΔRPQ_t	−0.31004	0.17011 [0.075]	−0.18802	0.29257 [0.524]
ΔSPQ_t	0.27962	0.089991 [0.003]	0.53785	0.15477 [0.001]
ECM_{t-1}	0.049118	0.028883 [0.095]	−0.17515	0.049675 [0.001]
R^2	0.32343		0.35118	

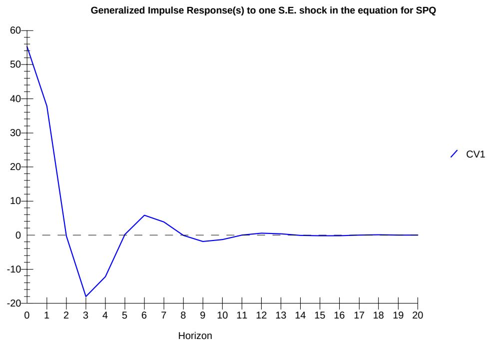
14.3 VEC model results

The VEC model is presented in Table 14.2. The results indicate significant serial correlation in the ECM representation for the SPQ equation. Re-estimation with a VAR(2) with seasonal dummies and a VAR(4) model do not substantially change the ECM coefficients, but do result in the elimination of the serial correlation. Since there is no gain in efficiency, at the expense of reducing the significance of the extra lagged variables, it was decided to retain the VAR(2) model with its serial correlation.

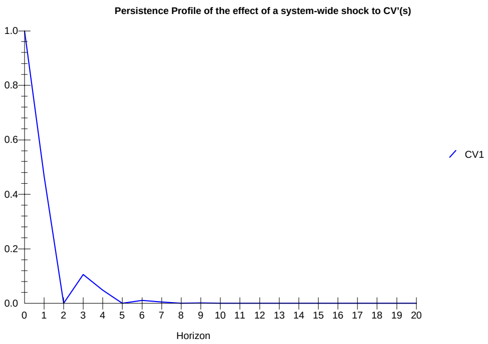
The ECM terms in the VEC model describe the speed of adjustment of the system to an exogenous shock in prices. The results indicate that the saleyard price for baconers has a much faster speed of adjustment (-0.17515) relative to the retail price of pork - which, in fact, is not significantly different from zero. The coefficients of the VEC model show that a \$1.00 increase in producer prices will increase retail prices by $\$0.28 \pm 0.09/kg$ but a change in the retail price will not significantly affect the producer price. This is indicative of the asymmetric price transmission between retail and producer prices. The model itself is not a very good fit of the data generating process, with an R^2 of only $0.32 - 0.35$, indicating that there are other factors influencing changes in retail and producer prices which have not been incorporated. This confirms the results in chapter 7, which suggest that the retail prices of meat substitutes have an important role to play in price determination. This issue will be taken up in chapter 15. The Impulse Response functions for the



(a)



(b)



(c)

Figure 14.1: Cointegrating vectors Impulse-Response functions and Persistence profiles

ECMs (See Figure 14.1) indicate that a shock to the system takes around 2 years (8 quarters) to dissipate, indicating that the relationship between retail and producer prices is very "sticky".

The impulse responses for retail and producer price (See Figure 14.2(a,b)) indicate that a shock to the system will result in the system moving to a new equilibrium due to the non-stationarity characteristics of the prices. The forecast error variance decompositions (See Figure 14.2(c,d)) indicate that around 75% of the variability in retail prices is explained by producer prices but only around 50% of the variability in producer prices is explained by retail prices. Again, the model fit is very low and variations in producer and retail prices are more likely to be explained by other factors.

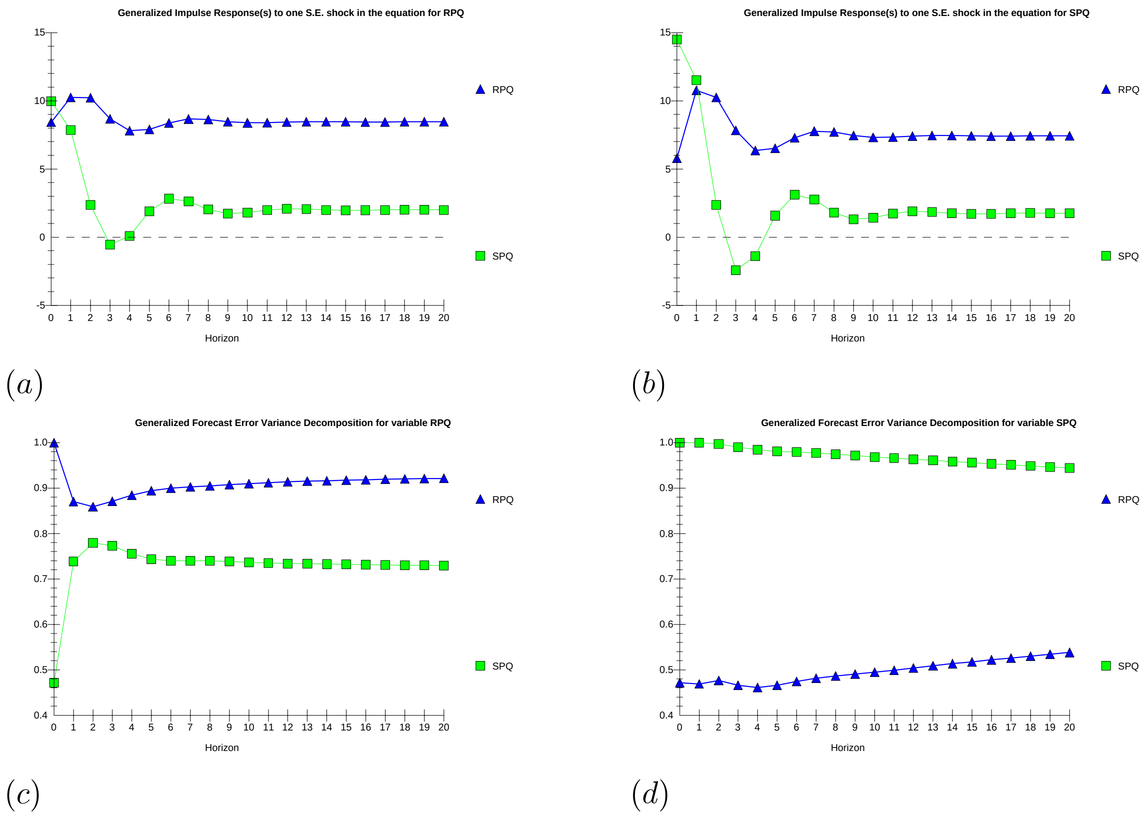


Figure 14.2: Impulse-Response functions and Forecast Error Variance Decompositions

Table 14.3: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$LR_{Crit,0.05}$	Trace	$LR_{Crit,0.05}$
$r = 0$	$r = 1$	77.0265	40.0600	141.1725	86.3000
$r \leq 1$	$r = 2$	35.8601	33.8100	64.1459	60.5400
$r \leq 2$	$r = 3$	22.8040	26.9500	28.2858	38.5000
$r \leq 3$	$r = 4$	5.4819	19.6200	5.4819	19.6200

Table 14.4: Cointegrating vectors

CI vector	WPM	PPRODM	RPM	SPM
β_1	0.0026696	0.1709×10^{-3}	0.9889×10^{-3}	0.0064756
β_2	-0.0089313	0.2978×10^{-4}	0.8577×10^{-3}	0.0029649
$\tilde{\beta}_1$	-1.0000	-0.064003	-0.37043	-2.4257
$\tilde{\beta}_2$	-1.0000	0.0033346	0.096030	0.33197

CI vector	SBFM	CANVM	CANPM
β_1	0.0013550	-0.1431×10^{-6}	0.0010493
β_2	-0.0092884	0.1424×10^{-6}	0.0022368
$\tilde{\beta}_1$	-0.50756	0.5359×10^{-4}	-0.39306
$\tilde{\beta}_2$	-1.0400	0.1594×10^{-4}	0.25044

CI matrix $= [\beta_1, \beta_2]$

Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2\right]$

14.4 Incorporating wholesale prices into the marketing margin

Since the model fit in the previous section was so low, it was decided to re-estimate the VEC taking into consideration wholesale prices as another step in the marketing chain. The model is estimated for monthly data from 1993:7 to 1998:6 and includes as endogenous $I(1)$ variables the wholesale price for bone-in leg meat (WPM), the retail price for pork (RPM), the saleyard price for baconers (SPM), and domestic production of pigmeat (PPRODM) (in tonnes). In addition the saleyard price for baconers (SBFM), import volumes (CANVM) (in kgs), and import prices (CANPM) are treated as exogenous $I(1)$ variables. The $I(0)$ variables are the 1^{st} to 11^{th} seasonal dummies and a dummy variable for the change in import protocol in 1997:11.

The Johansen maximum-likelihood test for cointegration is carried out on a VAR(2) with unrestricted intercepts and no trends and the results indicate that the hypothesis of two cointegrating vectors is not rejected (See Tables 14.3 and 14.4).

Table 14.5: VEC representation (I)

	ΔWPM	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	301.2036	97.8613 [0.004]
T	−1.0835	0.25868 [0.000]
ΔWPM_t	0.11624	0.13970 [0.411]
$\Delta PPRODM_t$	0.4600×10^{-3}	0.0010961 [0.677]
ΔRPM_t	−0.11553	0.31905 [0.719]
ΔSPM_t	0.45642	0.26161 [0.089]
$\Delta SBFM_t$	0.34232	0.21718 [0.123]
$\Delta CANVM_t$	-0.5536×10^{-5}	0.9290×10^{-5} [0.555]
$\Delta CANPM_t$	−0.049706	0.046225 [0.289]
ECM^1_{t-1}	0.059662	0.029417 [0.050]
ECM^2_{t-1}	0.41353	0.098416 [0.000]
M^1_t	−28.5335	7.9373 [0.001]
M^2_t	−24.7272	10.7797 [0.028]
M^3_t	−25.9372	10.4686 [0.018]
M^4_t	−25.6786	9.3344 [0.009]
M^5_t	−28.6546	10.0823 [0.007]
M^6_t	−21.7656	9.8885 [0.034]
M^7_t	−17.0877	9.3606 [0.076]
M^8_t	−17.5060	9.5378 [0.074]
M^9_t	−13.9647	7.7242 [0.079]
M^{10}_t	−7.0715	7.9498 [0.379]
M^{11}_t	8.0764	9.3517 [0.393]
$BREAK_{97:11}$	3.7805	6.3684 [0.556]
R^2	0.76561	

The VEC model is presented in Tables 14.5 to 14.8.
The results suggest that

1. Changes in the wholesale price are significantly affected by changes in the saleyard price for baconers with a \$1.00 increase in producer prices resulting in a $\$0.456 \pm 0.262/kg$ increase in the wholesale price. The error correction equation for the wholesale price in the VEC model exhibits significant serial correlation and heteroscedasticity, indicating that the estimates will be inefficient (have a large variance attached to them).

2. Changes in production of pigmeat are significantly affected by changes

Table 14.6: VEC representation (II)

	$\Delta PPRODM$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	84772.5	9891.8 [0.000]
T	-15.5314	26.1468 [0.556]
ΔWPM_t	20.5911	14.1203 [0.153]
$\Delta PPRODM_t$	0.21595	0.11079 [0.059]
ΔRPM_t	22.4304	32.2493 [0.491]
ΔSPM_t	63.7623	26.4433 [0.021]
$\Delta SBFM_t$	35.5889	21.9525 [0.113]
$\Delta CANVM_t$	-0.6746×10^{-3}	0.9390×10^{-3} [0.477]
$\Delta CANPM_t$	4.4525	4.6724 [0.347]
ECM^1_{t-1}	26.4640	2.9734 [0.000]
ECM^2_{t-1}	-4.6007	9.9478 [0.646]
M^1_t	-2390.1	802.3049 [0.005]
M^2_t	-2220.2	1089.6 [0.049]
M^3_t	-1529.2	1058.2 [0.157]
M^4_t	-1759.8	943.5188 [0.070]
M^5_t	1208.4	1019.1 [0.243]
M^6_t	165.3409	999.5300 [0.870]
M^7_t	-1492.6	946.1693 [0.123]
M^8_t	-2449.4	964.0807 [0.015]
M^9_t	-1577.7	780.7606 [0.051]
M^{10}_t	-1641.3	803.5646 [0.048]
M^{11}_t	-1058.2	945.2684 [0.270]
$BREAK_{97:11}$	-1762.3	643.7165 [0.009]
R^2	0.89164	

Table 14.7: VEC representation (III)

	ΔRPM	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	59.3881	51.8398 [0.259]
T	-0.11014	0.13703 [0.427]
ΔWPM_t	0.087742	0.074000 [0.243]
$\Delta PPRODM_t$	0.2757×10^{-3}	0.5806×10^{-3} [0.638]
ΔRPM_t	-0.21650	0.16901 [0.208]
ΔSPM_t	0.17806	0.13858 [0.207]
$\Delta SBFM_t$	0.11080	0.11505 [0.342]
$\Delta CANVM_t$	0.4955×10^{-6}	0.4921×10^{-5} [0.920]
$\Delta CANPM_t$	-0.012375	0.024486 [0.616]
ECM^1_{t-1}	0.015194	0.015583 [0.336]
ECM^2_{t-1}	0.048513	0.052133 [0.358]
M^1_t	7.3596	4.2046 [0.088]
M^2_t	6.0323	5.7103 [0.298]
M^3_t	0.49541	5.5455 [0.929]
M^4_t	-6.8073	4.9447 [0.177]
M^5_t	0.20456	5.3409 [0.970]
M^6_t	-0.19520	5.2382 [0.970]
M^7_t	2.7345	4.9586 [0.585]
M^8_t	-3.7065	5.0524 [0.468]
M^9_t	-2.2688	4.0917 [0.583]
M^{10}_t	12.4017	4.2112 [0.006]
M^{11}_t	3.1729	4.9539 [0.526]
$BREAK_{97:11}$	-5.5147	3.3735 [0.111]
R^2	0.56260	

Table 14.8: VEC representation (IV)

	ΔSPM	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	50.1156	64.1992 [0.440]
T	0.051516	0.16970 [0.763]
ΔWPM_t	0.014377	0.091643 [0.876]
$\Delta PPRODM_t$	0.0010669	0.7191×10^{-3} [0.146]
ΔRPM_t	0.0083771	0.20930 [0.968]
ΔSPM_t	0.24147	0.17162 [0.168]
$\Delta SBFM_t$	−0.29216	0.14248 [0.047]
$\Delta CANVM_t$	-0.1342×10^{-4}	0.6094×10^{-5} [0.034]
$\Delta CANPM_t$	0.033033	0.030324 [0.283]
ECM^1_{t-1}	0.020173	0.019298 [0.303]
ECM^2_{t-1}	−0.049428	0.064563 [0.449]
M^1_t	−10.9495	5.2071 [0.042]
M^2_t	−1.9459	7.0717 [0.785]
M^3_t	−2.0401	6.8676 [0.768]
M^4_t	−8.7540	6.1236 [0.161]
M^5_t	6.4613	6.6142 [0.335]
M^6_t	5.9484	6.4871 [0.365]
M^7_t	16.3172	6.1408 [0.012]
M^8_t	15.4363	6.2570 [0.018]
M^9_t	8.7135	5.0673 [0.094]
M^{10}_t	8.0347	5.2153 [0.132]
M^{11}_t	12.3282	6.1349 [0.052]
$BREAK_{97:11}$	−4.6141	4.1778 [0.277]
R^2	0.69375	

in the saleyard price for baconers, with a 1¢/kg increase in producer prices resulting in a 63.76 ± 26.44 tonne increase in production. The saleyard price for cattle does not significantly affect pigmeat production, but it is borderline, being within 0.65% of the critical value. For every \$1.00 increase in cattle prices pigmeat production increases by 35.59 ± 21.95 tonnes. The introduction of new import protocols after November 1997 has significantly decreased pigmeat production by 1762.3 ± 643.72 tonnes (per month). Industry sources indicate that quota limits on contract sales to abattoirs have been strictly enforced during 1998 in an effort to restrict supply and this could be an explanation for the negative coefficient on the structural break term. The error correction equation for pigmeat production in the VEC model exhibits significant serial correlation, again indicating that the estimates will be inefficient.

3. Changes in the retail price for pork are not significantly affected by the variables in the regression model, indicating that the DGP for retail prices is influenced by other factors. This result confirms the results in the section above, and the results from chapter 10. The structural break parameter is borderline on being significant, and indicates that import protocols may have decreased retail price by $5.51 \pm 3.37¢/kg$. The error correction equation for retail prices in the VEC model exhibits significant heteroscedasticity.

4. Changes in the saleyard price for baconers are significantly affected by changes in the saleyard price for cattle. A \$1.00 increase in the price for cattle depresses producer prices by $29.22 \pm 14.25¢/kg$. Import volumes also depress producer prices, with every 1000 tonnes of imports depressing producer prices by $13.42 \pm 6.094¢/kg$. The VEC model suggests that producer prices have not been significantly affected by the introduction of the new import protocols after November 1997 but that actual import volumes are contributing to the decline in price.

The impulse response functions and forecast error variance decompositions are unable to be calculated in the presence of $I(1)$ exogenous variables.

14.5 Summary

This chapter has examined asymmetric price transmission in a VEC framework. Two models are presented. The first model attempts to capture the price transmission between producer and retail prices and the second model incorporates an intermediate stage with the addition of wholesale prices. The results of the first model suggest that increases in producer prices will increase retail prices by $\$0.28 \pm 0.09/kg$ for every $1.00 increase but increases in retail prices will not have a significant effect on producer prices. This is borne out by the forecast error variance decompositions which suggest a lower contribution of retail prices to producer price variability but a much higher contribution of producer prices to retail price variability.

The model is not a very good fit of the data generating process and this confirms the results in chapter 7.

The results of the second model which incorporates wholesale prices into the price transmission mechanism suggest that:

1. A $1.00 increase in producer prices results in a $\$0.456 \pm 0.262/kg$ increase in the wholesale price.

2. A 1¢/kg increase in producer prices results in a 63.76 ± 26.44 tonne increase in production.

3. A $1.00 increase in cattle prices results in a 35.59 ± 21.95 tonne increase in pigmeat production.

4. The retail price for pork is not significantly affected by the variables in the regression model. This result confirms the results in the section above, and the results from chapter 10.

5. A $1.00 increase in the price for cattle depresses producer prices by $29.22 \pm 14.25¢/kg$.

6. A 1000 tonnes increase in imports depresses producer prices by $13.42 \pm 6.094¢/kg$.

7. While retail prices have declined by $5.51 \pm 3.37¢/kg$ after November 1997, producer prices have not been significantly affected by the introduction of the new import protocols after November 1997. This suggests that actual import volumes are contributing to the decline in producer price rather than the threat of imports under the new protocols.

8. The introduction of new import protocols after November 1997 significantly decreases pigmeat production by 1762.3 ± 643.72 tonnes (per month). Industry sources indicate that quota limits on contract sales to abattoirs have been strictly enforced during 1998 in an effort to restrict supply and this could be an explanation for the negative coefficient on the structural break term.

Chapter 15

A VEC model of the Australian retail meat sector

15.1 Introduction

Hyde and Perloff [52] estimate market power for the Australian retail meat sector and suggest that in the presence of market power in some markets but not in others the estimation of market power is biased when conducted in a single equation framework (one market at a time) compared with the estimation in a simultaneous market framework. Hyde and Perloff estimate market power between retail and wholesale prices using a model based on the Almost Ideal Demand System (AIDS) combined with optimal pricing conditions for each industry. They find that over the period 1970-1988 market power was insignificant and unchanging over time.

Granger causality tests in chapter 11 suggest that there is a causal link between retail meat prices and so in this chapter we formulate a vector error correction model of the Australian retail meat sector that does not impose an ad-hoc structure on the dataset and allows dynamic interactions to take place. The model is estimated over the period 1990:1 to 1997:2, the period after the introduction of pigmeat imports, and models the interactions between retail and producer prices. The model dataset comprises of retail and producer prices for pigmeat, beef and lamb, and retail prices for chicken (producer prices for chicken meat were unavailable).

15.2 Testing for multivariate cointegration

The Johansen maximum-likelihood test for cointegration is carried out on a VAR(2) with unrestricted intercepts and trends for the period 1990:1 to

Table 15.1: Johansen ML test for Cointegration

H_0	H_1	Max-Eigenvalue	$\text{LR}_{Crit,0.05}$	Trace	$\text{LR}_{Crit,0.05}$
$r = 0$	$r = 1$	104.8750	48.5700	253.3066	140.0200
$r \leq 1$	$r = 2$	52.3722	42.6700	148.4315	109.1800
$r \leq 2$	$r = 3$	37.9674	37.0700	96.0593	82.2300
$r \leq 3$	$r = 4$	26.8886	31.0000	58.0918	58.9300
$r \leq 4$	$r = 5$	16.0288	24.3500	31.2033	39.3300
$r \leq 5$	$r = 6$	11.8494	18.3300	15.1745	23.8300
$r \leq 6$	$r = 7$	3.3251	11.5400	3.3251	11.5400

1997:2 and the results indicate that the hypothesis of three cointegrating vectors is not rejected (See Tables 15.1 and 15.2).

15.3 VEC model results

The VEC model is presented in Tables 15.3 to 15.6. The results indicate that:

1. The retail price for pork exhibits a significant upward trend with every quarter adding $1.9 \pm 0.89¢/kg$ to the price. Every additional \$1.00/kg increase in cattle prices increase pork retail prices by $\$0.45 \pm 0.16/kg$.

2. The saleyard price for baconers does not seem to be influenced by other meats' producer or retail prices.

3. The retail price of beef exhibits a significant upward trend with each quarter adding $2.77 \pm 1.25¢/kg$ to the price. The retail price of beef is also influenced by lamb prices, with a \$1.00/kg increase in saleyard price for lambs resulting in a $\$0.479 \pm 0.173/kg$ increase in the price of beef. In contrast, a \$1.00/kg increase in the retail price of lamb results in a decline of $\$0.602 \pm 0.211/kg$ in the price of beef.

4. Changes in the saleyard price for cattle appear to be driven by changes in the retail pork price, with a $1¢/kg$ increase in pork prices resulting in a $1.157 \pm 0.4556¢/kg$ increase in the cattle price. Retail prices of beef also play an important role, with a \$1.00/kg increase in beef prices resulting in a $\$0.95948 \pm 0.36418/kg$ increase in cattle prices. Lamb prices contribute to changes in cattle prices. A $1¢/kg$ increase in the retail price of lamb results in a $1.08 \pm 0.27¢/kg$ decrease in cattle prices. In contrast, a \$1.00/kg increase in the saleyard price of lamb results in a $\$0.578 \pm 0.219/kg$ increase in cattle prices.

Table 15.2: Cointegrating vectors

CI vector	RPQ	SPQ	$RBFQ$	$SBFQ$
β_1	0.023907	0.017213	0.025361	0.035505
β_2	0.026465	−0.027467	0.0087471	−0.017248
β_3	−0.0094711	0.013080	0.022769	0.0002052
$\tilde{\beta}_1$	−1.0000	−0.71998	−1.0608	−1.4851
$\tilde{\beta}_2$	−1.0000	1.0379	−0.33052	0.65174
$\tilde{\beta}_3$	−1.0000	1.3810	2.4041	0.021670

CI vector	$RPQC$	$RPQL$	$SPQL$
β_1	0.039484	−0.042480	0.031828
β_2	−0.036474	0.0073235	−0.0003547
β_3	0.0088049	−0.0097205	0.015006
$\tilde{\beta}_1$	−1.6515	1.7769	−1.3313
$\tilde{\beta}_2$	1.3782	−0.27673	0.013405
$\tilde{\beta}_3$	0.92966	−1.0263	1.5844

CI matrix $= [\beta_1, \beta_2, \beta_3]$

Normalised CI matrix $= \left[\tilde{\beta}_1, \tilde{\beta}_2, \tilde{\beta}_3\right]$

5. The retail price of lamb exhibits a significant upward trend with each quarter adding 6.487 ± 2.926¢$/kg$ to the price. A \$1.00/kg increase in the saleyard price of lamb results in a $\$1.251 \pm 0.404/kg$ increase in the retail price whereas a \$1.00/kg increase in the retail price of chicken results in a $\$0.446 \pm 0.801/kg$ decline in the retail price for lamb.

6. Neither the saleyard price of lamb nor the retail price of chicken appear to be influenced by other meats' retail or producer prices.

The results appear to be consistent with the results of the models estimated in the previous chapters. What seems obvious though is that the data generating process underlying producer and retail prices of meat in the Australian meat industry is not solely reliant on substitution effects between meats, at both the producer and the retail level. In order to capture the data generating process information on production as well as consumer demand needs to be incorporated. The incorporation of such additional information in a VEC framework is extremely data intensive, and data with a higher frequency must be used in order to obtain sufficient degrees of freedom.

The impulse response functions and the forecast error variance decompositions for the VEC model are presented in Figures 15.1 to 15.4.

The ECM terms in the VEC model describe the speed of adjustment of the system to an exogenous shock in prices. The results indicate that the short-

Table 15.3: VEC representation for pigmeat

	ΔRPQ		ΔSPQ	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	570.2409	242.3925 [0.033]	0.92927	618.3310 [0.999]
ΔRPQ_t	0.025070	0.25667 [0.923]	−0.47290	0.65475 [0.481]
ΔSPQ_t	−0.080532	0.11329 [0.488]	0.22444	0.28901 [0.449]
$\Delta RBFQ_t$	−0.31234	0.20519 [0.881]	−0.099994	0.52343 [0.851]
$\Delta SBFQ_t$	0.44587	0.15796 [0.013]	0.42727	0.40296 [0.306]
$\Delta RPQL_t$	−0.11487	0.15062 [0.457]	0.055204	0.38422 [0.888]
$\Delta SPQL_t$	−0.0038183	0.12361 [0.976]	0.14371	0.31531 [0.655]
$\Delta RPQC_t$	−0.37207	0.24504 [0.150]	0.43598	0.62507 [0.496]
T	1.9051	0.89473 [0.050]	−3.2577	2.2824 [0.174]
Q_t^1	−4.7773	0.47516 [0.331]	−1.4442	12.1211 [0.907]
Q_t^2	−3.2322	5.3903 [0.558]	−22.3913	13.7504 [0.124]
Q_t^3	2.3106	4.3156 [0.600]	3.9406	11.0089 [0.725]
ECM_{t-1}^1	0.33790	0.11897 [0.012]	0.21612	0.30348 [0.487]
ECM_{t-1}^2	0.49035	0.13169 [0.002]	−0.40796	0.33594 [0.243]
ECM_{t-1}^3	0.13370	0.047129 [0.012]	0.14742	0.12022 [0.239]
R^2	0.85695		0.78592	

Table 15.4: VEC representation for beef

	$\Delta RBFQ_t$		$\Delta SBFQ_t$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	973.5499	339.6431 [0.012]	2334.2	430.2081 [0.000]
ΔRPQ_t	0.54292	0.35965 [0.152]	1.1568	0.45555 [0.023]
ΔSPQ_t	−0.14286	0.15875 [0.382]	−0.31716	0.20108 [0.136]
$\Delta RBFQ_t$	1.1553	0.28751 [0.001]	0.95948	0.36418 [0.019]
$\Delta SBFQ_t$	−0.0038685	0.22134 [0.986]	0.66763	0.28036 [0.031]
$\Delta RPQL_t$	−0.60209	0.21105 [0.012]	−1.0833	0.26732 [0.001]
$\Delta SPQL_t$	0.47944	0.17320 [0.014]	0.57805	0.21938 [0.019]
$\Delta RPQC_t$	−0.37484	0.34335 [0.292]	−0.64424	0.43490 [0.159]
T	2.7749	1.2537 [0.043]	1.6987	1.5880 [0.302]
Q_t^1	4.2981	6.6580 [0.528]	−8.6029	8.4333 [0.324]
Q_t^2	4.6138	7.5529 [0.550]	3.7004	9.5669 [0.704]
Q_t^3	8.3648	6.0471 [0.187]	7.4916	7.6595 [0.344]
ECM_{t-1}^1	0.27595	0.16670 [0.119]	0.94593	0.21115 [0.000]
ECM_{t-1}^2	0.54375	0.18453 [0.010]	0.64651	0.23373 [0.014]
ECM_{t-1}^3	−0.14820	0.066038 [0.040]	−0.18499	0.083646 [0.043]
R^2	0.75376		0.76497	

Table 15.5: VEC representation for lamb

	$\Delta RPQL_t$		$\Delta SPQL_t$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	1174.4	792.5694 [0.159]	1096.6	807.5415 [0.195]
ΔRPQ_t	−0.087616	0.83925 [0.918]	−0.40847	0.85511 [0.640]
ΔSPQ_t	0.075688	0.37045 [0.841]	0.095734	0.37744 [0.803]
$\Delta RBFQ_t$	1.0776	0.67093 [0.129]	0.039546	0.68360 [0.955]
$\Delta SBFQ_t$	−0.34668	0.51651 [0.512]	−0.25134	0.52627 [0.640]
$\Delta RPQL_t$	−1.0760	0.49249 [0.045]	−0.37177	0.50179 [0.470]
$\Delta SPQL_t$	1.2506	0.40416 [0.007]	0.34077	0.41180 [0.421]
$\Delta RPQC_t$	−0.44551	0.80121 [0.586]	−0.075441	0.81635 [0.928]
T	6.4871	2.9256 [0.042]	4.1750	2.9808 [0.182]
Q_t^1	39.6721	15.5366 [0.022]	45.3611	15.8301 [0.012]
Q_t^2	8.6688	17.6251 [0.630]	35.4383	17.9580 [0.067]
Q_t^3	30.0714	14.1111 [0.050]	32.1068	14.3776 [0.041]
ECM_{t-1}^1	0.17732	0.38900 [0.655]	0.26248	0.39634 [0.518]
ECM_{t-1}^2	0.97944	0.43061 [0.038]	0.69120	0.43874 [0.136]
ECM_{t-1}^3	−0.28728	0.15410 [0.082]	−0.21467	0.15701 [0.192]
R^2	0.80176		0.82498	

Table 15.6: VEC representation for chicken

	$\Delta RPQC_t$	
	$\hat{\beta}_i$	$S_{\hat{\beta}_i}$
α_0	540.8654	230.7257 [0.033]
ΔRPQ_t	0.19761	0.24432 [0.431]
ΔSPQ_t	0.034617	0.10784 [0.753]
$\Delta RBFQ_t$	0.14005	0.19531 [0.484]
$\Delta SBFQ_t$	0.14631	0.15036 [0.346]
$\Delta RPQL_t$	−0.18514	0.14337 [0.216]
$\Delta SPQL_t$	0.16240	0.11766 [0.188]
$\Delta RPQC_t$	0.025607	0.23324 [0.914]
T	−1.1579	0.85166 [0.194]
Q_t^1	9.7291	4.5229 [0.048]
Q_t^2	2.5450	5.1308 [0.627]
Q_t^3	−6.0772	4.1079 [0.160]
ECM_{t-1}^1	0.33891	0.11324 [0.009]
ECM_{t-1}^2	−0.074721	0.12535 [0.560]
ECM_{t-1}^3	0.034071	0.044861 [0.459]
R^2	0.75024	

run deviations from the long-run equilibrium take a long time to dissipate - around 10 quarters for most of the prices. The ECMs tend to counterbalance each other and the system wide speed of adjustment is faster, taking around 8 quarters to dissipate (See Figure 15.4(d)).

The impulse response functions for the producer and retail prices indicate that a shock to the respective price results in a permanent deviation from the previous long-run equilibrium. This is a feature of non-stationary series where even a temporary disturbance away from the equilibrium results in a permanent effect.

The forecast error variance decompositions indicate that in the long run (20 quarters):

1. 70% of the variability in the retail price of pork is explained by changes in the saleyard price for baconers, 5% by the retail price for beef, 35% by the saleyard price for cattle, 70% by the retail price for lamb, 20% by the saleyard price for lamb, and 8% by the retail price of chicken.

2. 40% of the variability in the saleyard price for baconers is explained by the retail price for pork, 5% by the retail price for beef, 20% by the saleyard price for cattle, 60% by the retail price for lamb, 18% by the saleyard price for lamb, and 2% by the retail price for chicken.

3. 5% of the variability in the retail price for beef is explained by the retail price for pork, saleyard price for baconers, and saleyard price for cattle. A further 10% is explained by the retail price for lamb, 75% by the saleyard price for lamb, and 9% by the retail price for chicken.

4. 25% of the variability in the saleyard price for cattle is explained by the retail price for pork, 30% by the saleyard price for baconers, 10% by the retail price for beef, 20% by the retail price for lamb, 10% by the saleyard price for lamb and 5% by the retail price for chicken.

5. 5% of the variability in the retail price for lamb is explained by the retail price for pork, the saleyard price for baconers, the saleyard price for cattle, and the retail price for chicken. A further 40% and 45% are explained by the saleyard price for lamb and the retail price for beef respectively.

6. 5% of the variability in the saleyard price for lamb is explained by the retail price for pork, the saleyard price for cattle, and the retail price for chicken. A further 10% is explained by the saleyard price for baconers, 60% by the retail price for beef, and 15% by the retail price for lamb.

7. 18% of the variability in the retail price of chickens is explained by the retail price for pork, 15% by the saleyard price for baconers, 2% by the retail price for beef, 60% by the saleyard price for beef, 25% by the retail price for lamb, and 10% by the saleyard price for lamb.

15.4 Summary

This chapter has presented a model of the factors affecting the retail meat sector. Although the results are consistent with the results in previous chapters the VEC model formulated in this chapter has not been adequate to capture the data generating process underlying the retail meat sector. Producer and consumer decisions need to be incorporated into the VEC framework in order to boost the model fit.

The results confirm the Granger Causality tests (See Table 11.1) carried out in chapter 11. Retail and producer prices are linked by bi-directional and uni-directional Granger Causality and through transitivity.

The results indicate that:

1. Every additional \$1.00/kg increase in cattle prices increase pork retail prices by $\$0.45 \pm 0.16/kg$.

2. A \$1.00/kg increase in saleyard price for lambs results in a $\$0.479 \pm 0.173/kg$ increase in the price of beef.

3. A \$1.00/kg increase in the retail price of lamb results in a decline of $\$0.602 \pm 0.211/kg$ in the price of beef.

4. A $1¢/kg$ increase in pork prices results in a $1.157 \pm 0.4556¢/kg$ increase in the cattle price.

5. A \$1.00/kg increase in beef prices results in a $\$0.95948 \pm 0.36418/kg$ increase in cattle prices.

6. A $1¢/kg$ increase in the retail price of lamb results in a $1.08 \pm 0.27¢/kg$ decrease in cattle prices.

7. A \$1.00/kg increase in the saleyard price of lamb results in a $\$0.578 \pm 0.219/kg$ increase in cattle prices.

8. A \$1.00/kg increase in the saleyard price of lamb results in a $\$1.251 \pm 0.404/kg$ increase in the retail price.

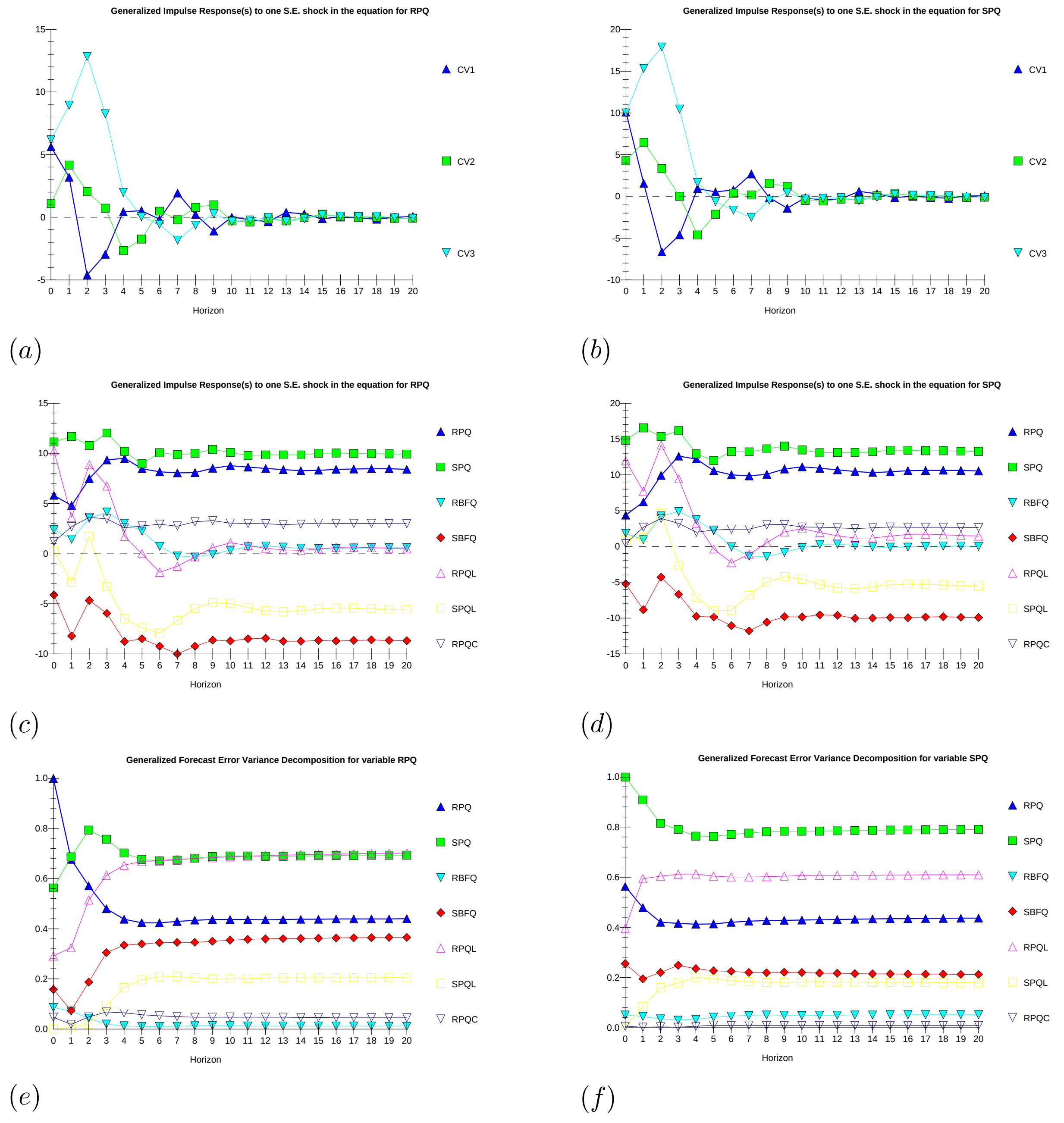


Figure 15.1: Impulse-Response and Forecast Error Variance Decompositions for Pigmeat

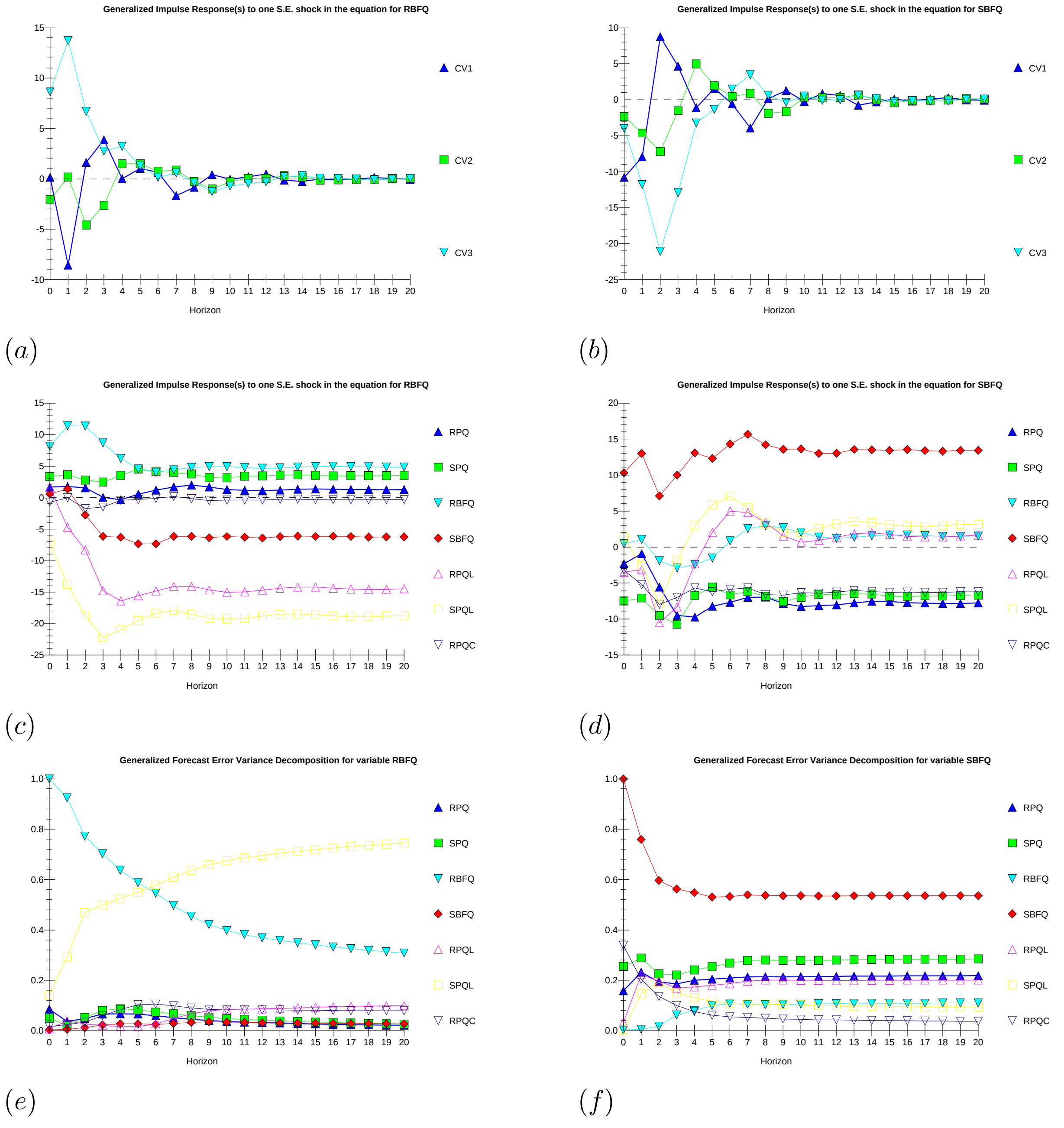


Figure 15.2: Impulse-Response and Forecast Error Variance Decompositions for Beef

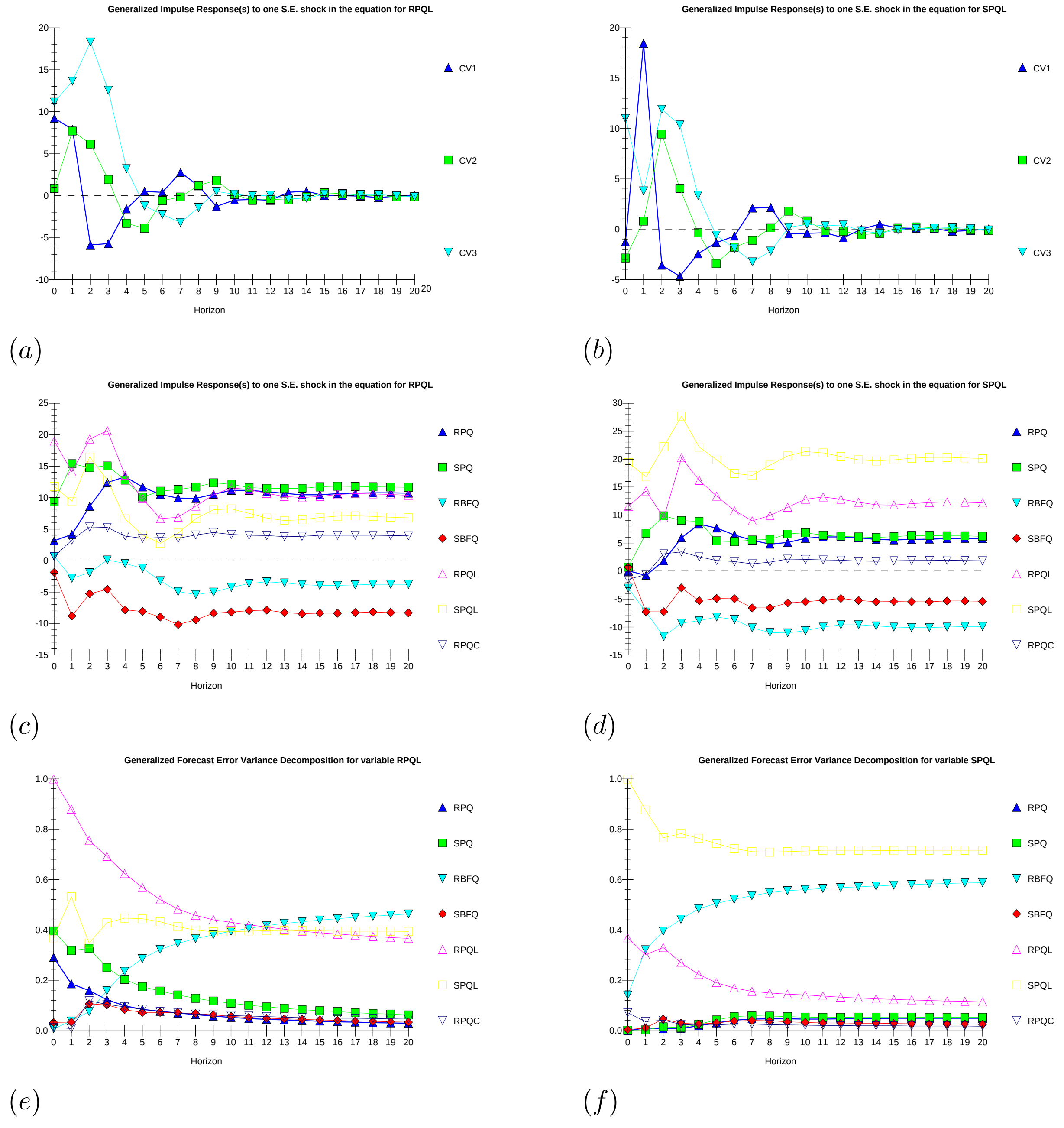


Figure 15.3: Impulse-Response and Forecast Error Variance Decompositions for Lamb

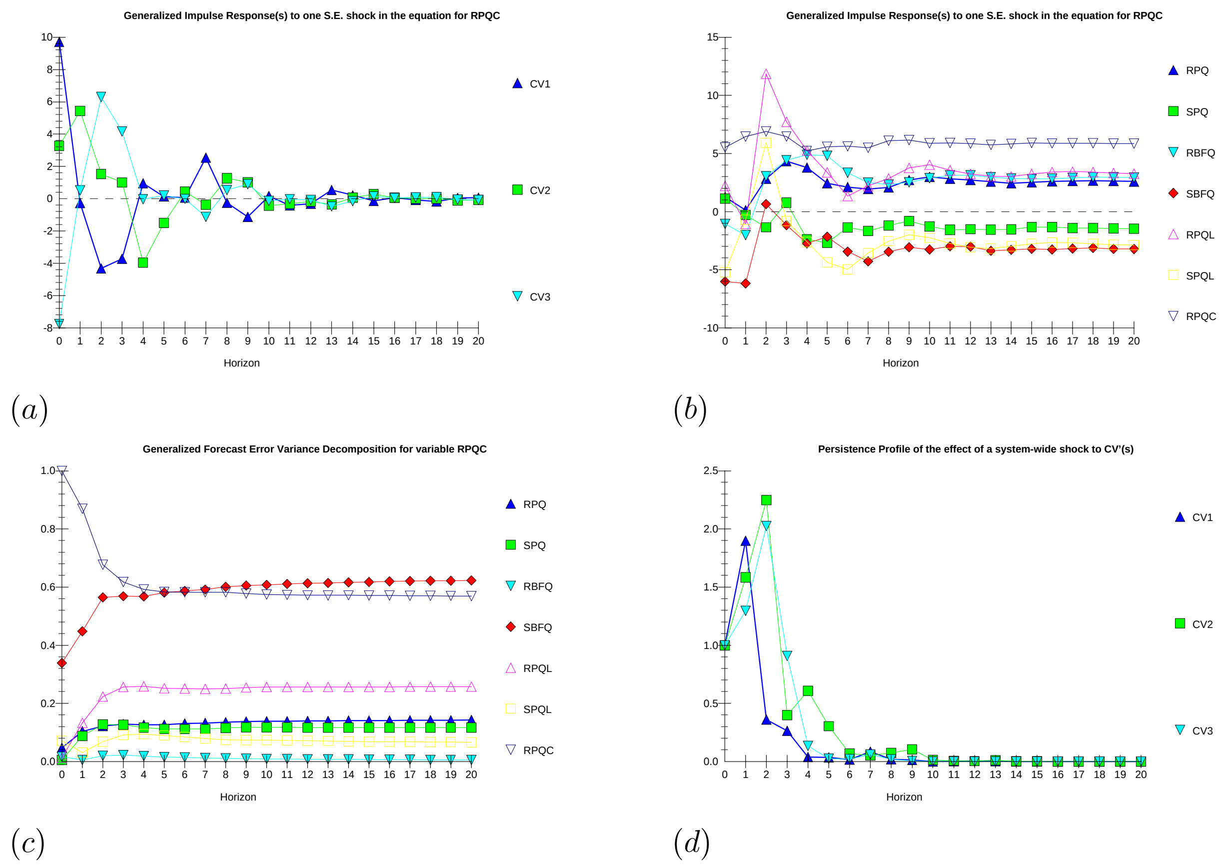


Figure 15.4: Impulse-Response and Forecast Error Variance Decompositions for Chicken and Persistence Profile for ECMs

9. A \$1.00/kg increase in the retail price of chicken results in a $\$0.446 \pm 0.801/kg$ decline in the retail price for lamb.

10. Neither the saleyard price of lamb nor the retail price of chicken nor the saleyard price for baconers appear to be influenced by other meats' retail or producer prices.

The impulse response functions indicate that a shock to the respective price results in a permanent deviation from the previous long-run equilibrium and the forecast error variance decompositions indicate strong relationships between variables.

Chapter 16

Imperfect competition and reform of the pig industry

16.1 Introduction

This chapter discusses the consequences of industry deregulation in the context of imperfect competition due to institutional structures. We show that the assumed benefits of trade reform - lower consumer prices and an expansion of the production possibility frontier - do not eventuate under institutional rigidities and the exercise of market power. We start in section 16.2 by a discussion of the redistribution of welfare under trade liberalisation in the presence of market power and then in section 16.3 we discuss how a Pareto-optimal outcome of trade reform may not necessarily eventuate if the assumption of perfect competition is violated.

We present a Pareto-efficiency argument for industry assistance in section 16.4 where we discuss the possibility that in particular situations of imperfect competition there are welfare gains to be made from market regulation. Finally, in section 16.5 we present a sectorial equity or distributional argument for industry assistance where the contraction of the industry would not be in the national interest.

16.2 Market power and international trade

International trade theory suggests that benefits of trade liberalisation come about due to the concomitant decline in both producer and consumer prices, and an increase in quantity produced and consumed. This can be seen in Figure 16.1. Before trade liberalisation the domestic market equilibrium between domestic supply, SS', and domestic demand, DD', is at f, with

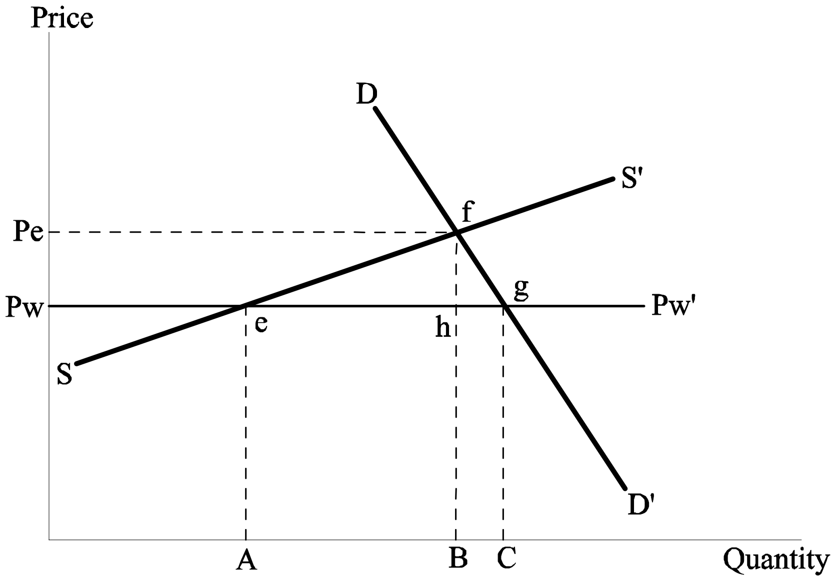


Figure 16.1: Effect of trade liberalisation on a domestic market

price P_e and quantity B produced and consumed. After trade liberalisation the domestic supply curve is kinked, now being SP_w'. The new equilibrium is at g with price P_w and quantity C being consumed, an increase from B previously. Domestic production reduces from B to A and imports make up the difference, AC. Producer rent, the area $P_w efP_e$, is now transferred to consumers and foreign producers - the area $ehBCgf$ - with a consumer deadweight gain of hgf.

Even though domestic producers have lost under trade liberalisation, domestic consumers have gained more - their deadweight gain of hgf - and foreign producers have gained as well. Resources that were previously used in domestic production are now transferred to other, more efficient industries, and global welfare has increased.

One of the problems with the standard Heckscher-Ohlin-Samuelson (HOS) model of international trade is that it assumes factor mobility across sectors and a perfectly competitive outcome under trade liberalisation. An alternative model is the Ricardo-Viner, or specific factors model which does not have the assumption of fully mobile factors. The specific factors model also predicts that there are welfare gains to trade, but suggests that if the once protected industry contracts the value of the specific factor used in that industry and the discounted cash flow of that industry will have to be compensated by the gains to trade in order for liberalisation to be justified. As with the HOS model the benefits of trade liberalisation in the specific factors model is that the mobile resources that were used in the protected industry can now be employed more efficiently elsewhere.

The factor intensity of an industry is important in the specific factors model. If the industry uses the mobile factor intensively then trade liberalisation will be of benefit since this factor can move to a higher valued use in another industry. If the industry uses the specific factor intensively then trade liberalisation may or may not be of benefit. If the specific factor cannot move to a higher valued use in another industry, then the value of that factor needs to be written off. Gains to trade will result if the industry is small relative to the rest of the economy, as the gains to trade will more than compensate for the loss of the industry. If the industry is large relative to the rest of the economy, then the gains to trade will not compensate for the loss of the industry. This is an empirical issue.

The pig industry is not only characterised by capital specificity (e.g. buildings and plant designed solely for pig production) but also has a unique situation where labour is less mobile, since labour also owns the capital. Under the assumption of perfect competition, the HOS model lends itself naturally to the conclusion that liberalisation is preferable to any type of imperfect competition. If, however, the institutional framework of the industry is such that there is a marketing chain, which is imperfectly competitive at each stage, then reform of one particular point on the marketing chain without reference to the others will result in a situation where the reform may actually increase imperfect competition of the industry as a whole rather than reduce it. In such a situation it is conceivable that any welfare gains due to trade predicted by the HOS model will in fact be welfare losses due to trade. Even if reform was carried out on the whole marketing chain it does not necessarily follow that the industry will move from a situation from imperfect competition to perfect competition (with resultant welfare gains as predicted by the HOS model). Perfect competition is an economic concept rather than a reality and industry reform will, at best, reduce the level of market power of the players but not eliminate it. In such a situation it is desirable that analysis be carried out to determine the actual welfare gains (losses) captured by the economy. If reform of an industry leads to an oligopolistic outcome due to economies of scale and scope, for instance, the question needs to be asked whether government intervention is needed to counteract the market imperfections.

In terms of the pig industry, consumers do not seem to be benefitting from trade reform while producers are seeing both prices and production (and therefore revenue) decline. The benefits of trade reform seem to be captured by the increased marketing margin. This can be seen in Figure 16.2. Under

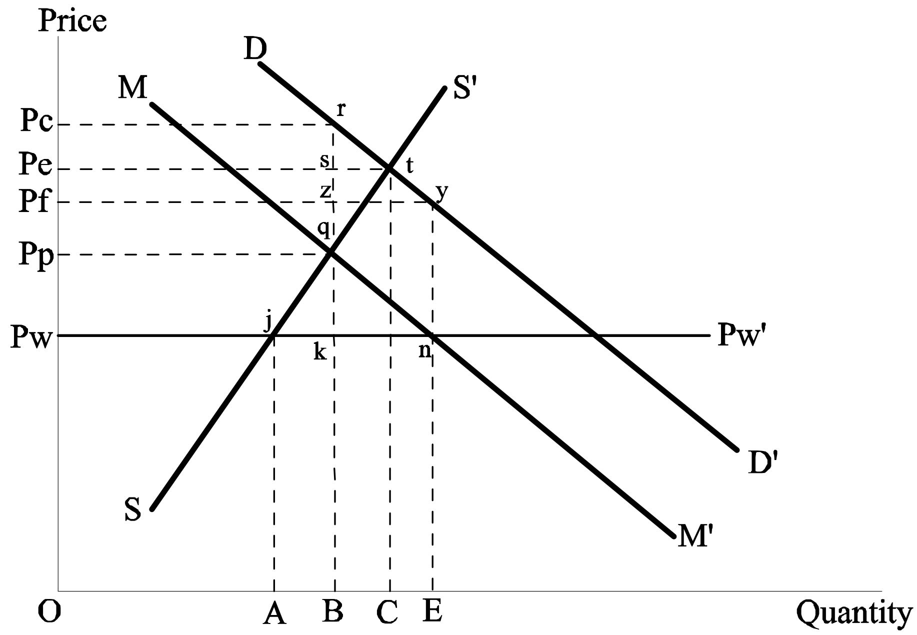


Figure 16.2: Effect of trade liberalisation under marketing margins and imperfect competition

autarchy (no international trade) the producer supply curve is SS' with the middleman demand curve being MM' and the consumer demand curve being DD'. Farm-gate equilibrium is at point q, where producers are receiving price P_p and producing quantity OB. Under a marketing margin imposed by middlemen consumers are facing a retail price of P_c. In the absence of middlemen the market equilibrium would be at point t, leading to a drop in retail price from P_c to P_e with a deadweight welfare gain of the triangle rst and an increase in consumption of BC. Producer price would also rise to P_e, with a producer rent increase of the area P_pP_etq.

This is not to say that middlemen do not perform a necessary processing and distribution function in the marketplace, nor that the width of the marketing margin is not justified. Under trade liberalisation the equilibrium for producers moves from point q to point j. Producer prices drop to the world price, P_w, with a corresponding fall in domestic production to OA. With no market power exhibited by middlemen imports expand to AE. The welfare loss of domestic producers, the area jqk, is compensated by a welfare gain by middlemen of the area knq. With total supplies in the domestic market of OE, consumer price falls from P_c to P_f with a welfare gain by consumers of the area zyr. If middlemen exert market power, then they can maintain consumer price at P_c while forcing domestic producer price down to the world price P_w. Overall supplies do not increase, but domestic producer share of the market falls to OA, with imports taking the share AB. Rather than middlemen earning in revenue the area P_pqrP_c, before trade liberalisation, they can now increase their revenue to the area P_wkrP_c, which is larger than the revenue area P_wnyP_f they would have received under trade liberalisation even if they hadn't exerted market power.

In other words, by maintaining consumer prices at their pre-trade liberalisation levels domestic demand does not increase. Coupled with price competition from imports this forces domestic producer prices down to world price levels without a concomitant increase in production leading to falls in producer revenue. Middlemen capture revenue that would have been accruing to producers under trade liberalisation and restrict the benefits to consumers arising from international trade. Economy-wide welfare is not maximised, as the consumer deadweight gain, zyr, is not realised.

This suggests that there is further scope for removing marketing margin inefficiencies and institutional barriers to trade. Further research needs to be carried out to determine whether consumer prices have been affected by trade liberalisation, the conclusion being, if they are not, that there exists some market power exerted by middlemen to keep consumer prices high. Whether this marketing margin is justified in terms of processing and distribution costs also needs to be examined.

16.3 Welfare effects of trade liberalisation

There is ample theoretical argument and empirical evidence that trade liberalisation results in a Kaldor-Hicks optimum where gains more than offset any loss caused to the liberalised industry. The main reasons for this are that, firstly, consumers benefit from lower prices and an increased range of goods and, secondly, that un- or under-utilised resources in the now liberalised industry can be reallocated to more efficient industries.

Under a partial equilibrium analysis there appears to be a net welfare loss to the industry undergoing reform. Under a general equilibrium analysis, where reallocation of resources between sectors occurs, the efficiency gains from a reduction in market distortions (barriers to trade) generally outweigh the industry-specific losses.

There are cases where this welfare gain does not happen, particularly when the assumptions underlying the analysis are violated. Two of the main assumptions underlying general and partial equilibrium analysis are that firstly, resources are transferred costlessly and fully between sectors based on relative wage rates and, secondly, trade liberalisation moves from an imperfectly competitive to a perfectly competitive outcome. The violation of these can be thought of as market imperfections.

The theory of the second best, where government intervention which distorts incentives in a particular market may increase social welfare if it offsets the consequences of market failures elsewhere, is used to argue the case for government intervention for example, in the form of tariffs or subsidies. Under trade liberalisation it is assumed that resources allocated to the once protected industry can be reallocated to other industries when production falls due to a reduction in equilibrium price. In the pig industry, labour and capital (in the form of equipment and buildings) are unlikely to be allocated to other productive uses in the short to medium term. Under this type of market failure the gains to trade can be offset by the costs to the particular industry, flow-on effects to other industries and to treasury.

Under market failure the theory of the second best indicates that government intervention may increase social benefits. This raises the question as to what is the most appropriate form of that government intervention. Krugman and Obstfeld [59, pp. 227-236] argue that when dealing with market failures it is preferable to target the failure directly, rather than use indirect policy instruments. If a market failure is isolated on the domestic production side, then the appropriate instrument to use is one that targets domestic production, for example subsidies. If a market failure is caused by international trade distortions, then government policy could be targeted toward those distortions by using, for example, duties (tariffs) or quotas.

16.4 Benefits to the domestic economy

The government maintains that economy-wide trade liberalisation will bring long-term benefits to the economy which will more than offset the declining fortunes of the pig industry. Simulations with ORANI, MONASH, and GTAP - static and dynamic economy-wide, and global economy models respectively - certainly support this viewpoint. However, it should be pointed out that these models assume a perfectly competitive microeconomic structure. It follows that in any simulations moving from a regulated to a totally deregulated economy the perfectly competitive structure will always be preferable to the regulated case. It is a well known result[1] that under situations of imperfect competition there are gains to be made through strategic trade. Under any situation where the economy is moving from one market

[1] See [59] or [15] for textbook examples.

structure to another, which may not necessarily be more competitive, welfare as a whole might not increase, at least in the short-run.

Norman and Goddard [66] provide an extensive literature review of studies examining the welfare implications of supply management. Most conventional studies assess the benefit/cost of trade restrictions compared with the alternative scenario of perfect competition. In situations where there exists imperfectly competitive institutional structures in an industry, for example middlemen with monopoly/monopsony or oligopoly/oligopsony powers, it is shown that countervailing powers actually increase both producer and consumer welfare.

In the situation where producers are assumed to be perfectly competitive but there exists market power by processors a monopoly/monopsony situation occurs (See Figure 16.3). Since processors are monopolistic they sell where marginal revenue (MR) equates with retail supply. Consumers are faced with a retail price (P_{retail}) which is above the perfectly competitive retail price. Processors demand quantity Q which transforms the farm level demand into a marginal revenue product (MRP) curve. Farm level equilibrium is where marginal revenue product equates with marginal expenditure.

This can be compared with the situation where producers can undertake supply management (See Figure 16.4). Under regulation, where the price paid by processors is exogenously set at CoP (Cost of Production), the quantity produced is Q, where the price paid by processors crosses the effective demand curve (MRP). The quantity produced is still below the competitive equilibrium but the producer price is higher and the consumer price is lower than under deregulation.

The results suggest that if deregulation and trade liberalisation do not remove market power held by middlemen then the presumed beneficiaries of reform, consumers, will lose to the benefit of middlemen.

16.5 Economic regrets from industry demise

Under any deregulation scheme, long-run benefits to the economy most often have short-run adjustment costs. Most economy-wide models do not analyse the adjustment path taken. Where welfare benefits are marginal, as in the case where the industry makes a small contribution to the whole economy, the adjustment costs to that industry may far outweigh the long-run benefits to the economy as a whole. This is especially so when social costs, economic regrets, environmental issues and the like are not taken into consideration.

Increased freedom of agricultural trade has the potential to increase the welfare of Australian consumers. However, the substantial contraction of an

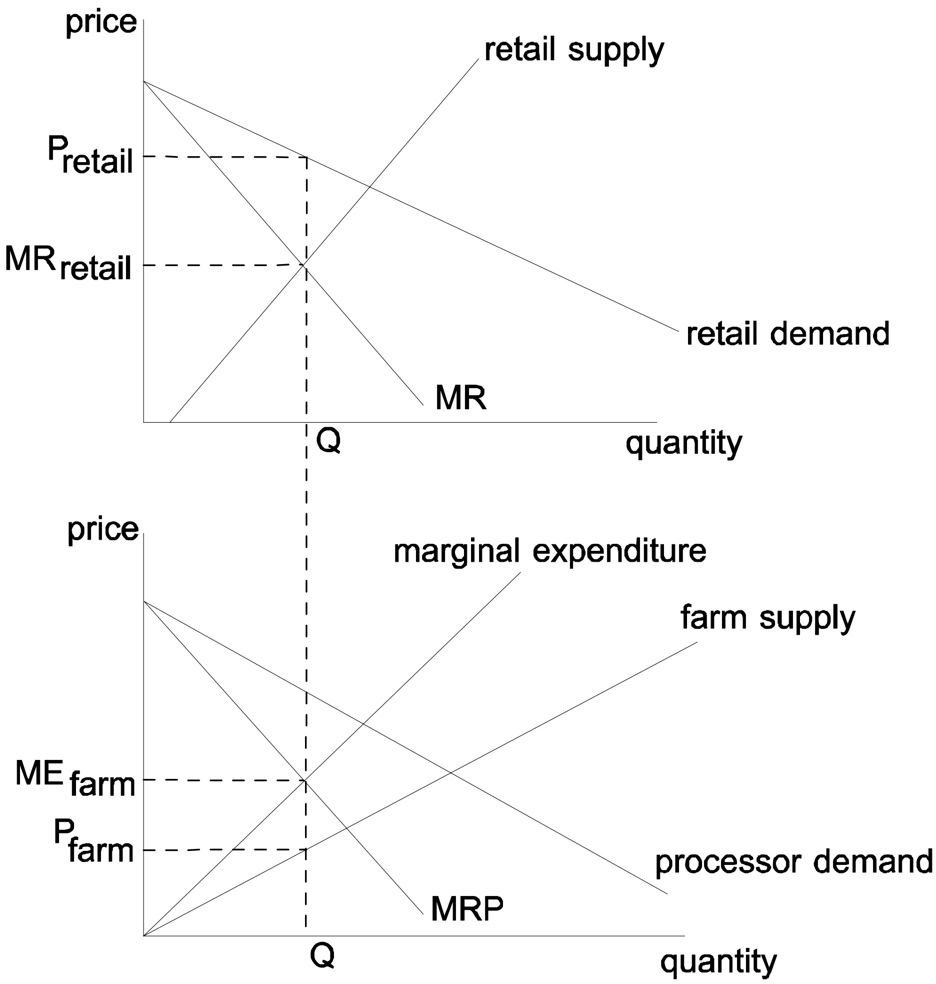


Figure 16.3: Supply/Demand graph of a Monopoly/Monopsony industry (Source: [66, p. 18])

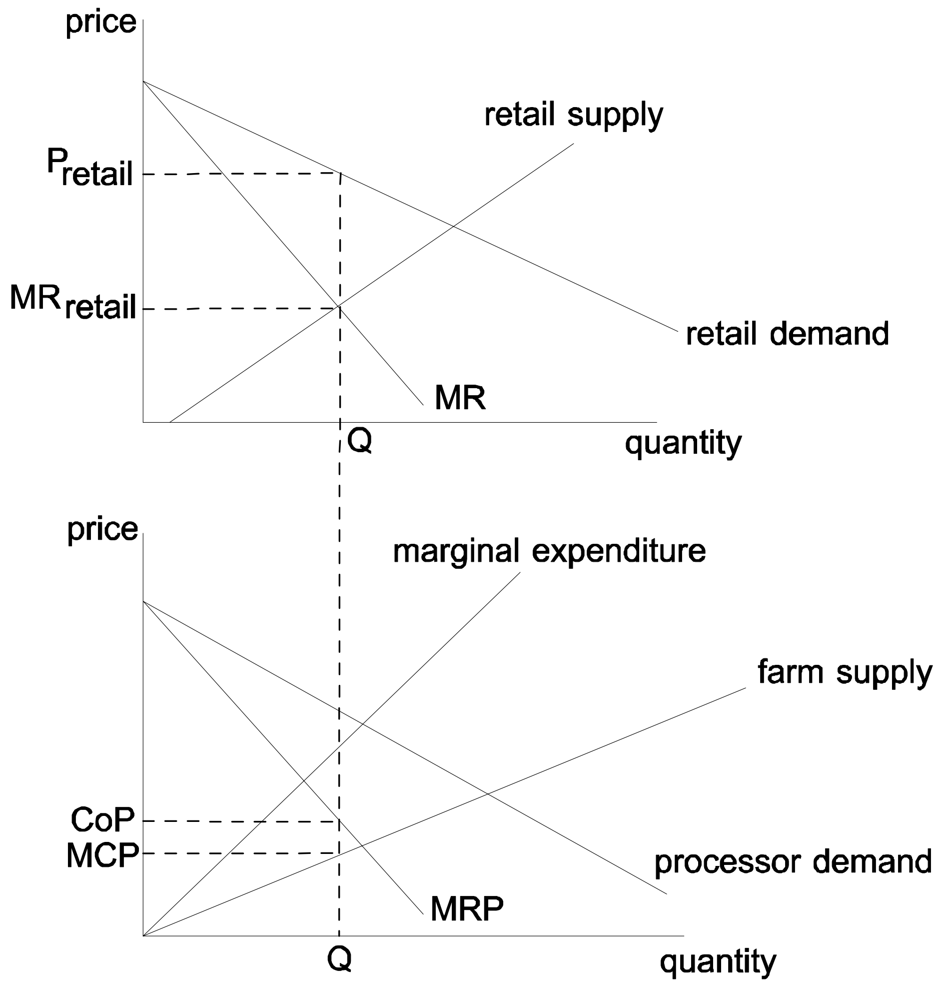


Figure 16.4: Supply/Demand graph of a Monopoly/Monopsony industry with supply management (Source: [66, p. 19]

industry may bring about a number of “economic regrets”.

Loss of jobs If the pig production and processing sectors decline, jobs may be lost in the industry, and in upstream (input supply) industries.

Loss of regional economic flow-on benefits As in the case of jobs, reduced income in the pig production and processing sectors could lead to reduced incomes in input supply-related sectors, e.g. the grains industry or transportation. Collapse of a very large piggery could have a major local economic impact. With the decline of the rural population, rural towns may be vulnerable to loss of banks, schools and other important services.

Decline in value of assets Many of the assets used in pig production, such as intensive pig housing, are not well suited to other industries, hence the value of these assets will be written down, representing a loss to producers.

The stylised facts of the pig industry suggest that productivity gains in pig production will only lead to marginal profitability gains. Ferguson [38] suggests that productivity gains in downstream (processing) industries are more likely to lead to greater increases in profitability than the equivalent productivity gains in agricultural production itself. In such a scenario, the general equilibrium gains from the redistribution of resources will only occur if resources are redistributed to industries which do not face such institutional constraints.

16.6 Summary

In this chapter we discussed the possibility that gains from trade may not eventuate if institutional distortions are not eliminated prior to or concurrent with industry reform.

In the presence of market power exercised by middlemen which is not removed under trade liberalisation there exists a second best argument for protection. The need for efficiency gains in the pigmeat industry is unquestioned, as for any rural industry. However, the process of adjustment for an industry recently subjected to strong international competition needs care. It is probable that competition from pigmeat imports will continue, and the industry will need to adapt to the changed circumstances. The Common Agricultural Program (CAP) of the European Community is likely to continue to subsidise farm production and an aggressive export push by highly efficient North American pig producers appears inevitable. The resumption of Taiwanese exports into the Japanese market after the eradication of foot-and-mouth-disease will also add to international supplies.

Austin [13] quotes Kleckner (president of the American Farm Bureau Federation) as saying that adjustment is inevitable, but that industries should be given at least five years warning of major structural adjustment. This time allows producers to place their business of a competitive footing or switch to other enterprises.

When prices below cost of production are received, pig producers can be expected to continue in operation in the short run if average variable cost is being met. To not produce would cause a greater loss, given overhead costs must always be met. But in the longer term and as assets can be disposed of, exit of producers from the industry would be expected.

Unlike mixed cropping or extensive grazing where it is easier to switch between enterprises, in modern pig farming with purpose built buildings and facilities, it is not feasible to switch to other enterprises. The assets which become redundant are not easily disposed of. Hence industry contraction can be slow and expensive.

When pig producers are unable to sell their stock, because meatworks will not accept them, they are faced with a difficult dilemma. Stock may be fed on, at the expense of feed and other inputs, or destroyed. In any case there is typically a drastic effect on farm income.

Chapter 17

Safeguard measures to remedy serious injury

17.1 Introduction

This chapter discusses quotas, tariffs and subsidies as possible assistance measures for government support to the pig industry. It is argued that under particular circumstances subsidies are preferred to tariffs as a measure for short-term assistance.

The Productivity Commission in its issues paper [76, pp. 9-10] invited suggestions as to what particular measures would be appropriate to remedy serious injury. In essence, there are three options, a quota, a tariff or a subsidy - including lump sum compensation. A quota is the least preferred option since compared with tariffs, which only create an opportunity to exercise monopoly power once it has excluded all imports, a quota creates an opportunity to exercise monopoly power even if the quota is not prohibitive. We start the discussion by arguing in section 17.2 that subsidies are preferred to tariffs because they are less distorting. In section 17.3 we argue that in the presence of imperfect competition a quota may be a third best optima because it removes the threat of unlimited imports and consequently the ability for middlemen to play a Bertrand bargaining game against producers[1]. Finally in section 17.4 we argue that the best outcome for the industry would be a lump-sum compensation but that this would be unlikely to be acceptable to the government due to its political cost.

[1] See chapter 7.

17.2 The case for subsidies in preference to tariffs

Even if Australia were able to impose tariffs on the importation of pigmeat, under certain circumstances it has been shown that subsidies are preferred to tariffs from a Pareto-optimum point of view. Under the assumption of a small country (i.e. a perfectly elastic demand curve) the optimal tariff is shown to be close to zero. Corden [23, pp. 7-10] outlines the partial equilibrium theory of an optimal subsidy in the presence of a social[2] benefit associated with the existence of a domestic industry (for example, the economic regrets case). The argument is along the following lines:

A diagram of domestic supply (GG′) and domestic demand (DD′) for an importable product is outlined (see Figure 17.1). With the foreign supply curve at PP′, domestic production would be at OA, domestic consumption at OB, and the excess demand, catered for by imports, would be AB. If GG′ is viewed as the marginal private cost of production, then there exists a marginal social cost, HH′, which is less than the marginal private cost of production[3]. That is, there are some benefits attached to domestic production which are not taken into consideration in the determination of the domestic producers' supply curve. Some of these benefits are incorporated into a general equilibrium framework where linkages between industries are modelled. For example, there are linkages between the pig industry and the rural community in which it is located. Other benefits, such as the economic regrets case outlined in Section 16.5, are not typically modelled in either a partial or general equilibrium setting but still need to be considered.

With the added assumptions that DD′ represents the full (private plus social) marginal value of consumption and that PP′ represents the full (private and social) marginal cost of imports[4], then OB is the socially desirable level of consumption (this occurs without intervention) and OC is the socially desirable level of domestic production.

Without intervention the market is in equilibrium when domestic production is at OA, but OC is the desirable level of domestic production from society's point of view. Thus intervention is required to obtain the socially desirable level of domestic production. The intervention would take place in

[2]In economic terms the social benefit (or cost) is the economic benefit (or cost) borne by the whole community

[3]This difference arises because of the flow-on effects of production, for example to the feed-grains and transport sectors.

[4]These assumptions are needed so that there is no divergence between private and social benefits for the world supply and for domestic consumption, as there is in the case of domestic production.

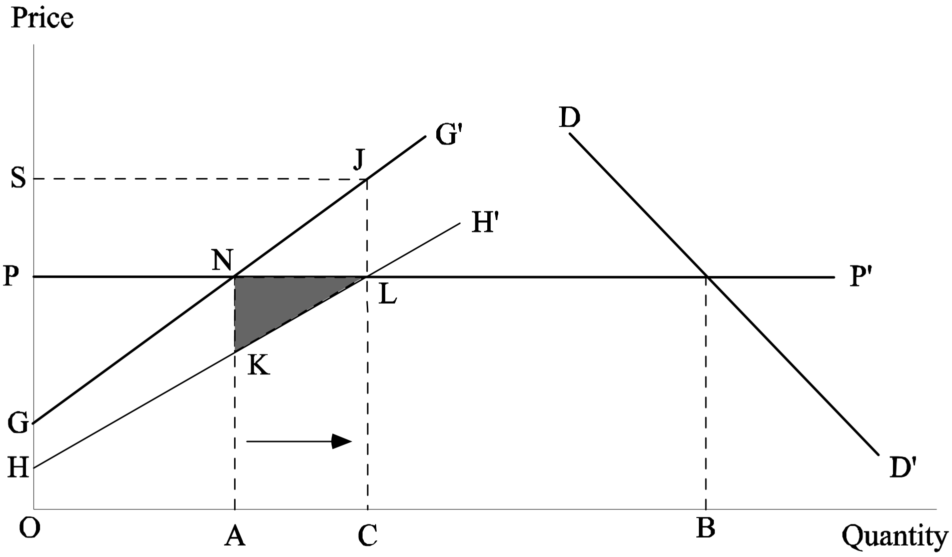


Figure 17.1: Effect of a production subsidy on an importable product (Source: [23, Fig 2.1 p. 7])

the form of an output subsidy, raising the price paid to producers to OS, at a cost to the treasury of PSJL, but with consumer price remaining at OP. With the further assumptions that the income distribution effects are cancelled out and the (re)distribution of income is costless in its implementation, there is a net social benefit from the introduction of a production subsidy. The social cost of the subsidy is AKLC which is less than the cost of the imports replaced (ANLC) by the shaded area KNL, which is the social gain of the subsidy. While taxpayers lose PSJL, this is the same as the gain to producers, and in addition, there is a gain of KNJL, the difference between the (lower) social cost and the (higher) private cost.

The social benefits of a subsidy can be compared with the distortionary effects of a tariff, as shown in Figure 17.2. Imposing a tariff of PS would raise the producer price to OS, decrease imports to CB′, and increase domestic production by AC. This would produce the same social gain as in the subsidy case, but also introduce a consumption effect, creating a social welfare loss. Under a tariff, consumer price would increase to OS, decreasing consumption to OB′ and resulting in a deadweight loss of the shaded area FEQ. The relative sizes of KNL, the gain to society, and FEQ, the loss to consumers, are an empirical matter.

While it appears that subsidies are more efficient than tariffs under certain circumstances, we have not yet said anything about what type of subsidy

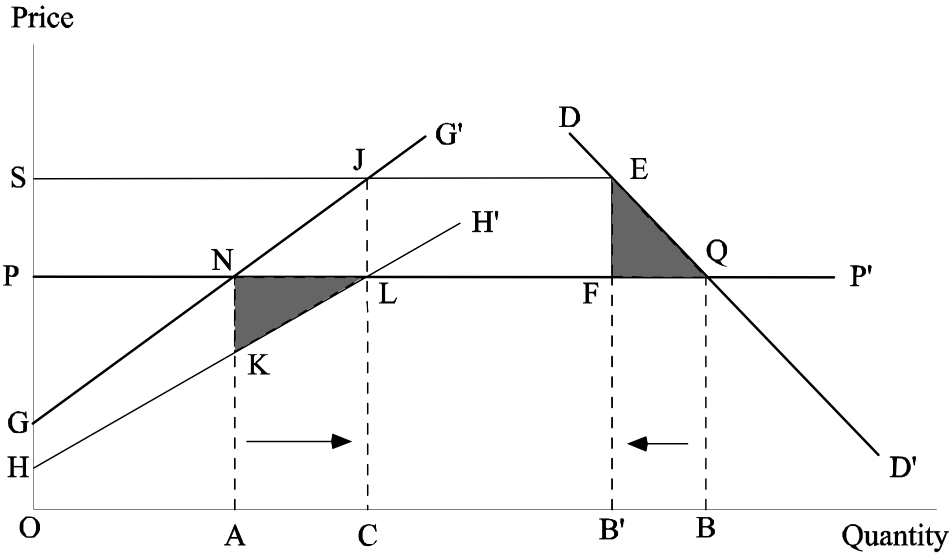


Figure 17.2: Effect of a tariff on an importable product (Source [23, Fig 2.2 p. 9])

would be preferred. While it is not our intention to analyse the distortionary effects of different subsides, it is perhaps useful to outline some particular forms of subsidies which may be granted to agricultural industries.

Annex 2 of the 1994 GATT Agreement on Agriculture outlines domestic support instruments which are approved under the GATT for exemption from reduction commitments:

> The fundamental requirement is that they have no, or at most minimal, trade distortion effects or effects on production. [39, Agreement on Agriculture Annex 2(1)]

Such support instruments include general services such as:

1. Research and development

2. Pest and disease control

3. Training, extension and advisory services

4. Inspection services

5. Marketing and promotion services

6. Infrastructural services

It is noted that the government has already committed itself to provide $10 million in research, development, and marketing funds over three years to assist the industry to increase its international competitiveness and move to an increased export focus [64, p. 1].

Other support instruments include

1. Direct payments to producers - so long as they meet the fundamental requirement set out above
2. Decoupled income support - not related to production levels
3. Income insurance or safety-net programmes
4. Structural adjustment programmes and
5. Rural assistance programmes

17.3 The case for quotas

Quotas create an artificial scarcity of the particular commodity to which it is applied and thereby raises its selling price. Of course this is under the assumption of a perfectly competitive domestic market where the increase in price is passed directly onto the consumer and results in an increase in producer price. An increase in consumer price reduces consumer welfare whereas an increase in producer price distorts production decisions and draws resources into the (inefficient) protected industry and away from (efficient) unprotected industries.

Relative to the free-trade position under perfect competition quotas are distortionary as they allow monopolistic rents to be captured. In the presence of middlemen driving a wedge between producer and retail prices quotas will distort the middlemens' demand curve giving monopolistic rents to the domestic producers[5]. In the presence of middlemen with market power it is an empirical question as to whether middlemen will pass on price rises to consumers - but maintain producer prices at a low level, or absorb the price rise in a reduced marketing margin. In the presence of middlemen quotas may actually be welfare enhancing if the marketing margin for middlemen is reduced. The rise in retail price due to the contraction of industry supply

[5] Relative to the middlemen and foreign producers. We are treating producers as being single entities and ignoring the issues of competition and efficiency within producer entities.

will be offset by the increase in production due to the increase in producer prices.

If the objective of government policy is to increase welfare and reduce market distortions due to the institutional structure of an imperfectly competitive industry, then there is an argument for quotas to be imposed. In such a situation the quota removes the threat of unlimited imports and imposes a capacity constraint for the foreign producer under a Bertrand bargaining game between produces and middlemen. The middlemen are only able to import up to the quantity of the quota and then must source the rest of their product from the domestic market.

Even if the quota is set at a higher level than current imports - thereby removing (or at least reducing) the objections of the exporting country - the imposition of the quota itself is enough to limit the market power of market intermediaries. Imports can only rise to the level of the quota and domestic production only has to fall by the amount of the quota to maintain supply to the domestic market for domestic prices to be maintained.

17.4 The case for compensation

Even if quotas reduce the ability of middlemen to exert market power the problem with quotas is that they allow monopoly powers to be exercised compared with the free trade alternative and removes the contestability of a market by restricting entry.

Under the Agreement on Safeguards of GATT 1994 [39] Safeguard measures like quotas or tariffs may only be applied for a period of four years in the first instance. Safeguard measures will give the industry time to restructure and seek out new export markets for higher valued pork bellies. However, unless appropriate action is taken by the protected industry during the period of application to restructure itself in preparation for trade liberalisation, the removal of the Safeguard measure will most likely return the industry to the same predicament that it was facing initially. It is doubtful whether in the absence of non-distorting market signals that industry players will conduct adequate adjustment.

In order for proper adjustment to take place it is important that correct market signals are sent to industry players. As such there is an argument for the use of subsides, and in particular lump-sum compensation, as the most appropriate measure of support which does not lead to a distortion of market signals.

In addition to GATT-legal subsidies, Lump-sum compensation is the most appropriate form of assistance to the industry. Compensation will give valuable time to efficient producers who are experiencing short-term liquidity problems and enable them to continue in the industry as well as providing producers wishing to exit the industry the ability to reduce or eliminate their debts.

There is a problem with subsidies and compensation payouts, in that they are politically costly. Subsidies are highly visible compared with quotas and tariffs which impose a much greater cost on the economy but are hidden from public scrutiny. In the situation where there is a political cost in applying external measures of protection the domestic political costs may be less, thereby justifying domestic measures of support in preference to external measures. It is a political economy question as to how great the political cost (or benefit) is in being seen to provide assistance to an industry undergoing structural adjustment.

17.5 Summary

This chapter has examined at the economic implications of assisting a domestic industry to cope with exposure to international market forces. Specifically, if the decision to offer assistance has been made, what is the most appropriate form of that support. Two instruments commonly used are tariffs and subsidies. It would appear that tariffs may well be a second-best policy compared with subsidies. Under particular assumptions, including that the market equilibrium does not take into account externalities, a subsidy will lead to a net social welfare gain, compared with the free-trade situation and compared with the tariff situation. The question of whether or not these assumptions hold for the Australian pig industry is an empirical question and one which needs to be asked on a continuing basis.

Even though quotas are more distortionary than tariffs, there is a case for preferring them. Under situations of domestic market distortions which have not been removed under trade liberalisation quotas may help reduce welfare losses.

The least distortionary measure of support, and one that will allow correct market signals to be sent to industry agents, is lump-sum compensation. Even though this carries a large political cost, it may be that the political benefit in providing assistance to an industry undergoing adjustment outweighs the cost.

Chapter 18

Conclusions

In response to industry concerns about the fall in pig producer prices from November 1997 (after a change in the import protocols) to levels below the cost of production, the Government initiated a Productivity Commission Inquiry into the effect of imports on the Australian pig industry.

This report has examined the effect of imports on the Australian pigmeat industry to determine whether safeguard actions under the Agreement on Safeguards, GATT 1994, are justified. A previous investigation by the Industry Commission in 1995 into the effect of imports on the Australian pig industry concluded that imports have had a minimal impact, if any at all, on the saleyard price of pigmeat products and the production of pigmeat [53]. Using advanced econometric techniques we have been able to explore data generating processes and identify relationships between equilibrium prices and production quantities that have been hidden when standard economic analysis has been applied.

There is ample econometric evidence to indicate that unless the correct data generating process is identified, and statistical analysis appropriately modified, then biased results, with consequently flawed conclusions, may result. The 1995 Industry Commission investigation relied on econometric analysis contained in submissions from ABARE and the NSW Government to reach their conclusions. These previous studies [1, 3, 45] have failed to take into consideration the effects of seasonal fluctuations in demand and supply, thereby either suggesting that a relationship exists when it may not, or suggesting a relationship does not exist when the evidence points towards a strong relationship.

Previous studies [1, 3] have also either failed to take into consideration the implications of the lack of a stationary long-term trend - and thereby assuming that the time series will return to its historical trend when it may not - or have wrongly identified the type of process underpinning the fluctuating trend.

Although the econometric techniques themselves were okay, they were not appropriate for the particular analyses undertaken in the ABARE and NSW Government studies. The conclusions reached must, therefore, be suspect. It is not sufficient to assert that standard microeconomic or international trade theory applies to the industry under consideration when it has already been shown that the underlying assumptions - perfectly competitive equilibria and stationary long-term trends as two examples - do not apply.

The Australian pig industry has consistently maintained that the decision to allow imports from Canada at the beginning of 1990 has fundamentally changed the equilibrium relationship between supply and demand in the domestic market. This is an assertion which needs to be tested to see whether the evidence stands up to statistical scrutiny.

The analysis conducted in this report has found that prior to 1990 pig producer prices were relatively stable and producers could be confident of being able to predict market movements. After 1990 there was a structural break which induced volatility in producer prices not only making producer decisions more difficult, but removing any long-run equilibrium relationship.

The removal of the long-run equilibrium relationship suggests that volatility in prices may persist with corresponding adverse effects on producers. If producer prices continue to be below the cost of production, or fluctuate wildly, producer decisions will not reflect future market conditions.

The existence of a structural break in the time series of saleyard prices for baconers at the first quarter of 1990 suggests that there has been some external event which has caused this shift in the market equilibrium.

This report has found that in addition to the structural break, the long-term trends of the various series fluctuate over time. This means that it is unlikely that the series in question, for example saleyard prices, will return to historical trends. Not only is there an effect on prices, but the advent of imports has fundamentally changed the dynamics of the supply response. The ABARE submission to the Industry Commission Report on Pigs and Pigmeat [1, p. 36] suggested that partial equilibrium analysis indicates that the introduction of imports would cause a once-off reduction in domestic pigmeat prices. The analysis in this report suggests that the introduction of imports continues to have a lasting effect on domestic pigmeat producer prices as it has introduced non-stationarity into a previously stationary supply response process. Impulse-Response functions, which show the time path of the market equilibrium in response to a shock to that equilibrium, indicate that in the presence of a shock the market moves to a new equilibrium and does not return to the old one.

Not only are the long-term trends of the prices and production series fluctuating over time, there are also seasonal effects compounding the fluctuation. If these seasonal effects are not taken into consideration, normal statistical techniques used to identify the fluctuation in the trend, and adjust economic interpretations accordingly, are flawed and conclusions reached are cast into doubt.

Having taken these factors into consideration, this report indicates that conclusions reached in previous studies appear to be misleading. The ABARE studies on the pig industry have contended that domestic prices are strongly influenced by domestic production, but this report has found that imports also play an important role. Unlike previous studies, this report has found a significant relationship between import volumes and import prices and domestic production and domestic prices at all levels of the marketing chain.

The significant relationship between imports and producer prices has been in the form of imports both inducing increased volatility in prices and inducing a fall in the producer price for baconers. Econometric modelling of the factors affecting producer prices indicates that for every additional 1000 tonnes of pigmeat imported, domestic producer prices fall by 20.14 ± 10.32¢$/kg$. This compares with the effect of domestic pigmeat production, where every 1000 tonnes of extra production dropped producer prices by 2.617 ± 1.225¢$/kg$. The ranges of these estimates are relatively large. Taking into account interactions between producer, wholesale and retail prices in alternative modelling techniques increases the precision of these estimates. Our results indicate that the estimate of the impact of imports on producer prices can be narrowed to 10.78 ± 4.697¢$/kg$ for every 1000 tonnes imported. The effect of imports on producer prices is quite large, relative to the effect of domestic production on producer prices. One possible explanation of this is that domestic market intermediaries are able to bargain down domestic prices to the level of import prices.

There is a question about whether the introduction of new import protocols after November 1997 have had an effect on producer prices, given that no actual imports have come in under the new protocols. That is, is the threat of imports rather than the actual realisation of imports the cause of the decline in producer price after November 1997? Our results indicate that producer prices have been significantly affected by exogenous events occuring after November 1997 and that the introduction of new import protocols may have something to do with this. Retail prices have also been affected by the new import protocols, but not as much as producer prices, only declining by 5.51 ± 3.37¢$/kg$. Production has also been affected by the introduction of new import protocols, declining by 1762.3 ± 643.7165 tonnes.

In determining whether imports have had a significant effect on producer prices we also looked at the possibility that changes in retail prices are driving changes in producer prices, rather than imports.

Economic theory predicts that in a perfectly competitive market there will be full price transmission between producer and retail prices. Our results suggest that the pig industry is not perfectly competitive when viewed vertically, although there is strong evidence in the speed of responses of producers to external shocks that producers are approaching perfect competition. The results suggest that increases in producer prices will be passed on in higher retail prices, but higher retail prices will not be passed on as higher producer prices, indicative of an asymmetric price transmission mechanism seen in pig industries in many other countries.

The results indicate that retail prices have not been subjected to an exogenous shock after the first quarter of 1990 and that the introduction of imports did not have a negative effect on retail prices. This implies that the assumed benefits of trade liberalisation, resulting from a reduction in consumer price and a concomitant expansion of the production possibility frontier, have not occurred. The question is therefore whether market intermediaries such as processors, wholesalers or retailers have benefited through increased marketing margins at the expense of producers and consumers. The speed of adjustment of retail prices to changes in producer prices is very slow, indicating that market power, in terms of intertemporal price averaging, exists. When close substitutes - such as beef, chicken and lamb - are taken into consideration, it seems that retail prices of pork are sensitive to changes in those retail prices, specifically changes in retail beef prices. The speed of adjustment of the retail price of pork is particularly fast when retail prices of beef are taken into consideration. This implies that pork is competitive with beef at the retail level, indicating horizontal but not vertical competition exists between these commodities.

Modelling results reveal that the Sydney market wholesale price for pork leg square cut (bone-in) has not been significantly affected by the introduction of imports after 1990 and the change in import protocols after November 1997. The pork leg square cut (bone-in) product is not directly comparable with imports, which are bone-out and wholesale prices of bone-out products are more likely determinates of changes at the same level of the marketing chain.

Using data obtained from Darling Downs Bacon (DDB), we are able to show that prices for DDB product lines are significantly affected by changes in prices of other products at the same processing stage. DDB product lines have been significantly affected by imports, with as-like products, such as Champagne Ham (bone-out) and Processed Shoulder Ham, registering declines in prices of $\$0.7039 \pm 0.3831/kg$ and $\$0.2692 \pm 0.1049/kg$ for every 1000 tonnes of imports respectively.

In addition, market conditions after the November 1997 import protocol changes have resulted in Champagne Ham prices dropping by $\$1.2722 \pm 0.32501/kg$.

One of the contentions by the Government [6],[7] and ABARE [3] is that increases in production and changes in consumption patterns leading to an oversupply of pigmeat is the primary cause of the fall in producer prices.

We show that the increase in production, as claimed by ABARE [3], only refers to the period between 1995 and 1998, a time when production was in fact below historical patterns. Modelling work indicates that there has been a change in the underlying supply response of the domestic pig industry and that production is in fact significantly below that which is predicted under historical patterns. Every cent increase in the producer price drops domestic production by around 60 to 100 tonnes while every cent increase in saleyard beef prices increases domestic production by between 60 and 90 tonnes. Imports of pigmeat have a significant effect on production with every kg of imported product dropping domestic production by around 7 kgs. Combined with results indicating that import volumes and prices have driven producer prices down, the implication is that imports are crowding out domestic production, import prices are driving producer prices down, and the concomitant depression in producer price has driven production down even further. In terms of whether a persistent oversupply in production has been the cause of low producer prices, modelling work indicates that producers respond quickly to market signals and any oversupply in domestic pigmeat is cleared, to all intents and purposes, within three months. Declines in pigmeat consumption have not resulted in an oversupply of pigmeat in the domestic market because production has followed changes in consumption.

The introduction of new import protocols after November 1997 significantly decreases monthly pigmeat production by 1762.3 ± 643.72 tonnes. Industry sources indicate that quota limits on contract sales to abattoirs have been strictly enforced during 1998 in an effort to restrict supply and this could be a possible explanation for declines in slaughterings.

ABARE has conducted simulations using large scale simultaneous equation econometric models to predict changes in supply and demand relationships over time. Using EMABA, ABARE [1, 3] found that observed changes in prices and production are due to normal seasonal effects. There appears to be a divergence between what the time series work reveals and the underlying assumptions of EMABA.

EMABA assumes that variables are stationary - that there is a long-term trend to which supply and demand indicators will return after a shock to the system is imposed. The simulations conducted only apply a temporary (or pulse) shock to the model. It is not surprising, therefore, that the EMABA simulations suggest that after a temporary shock the system returns to its long-run trend. However, the literature[1] suggests that a pulse effect imposed on a non-stationary series will have a shift effect instead. In any case, unlike the EMABA simulations, our contention is that the introduction of imports have had a shift effect, rather than a pulse effect.

The econometric time series work in the ABARE report [1] indicates that the underlying assumption of EMABA, that the series are stationary, is violated and so there is no long-run equilibrium to return to.

This report corrects for this violation, and uses a simulation model which does not presuppose stationary time series. We utilise vector autoregression (VAR) and vector error correction (VEC) techniques to develop an alternative to EMABA, to examine the dynamic inter-relationships of prices and production in the Australian pig industry.

Causality tests support the contention that import volumes and prices have an effect on domestic production and on the dynamics of the industry market equilibrium. The tests also support the generally accepted view that saleyard cattle prices and pigmeat production have an effect on saleyard prices for baconers and on retail prices for pork.

One of the problems with the standard model of international trade is that it assumes factor mobility across sectors and a perfectly competitive outcome under trade liberalisation, lending itself naturally to the conclusion that liberalisation is preferable to any type of imperfect competition. If factors are specific to an industry, especially in the short-run, then gains to trade may not be realised. In addition, if the institutional framework of the industry is such that there is a marketing chain, which is imperfectly competitive at each stage, then reform of one particular link on the marketing chain without reference to the others will result in a situation where the reform may actually reduce competition in the industry as a whole. In such a situation, it is desirable that analysis be carried out to estimate the real welfare gains (losses) captured by the economy. If reform of an industry leads to an oligopolistic outcome due to economies of scale and scope, for instance, the question needs to be asked whether government intervention is needed to counteract market imperfections.

With reference to the pig industry, consumers do not seem to be benefitting from trade reform while producers are seeing both prices and production (and therefore revenue) decline with the benefits of trade reform seeming to be captured by the increased marketing margin. In situations where there exists imperfectly competitive institutional structures in an industry, for example middlemen with monopoly/monopsony or oligopoly/oligopsony powers,

[1] Perron [69, 70] and Perron and Vogelsang [71]

it can be shown that countervailing powers actually increase both producer and consumer welfare.

Faced with the options of imposing a quota, tariff, or a subsidy (including a lump-sum compensation) economic theory shows that a subsidy is less distorting than a tariff, which is less distorting than a quota. We argue that if the political economy is such that lump-sum compensation is not feasible then under certain conditions a quota is preferable to a tariff, because the institutional structure of the domestic industry is such that a capacity constraint on imports will be the most effective method of raising producer prices. One of the conditions is that increases in producer prices will not be fully passed on as increases in retail prices, because consumer welfare loss is one of the prime arguments for not imposing a quota.

If tariffs are imposed in preference to quotas then the imposition of a \$/kg tariff will result in the same level of protection as a quota. If tariff revenue is directed towards domestic producer compensation then declines in domestic market share will be funded by exporters.

Bibliography

[1] ABARE. 1995. *The impact of imports on the Australian pig industry: An ABARE submission to the Industry Commission Research Inquiry on the Australian pig and pigmeat industries.* Canberra: Australian Bureau of Agricultural and Resource Economics.

[2] ABARE. various issues. *Commodity Statistical Bulletin.* Canberra: Australian Bureau of Agricultural and Resource Economics.

[3] ABARE. 1998. *Interim report on the current situation in the pig industry: Briefing note to Rural Adjustment Scheme Advisory Council. (May 1998)* Canberra: Australian Bureau of Agricultural and Resource Economics.

[4] Australian Bureau of Statistics. various issues. *ABS 7215.0 Agricultural Statistics.* Canberra: ABS.

[5] Akaike, H. 1970. Statistical predictor identification. *Annals of the Institute of Statistical Mathematics* 22:203-17.

[6] Anderson, J. 1998. *O'Keefe reveals hypocrisy on pig industry: Media Release, Federal Minister for Primary Industries and Energy, Mr. John Anderson.* Canberra: Department of Primary Industries and Energy (11 June 1998).

[7] Anderson, J. and T. Fisher. 1998. *Government announces pig industry assistance: Joint Statement, Federal Minister for Primary Industries and Energy, Mr. John Anderson and Deputy Prime Minister and Minister for Trade, Tim Fisher.* Canberra: Department of Primary Industries and Energy (10 June 1998).

[8] Australian Pork Corporation. various issues. *PigStats, Australian Pig Industry Handbook.* Sydney: Australian Pork Corporation

[9] Australian Pig Industry Policy Council. 1991. *Annual Report 1990-1991.* Australian Government Printing Service: Canberra.

[10] Australian Pig Industry Policy Council. 1992. *Annual Report 1991-1992.* Australian Government Printing Service: Canberra.

[11] Australian Pig Industry Policy Council. 1993. *Annual Report 1992-1993.* Australian Government Printing Service: Canberra.

[12] Australian Pig Industry Policy Council. 1993. *Final Report 1993-1994.* Australian Government Printing Service: Canberra.

[13] Austin, P. 1998. Trade reform is irreversible. *Queensland Country Life.* (9 April 1998) :15.

[14] Banerjee, A., J. Dolado, J.W. Galbraith and D.F. Hendry. 1993. *Co-integration, error-correction, and the econometric analysis of non-stationary data.* New York: Oxford University Press.

[15] Basu, K. 1993. *Lectures in industrial organisation theory.* Oxford: Blackwell.

[16] Blank, S.C. and B.H. Schmiesing. 1990. Whimsical aggregation of temporal data, market identification, and fragile results. *Agribusiness* 6:33-40.

[17] Brillinger, D. 1975. *Time series.* New York: Holt, Rinehart, Winston.

[18] Bureau of Agricultural Economics. 1972. *Pig raising in Australia.* Canberra: Bureau of Agricultural Economics.

[19] Charemza, W. W., and D. F. Deadman. 1992. *New directions in econometric practice: general to specific modelling, cointegration and vector autoregression.* 1st ed. Cheltenham, UK: Edward Elgar.

[20] Charemza, W. W., and D. F. Deadman. 1997. *New directions in econometric practice: general to specific modelling, cointegration and vector autoregression.* 2nd ed. Cheltenham, UK: Edward Elgar.

[21] Chow, G.C. 1960. Tests of equality between sets of coefficients in two linear regressions. *Econometrica.* 28:591-605.

[22] Cooley, T.F., and S.F. LeRoy. 1985. Atheoretical macroeconomics: A critique. *Journal of Monetary Economics.* 16:283-308.

[23] Corden, W.M. 1997. *Trade policy and economic welfare.* 2nd ed. New York: Oxford University Press.

[24] von Cramon-Taubadel, S., J.-P. Loy, and E. Musfeldt. 1995. Empirische Methoden zur Analyse de Marktintegration am Beispiel des EU-Schweinefleischmarktes. *Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues* 31:119-137.

[25] von Cramon-Taubadel, S. 1998. Estimating asymmetric price-transmission with the error correction representation: An application to the German pork market. *European Review of Agricultural Economics.* 25:1-18.

[26] Cross, R.G. 1998. *Revenue management: Hard-core tactics for profit-making and market domination.* London: Orion Business Books.

[27] Cryer, J.D., 1986. *Time series analysis.* Boston: Duxbury Press.

[28] Darling Downs Bacon. 1998. *Personal Communication.*

[29] Davidson, R., D. H. Hendry, F. Srba, and S. Yeo. 1978. Econometric modelling of the aggregate time-series relationship between consumers' expenditure and income in the United Kingdom. *Economic Journal* 88 (December):661-92.

[30] Davidson, R., and J.G. Mackinnon. 1993. *Estimation and inference in econometrics.* New York: Oxford University Press

[31] Dewbre, J., I. Shaw, G. Corra, D. Harris. 1985. *EMABA: Econometric Model of Australian Broadacre Agriculture.* Canberra: Bureau of Agricultural Economics.

[32] Dickey, D. A., and W. A. Fuller. 1979. Distributions of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association.* 74:427-431.

[33] Dickey, D. A., and W. A. Fuller. 1981. Likelihood Ratio statistics for autoregressive time series with a unit root. *Econometrica* 49 (4):1057-72.

[34] Dickey, D. A., D.P. Hasza and W. A. Fuller. 1984. Testing for unit roots in seasonal time series. *Journal of the American Statistical Association* 79:355-367.

[35] Dickey, D.A. and S.S. Pantula. 1987. Determining the order of differencing in autoregressive processes. *Journal of Business and Statistics* 5:455-461.

[36] Doan, T.A. 1990 *Regression Analysis for Time Series: RATS ver 3.10 user's manual.* Illinois: VAR Econometrics.

[37] Engle, R. F., and C. W. J. Granger. 1987. Co-integration and error correction: Representation, estimation and testing. *Econometrica* 55:251-76.

[38] Ferguson, J. 1998. *Agriculture: A case study in industrial relations reform.* 42nd Annual Conference of the Australian Agricultural and Resource Economics Society. 19-21 January 1998. Armidale: University of New England.

[39] GATT. 1994. *General Agreement on Tariffs and Trade: Uruguay Round of Multilateral Trade Negotiations. Final Act 15 December 1993.* Geneva: GATT Secretariat.

[40] Gordon, R.J., and S.R. King. 1982. The output cost of disinflation in traditional and vector autoregressive models. *Brookings Papers on Economic Activity* 1(1982):205-244.

[41] Granger, C. W. J. 1969. Investigating causal relationships by econometric models and cross-spectral methods. *Econometrica* 37:24-36.

[42] Granger, C. W. J., and P. Newbold. 1977a. *Forecasting economic time series*. New York: Academic Press.

[43] Granger, C. W. J., and P. Newbold. 1977b. The time series approach to econometric model building. In *New Methods in Business Cycle Research: Proceedings from a Conference*, ed. Federal Reserve Bank of Minneapolis, 6-21. Minneapolis: Federal Reserve Bank of Minneapolis. Federal Reserve Bank of Minneapolis; Minneapolis; N.

[44] Granger, C.W.J. and T.-H. Lee. 1989. Investigation of production, sales and inventory relationships using multicointegration and non-symmetric error correction models. *Journal of Applied Econometrics* 4:S145-S159.

[45] Griffith, G. 1995. *A causality analysis of the impact of Canadian pork imports on New South Wales pig prices.* Industry Commission Research Report on the Australian Pigmeat Industry. Submission 26, appendix 2.

[46] Griffith, G.R. 1977. A note on the pig cycle in Australia. *Australian Journal of Agricultural Economics.* 21:130-139.

[47] Hahn, W.F. 1990. Price transmission asymmetry in pork and beef markets. *The Journal of Agricultural Economic Research.* 42:21-30.

[48] Hahn, W.F. and L.A. Duewer. 1991. An evaluation of farm to retail price spreads for pork in 1990. Paper presented at the 1991 American Agricultural Economics Association 4-7 August 1991, Manhattan, KS.

[49] Hamilton, J.D. 1994. *Time series analysis.* Princeton: Princeton University Press.

[50] Hannan, E.J. and B.G. Quinn. 1979. The determination of the order of an autoregression. *Journal of Royal Statistical Society B.* 41:190-195.

[51] Hylleberg, S., R.F. Engle, C.W.J. Granger and B.S. Yoo. 1990. Seasonal integration and cointegration. Journal of Econometrics 44:215-238.

[52] Hyde, C.E. and J.M. Perloff. 1997. Multimarket market power estimation: The Australian retail meat sector. Paper presented at the 41^{st} Australian Agricultural and Resource Economics Society Conference, Gold Coast 20-25 January 1997.

[53] Industry Commission. 1995. *Industry Commission research project: Pigs and pigmeat.* Canberra: Australian Government Printing Service.

[54] Johansen, S. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12:231-254.

[55] Johansen, S. 1995. *Likelihood-based inference in cointegrated Vector Autoregressive models.* Oxford University Press.

[56] Johnston, J. 1984. *Econometric methods.* (3rd Ed.) Singapore: McGraw-Hill.

[57] Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lütkephol and T.C. Lee. 1985. *The theory and practice of econometrics.* (2nd Ed.) New York: John Wiley and Sons.

[58] Karunaratne, N.D. 1992. Growth and trade liberalisation debate in Australia: A VAR analysis. *University of Queensland Department of Economics Discussion Paper* 100.

[59] Krugman, P.R., and M. Obstfeld. 1994. *International economics: Theory and policy.* 3rd Ed. New York: Harper Collins.

[60] Liu, T.C. 1960. Underidentification, structural estimation, and forecasting. *Econometrica* 28:855-865.

[61] Mas-Collel, A., M. D. Whinston, and J. R. Green. 1995. *Microeconomic theory.* New York: Oxford University Press.

[62] Moulis, D. 1998. *In the Productivity Commission inquiry into pig and pigmeat industries: Public hearing submission of the Canadian Meat Council and the Canadian Pork Council.* Canberra: Freehill, Hollingdale and Page, Solicitors.

[63] Myers, R.J., R.R. Piggott, and W.G. Tomek. 1990. Estimating sources of fluctuations in the Australian wool market: An application of VAR methods. *Australian Journal of Agricultural Economics* 34:3-.

[64] National Pork Industry Development Program. 1998. *Description and program guidelines.* Canberra: Department of Primary Industries and Energy.

[65] Ng, S. and P. Perron. 1995. Unit Root tests in ARMA Models with data-dependent methods for selection of the truncation lag. *Journal of the American Statistical Association*.

[66] Norman, B. and E. Goddard. 1998. *Welfare effects of market regulation with an imperfectly competitive processing sector*. Paper presented at the 42^{nd} Australian Agricultural and Resource Economics Society Conference, Armidale, 19-21 January 1998.

[67] Osborn, D.R., A.P.L. Chui, J.P. Smith and C.R. Birchenhall. 1988. Seasonality and the order of integration for consumption. *Oxford Bulletin of Economics and Statistics.* 50:361-377.

[68] Osborn, D.R., and P.M.M. Rodrigues. 1998. *The asymptotic distributions of seasonal unit root tests: A unifying approach.* Mimeo. School of Economic Studies, University of Manchester.

[69] Perron, P. 1989. The Great Crash, the Oil Shock and the unit root hypothesis. *Econometrica*, 57:1361-1402.

[70] Perron, P. 1990. Testing for a unit root in a time series with a changing mean. *Journal of Business and Economic Statistics.* 8:153-162.

[71] Perron, P. and T.J. Vogelsang. 1992. Testing for a unit root in a time series with a changing mean: corrections and extensions. *Journal of Business and Economic Statistics.* 10:467-470.

[72] Pesaran, M.H. and Y. Shin. 1997. Generalised impulse response analysis in linear multivariate models. (Unpublished manuscipt). Cambridge University (http://www.econ.cam.ac.uk/faculty/pesaran/public.htm)

[73] Phillips, P.C.B., and P. Perron. 1988. Testing for a unit root in time series regression. *Biometrika*, 75:335-346.

[74] Pindyck, R. S., and D. L. Rubinfeld. 1991. *Econometric models and economic forecasts.* 3rd ed. New York: McGraw-Hill.

[75] Pork Council of Australia. 1998. *Securing the future of the Australian pork industry: Submission to the Rural Adjustment Scheme Advisory Council for Exceptional Circumstances Support.* Draft. May 1998

[76] Productivity Commission. 1998a. *Pig and pigmeat industries: Safeguard action against imports. Issues Paper July 1998.* Melbourne: Productivity Commission.

[77] Productivity Commission. 1998b. *Personal Communication.*

[78] Purcell, T. and R. Beard. 1998. *An imperfectly competitive CGE model of Australia's wheat trade.* Paper presented at the 42^{nd} Australian Agricultural and Resource Economics Society Conference, Armidale, 19-21 January 1998.

[79] Purcell, T.D. and S. Harrison. 1998. *The impact of trade liberalisation and increasing imports on Australian pig prices: A report prepared for the Queensland Department of Primary Industries.* Brisbane: Department of Primary Industries, Queensland.

[80] Queensland Pork Producers' Organisation. 1998. *Weekly indicative prices for porkers and baconers.* Unpublished dataset.

[81] Said, S.E. and D.A. Dickey. 1984. Testing for unit roots in autoregressive moving average models of unknown order. *Biometrika* 71:599-607.

[82] SAS Institute Inc. 1993. *SAS/ETS User's Guide, Version 6 Second Edition.* Cary, NC: SAS Institute Inc.

[83] Sims, C. A. 1980. Macroeconomics and reality. *Econometrica* 48 (1):1-48.

[84] Tisdell, C.A. 1982. *Microeconomics of markets.* Brisbane: John Wiley and Sons.

[85] Todd, R.M. 1990. *Improving economic forecasting with Bayesian Vector Autoregression*. in Granger, C.W.J. (ed) 1990. *Modelling economic series: Readings in econometric methodology.* Oxford: Oxford University Press