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# Beef Feedlot Supply Response in Australia

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## Abstract

Reliable estimates of demand and supply elasticities are required for industry-wide evaluations of new agricultural technologies, new primary product promotion campaigns or new policy initiatives impacting on agricultural industries. In developing an equilibrium displacement model of the Australian beef industry, recent supply elasticities for feedlot beef in Australia were not available. The issue of consistency of throughput of feedlot beef and utilisation of feedlot capacity is also an important industry concern. Feedlot survey data were used to estimate supply response functions for feedlot beef. The results indicated that price response was much more inelastic than shown in previous work, reflecting perhaps the industrialisation of the industry in recent years and the significant level of foreign investment. The price of fed cattle plays the largest role in influencing decisions to place cattle on feed. The price of feed is also a major input affecting utilisation of feedlot capacity, however the price of feeder steers plays a lesser role in feedlot decision making than previously thought.


## 1. Introduction

"Reduced demand from Japan, high feed grain prices and higher buy-in prices for feeder cattle are biting the feedlot industry, forcing many to scale back operations and sit out of the market." (The Land, 17/01/02, p7).

One of the crucial pieces of information required for industry-wide evaluations of new technologies, new promotion campaigns or new policy initiatives, is the response of producers and consumers to price changes, ie supply and demand elasticities. These elasticities determine the extent to which cost advantages and or consumer preferences are dissipated by subsequent price adjustments, and hence the ability of different sectors of the industry to appropriate the gains from R&D or effective promotion campaigns.

In developing an equilibrium displacement model of the Australian beef industry (Zhao 2000, Zhao *et al.* 2000), thorough reviews of existing studies on supply and demand elasticities for beef in Australia were undertaken (Griffith *et al.* 2001a,b). One of the areas where such values were almost non-existent was in the feedlot sector. The above quote confirms that feedlots do respond rationally to economic incentives, but the degree of this response has not been measured recently. Educated guesses were made to complete the model, and extensive sensitivity analyses were done, but this lack of feedlot supply response data was seen as a key limitation to the application of the model (Zhao *et al.* 2001). Hence, one of the major reasons for undertaking this study is to attempt to fill this gap in knowledge.

The paper proceeds as follows. Section 2 describes the background to the growth of the cattle feedlot industry in Australia and the large variations in output which have occurred. Section 3 details and justifies the specification of the various models examined, while data requirements are described in Section 4. Results and discussion are given in Section 5 and the paper concludes in Section 6.

## 2. Background

A number of production systems have emerged within the Australian beef industry in recent decades in response to the changing demands of various domestic and overseas markets (Clark, Lembit and Warr 1992). Of the approximately one-third of output which is sold on the domestic market, an increasing proportion is being sold through supermarkets and much of this is grain-finished to meet the growing demand by consumers for improved eating quality.  The recent development of Meat Standards Australia and its requirement for grain finishing in most of the recommended pathways is evidence of the strength of this demand.

Of the approximately two-thirds of output which is exported, the major market has traditionally been the US , importing mainly manufacturing grade beef. However, since the early 1990s, Australia 's reliance on the US market has decreased substantially, although the US remains Australia 's second largest beef export destination in most years, with 312kt exported in 1999/2000 and 389kt in 2000/01. The Australian industry has shifted its focus to Asia , with exports to Japan increasing from 27 per cent of total exports in 1990 to over 35 per cent in recent years. Japan is now Australia 's largest export market in most years, with 326kt exported in 1999/2000 and 336kt in 2000/01. In recent years, Australia held equal share of the Japanese market with the US , with 48 per cent of imports coming from each. Exports to South Korea have also grown from 1.7 per cent of beef exports in 1988 to around 6 per cent currently (MLA 2001b; ABARE 2000a, b).

With the Japanese market in particular demanding consistent high quality, marbled beef, the feedlot industry has expanded considerably since its emergence in Australia in the early 1960s.  Feedlot capacity in mid 2001 was 796,000 head as opposed to 428,000 head in early 1991. The feedlot industry has gone from an average of less than 80,000 cattle on feed in 1981 to 270,000 in 1991 and to an average of 693,000 in mid 2001.  This significant increase was associated with an increase of grainfed beef exports from 3.5 kt in 1987 to 33.8 kt in 1990 and to 50kt in 2000 (Clark, Lembit and Warr 1992). In 1995, the feedlot industry introduced a quality assurance program, the National Feedlot Accreditation Scheme.  The scheme ensures feedlots and feedlot managers in Australia comply with standards which ensure animal welfare, safe use of veterinary medicines and quality of beef in the industry.  In June 2001, over 700 feedlots were accredited with a capacity of approximately 800,000 head.  Of these, 80 or 11 per cent of feedlots had a capacity over 1000 head, but these feedlots account for almost 80 per cent of the total capacity (Lockyer 2000).

Although the feedlot industry has undergone considerable growth in the last decade, the supply of grainfed beef in Australia has been, and continues to be, extremely variable over time.  This variation in supply can be seen in Figure 1, which shows numbers on feed in Australian feedlots and capacity utilisation for the period 1990 - 2001. For example, in September 1996 utilisation was only 39 per cent of Australian feedlot capacity, while in June 2001 there was a 87 per cent utilisation rate.

Along with this, considerable variation occurs between states at any one time.  For example, in June 2001, capacity utilisation was 94 per cent in Queensland , 89 per cent in New South Wales , 82 per cent in Victoria , 61 per cent in Western Australia and 44 per cent in South Australia .

Another trend has been the shift in market destination over time. For example, of the 693,000 cattle on feed in June 2001, 38 per cent were destined for the domestic market, 57 per cent to the Japanese market and 2 per cent to the Korean market. Cattle destined for the Japanese market are fed a high energy, high protein ration for up to 300 days to meet the specifications required by the market, and cattle fed for the Korean market have at least 100 days on feed.  The Australian domestic consumers require a leaner beef product and cattle for this market are usually fed for an average of 70 days.

The Japanese market is the largest for grainfed cattle in Australia , and has consistently taken approximately 60 per cent of feedlot turnoff. Australian feedlotters supply the Japanese 'middle market', which demands a highly specified, quality product.  With such a large and valuable market, the supply of the beef product needs to be consistent to ensure Australia maintains its market share. This issue of consistency of throughput of lot fed beef and utilisation of feedlot capacity is also addressed in this study.

## 3. Model Specification [2]

The quote at the start of the paper confirms that economic factors have a major influence on lot fed beef supply, but the Australian literature on this subject is particularly sparse, with only two previous studies. Buffier and Freebairn (1975) reported an analysis of the short-term response in the number of cattle placed on feedlots to changes in the prices of fat cattle, store cattle and grain. Data for the study came from surveys of 10 feedlot operators in north-western New South Wales regarding their intended throughput of cattle at different price combinations during 1973/74. Price elasticities were calculated with respect to fat cattle price, store cattle price, cattle price (for perfectly correlated movements in fat cattle and store cattle prices) and grain price. For similar percentage movements in cattle and grain prices it was found cattle prices had a more important effect on the number of cattle placed on feedlots (Buffier and Freebairn 1975, p.48). The elasticity with respect to fat cattle price ranged between 1.4 and 9.6, that with respect to the store cattle price between -0.8 and -8.8, and that with respect to the grain price between -0.3 and -0.7.

Clark, Lembit and Warr (1992) reported a model which was used to estimate the likely regional impacts of changes in demand for grain fed beef and in grain feeding costs in order to assess the relative profitabilities between individual grass and grain feeding activities. The model estimated changes in the feedlot sector as a result of changes in costs and returns. The modelling approach used quadratic programming and was split into three beef producing regions and two beef selling regions with linking interregional activities and constraints. The model was constructed using a combination of 1989-90 prices, 1988-89 costs and 1989 resource availabilities. Three regions were selected including the main feedlotting areas in Queensland and northern New South Wales , the remainder of Queensland and the main feedlotting areas within southern New South Wales and Victoria . The two selling areas were Queensland and northern New South Wales , and southern New South Wales and Victoria . The study found that the production response to relatively large changes in feedgrain prices was small, but a strong substitution effect existed between various beef types fed on grain. The simulations conducted indicated that, for grain fed beef, demand was more important than feed costs in determining overall production. It was found that the effect of an increase in demand for grainfed beef on total beef production was small, however substantial substitution between grass and grain fed beef production occurred with different combinations of feeder and fed steers.

Given the need for estimates of beef feedlot supply response, the lack of recent relevant empirical evidence, and the above discussion, models are specified below which explain the economic factors that prompt changes in numbers on feed in Australian feedlots, to both the domestic and Japanese markets. The models also include two further sets of factors. The first of these is the influence of the US feedlot industry on the Australian industry, and the second is the effects of shifts in Japanese beef imports on the supply of grainfed beef in Australia . These factors have been included in the study due to the possibility that prices for export product does not completely reflect changes in demand and supply conditions in these major markets.

Standard production theory (Tomek and Robinson 1995, Goodwin 1994) is used to specify the factors that will influence the supply of grainfed beef in Australia, augmented by reference to previous studies in the US literature (for example, Aardland and Bailey 2001, Antonovitz and Green 1990). Separate models are specified for numbers on feed and destination. The numbers on feed models are also segregated for the three main producing states, New South Wales , Queensland and Victoria .

Input availability and cost is a major consideration when predicting supply. The major input costs influencing the supply of grainfed beef are the price of feeder steers and the price of feed. These two factors account for over 90 per cent of input costs involved in the production of grainfed steers. Other factors such as the price of labor and the cost of capital have a much lesser influence. However the prices of inputs and the end product can often move together, such as the price of fed cattle and feeder cattle. An increase in the price of fed cattle is quickly absorbed by a rise in the price of feeder cattle.

The supply of commodities can also shift when competing or alternative commodities, able to be produced with the same resources, become less or more profitable. For grainfed beef there are few alternatives to production considering the infrastructure required. However, decisions made by feedlotters can be influenced by prices received for the different types of grainfed cattle, such as domestic 70-day fed cattle or cattle fed for the Japanese market. An increase in margins for one of the markets could entice feedlotters to increase numbers fed for that market over other markets. Numbers destined for the domestic and Japanese markets are analysed in the study as these account for over 96 per cent of the grainfed beef markets.

An improvement in technology enables firms to produce more output with the same quantity of inputs. In the beef industry technological improvement can be seen mostly in the improvement of cattle breeds. Cattle are now genetically monitored for attributes such as marbling and feed conversion, to produce a more profitable product. However measurement difficulties prevented a suitable technology variable being included in this study.

Supply may also be influenced by perceived price risks. With a low risk of a decline in price between the time decisions are made and the commodity is sold, producers presumably will be motivated to make new investments or use additional inputs (Tomek and Robinson 1995). Similarly, the greater the risk, the less feedlotters are likely to produce (Antonovitz and Green 1990). The increased use of forward contracting in the feedlot industry in recent years and the greater use of on-farm grain storage facilities has decreased the risk involved in feeding cattle for the required periods of time. Given these developments and the difficulty in measuring risk on the supply of grainfed beef, this factor has been excluded from the study.

Adverse weather conditions usually increase production cost structures. However feedlots are much less exposed to the effects of drought than grass-feeding systems. Feed prices may rise but this is offset by cheaper feeder steer prices in drought periods. In any case, with the industry much more industrialised today it can be argued that environmental conditions are much less important when considering feeding decisions.

Supply of grainfed beef is also influenced by institutional factors such as government regulations. Many regulations are imposed for establishing a new feedlot which to a degree limits the extent to which feedlot capacity can increase, and license fees are paid by established feedlots. Environmental and animal welfare regulations also affect feedlots.

Goodwin (1994) also includes the level of fixed resources as a factor influencing the supply of agricultural commodities. In the short and intermediate terms, feedlot capacity determines the extent to which numbers on feed can rise. This fixed resource is included in the models and sets the upper limit to numbers to be placed on feed for a given period.

## 3.1 Numbers on Feed Model

Following Buffier and Freebairn (1975), the model for numbers on feed in Australia , across all States and to all destinations, is specified as follows:

$NOF = f(CAP, P_f, P_c, P_b, US, JAP, NOF_{t-1}, D, S)$

Where in any one period:

NOF = reported numbers on feed

CAP = reported capacity of feedlots

$P_f$ = price of feed

$P_c$ = price of feeder cattle

$P_b$ = price of fed cattle

US = numbers on feed in the US

JAP = beef imports into Japan

D = dummy variables for seasonal effects

$NOF_{t-1}$ = numbers on feed in the previous period

S = dummy variable for change in survey coverage (see below)

Six month lags are placed on all of the explanatory variables (except the lagged dependent variable and the dummy variables) to reflect the time between when the decision is made to purchase cattle for the feedlot and the average length of time they are reported as being "on feed" (60 to 300 days).

Variables measuring labour cost, capital cost, government regulation, drought conditions and technology are omitted based on the previous discussion. Due to the extent of the competition from the US feedlot sector, a variable for expected numbers placed on feed in the US has been included as a measure of market sentiment. US competition with Australian product is especially prevalent in the Japanese market. The threat from the US stems from the huge difference in scale between the Australian and US industries. The US beef herd stood at 106.8 million head in 1999, over four times that of Australia 's. The US feedlot industry in particular is more than ten times as large as that in Australia , with peak numbers on feed reaching more than 10 million head. US beef production has continued to rise over the past three years with 11993kt produced in 1999, up 1.6 per cent (Smith 2000). In recent years beef consumption per person in the US has declined as a result of competition from pork and poultry. This downward trend along with continued high production has seen the excess supply in the US directed towards exports.

Another market sentiment variable is expected Japanese imports. As the consumption of beef continues to rise in Japan and tariffs fall on imported beef, the Japanese market has played a major role in the expansion of Australia 's feedlot industry. With 60 per cent of grainfed beef currently exported to Japan , this market influences decisions made in Australia to a great extent. It is expected that expected levels of Japanese imports will have an important effect on the capacity of Australian feedlots.

There is another reason why activity in the Japanese market is included. Some believe that the price received by Australian producers for export beef to Japan does not fully reflect the changes in demand for the product. This argument can be supported by two factors. These are the domestic and import policies employed in Japan , and the level of Japanese investment in Australian beef feedlots.

Before 1991, Japan imposed an import quota on beef. This quota is significant as it covers a proportion of the data set used in the models estimated here. Under the quota imposed, beef imports were restricted to 274 kt in 1988. These restrictions were put in place to increase the returns to domestic beef producers, while funding the price stabilisation schemes put in place for them. Japan agreed to abolish import quotas in April 1991, however the domestic industry is still protected by a tariff on beef as well as the continuation of the wholesale price stabilisation scheme and the feeder-calf price stabilisation scheme. These two schemes are used to reduce the volatility in the domestic prices of beef. It is also argued that the schemes act primarily as a floor-price plan (ABARE 1988). The wholesale price stabilisation scheme is directed at the B-2 and B-3 grades of beef, which is the market supplied by Australian producers. These factors lead to reduced competitiveness for Australian producers, and therefore market changes in Japan may not be truly represented by the price received for Australian product.

Another factor contributing to the assumption of poorly transmitted prices is the level of Japanese investment in Australian feedlots and processing facilities. Meat Research Corporation (1993) proposed that Australian beef was priced at a 40 per cent discount to US beef and that the discount was rising even though the quality of Australian beef was improving. One reason given for this was that integrated processors are holding down prices by breaking even in Australia and making all their money in Japan (MRC 1993). Japanese investment in Australian feedlots has increased rapidly over the past decade (Jones 2000).

A lagged dependent variable has also been included in the equation to check whether there are any additional dynamic aspects to the equation. A partial adjustment framework is believed to hold as cattle are on feed for different amounts of time and therefore full adjustment to price and cost changes within a short time frame is unlikely.

## 3.2 Destination Models

Destination models are specified for the two major markets for grainfed beef, the domestic and Japanese markets. Approximately 35 per cent of grainfed beef is destined for the domestic market and about 60 per cent for the Japanese market. Reflecting the different lengths of time cattle are on feed for these markets, separate models have been specified. Three-month lags are placed on the capacity and price variables in the domestic model, and nine-month lags are placed on the capacity, price, US and Japan variables in the Japan model.

$DOMHD = f(CAP, P_f, P_c, P_b, DOMHD_{t-1}, D, S)$

$JAPHD = f(CAP, P_f, P_c, P_b, US, JAP, JAPHD_{t-1}, D, S)$

where

DOMHD = numbers on feed intended for the domestic market,

JAPHD = numbers on feed intended for the Japanese market,

and the other variables are as previously defined.

## 4. Data Requirements

Feedlot survey data were obtained from Meat and Livestock Australia (MLA 2001a), and cross-checked from the ALFA *Lotfeeding* publication (Anon 2000). The current National Accredited Feedlot Survey is conducted by the MLA and the Australian Lotfeeders Association (ALFA) and gives quarterly data on capacity, numbers on feed, utilisation, and market destinations. The survey is broken down into states, as well as by feedlot size.

In December 1990, ALFA replaced the previous "Lotfax" survey with a quarterly survey to provide greater accuracy and representation of feedlots in Australia , covering feedlots with a capacity of greater than 500 head (Maher 1990). In December 1995 the feedlot survey was again changed, as a result of the feedlot accreditation scheme finalised in late 1995. Feedlot accreditation allowed the new survey to include feedlots with a capacity of less than 500 head, giving a more precise indication of the feedlot population. Prior to the current survey, feedlot capacity and numbers on feed were underestimated due to feedlots of less than 500 head being unaccounted for. In September 1995, feedlot capacity was estimated at 565,901 head with 367,750 head on feed, however in the December quarter, the new survey indicated feedlot capacity in Australia stood at 825,000 head with 461,516 head on feed. These figures suggest that the previous survey underestimated feedlot capacity by approximately 260,000 head and numbers on feed by approximately 94,000 head. Previous surveys also lacked reference to market destinations as well as a break down of the industry by feedlot sizes. To account for these significant changes in the survey procedures and coverage, a dummy variable has been added to the models to split the data set at the end of 1995.

Sorghum prices were chosen for the feed price indicator, over other feed grains such as barley, wheat and oats. This choice was made due to the extensive use of sorghum in feedlots throughout the main beef producing states in Australia . Monthly sorghum prices were obtained from ABARE publications and transformed into quarterly average prices.

For the feeder steer price, the young cattle class 22-24, fat score three, was chosen as the indicator price. A full data set was available from MLA making this class a better choice over other classes available (FS two and four) which may have also been suitable indicators.

Two indicators were used for the price of fed cattle. The first is a QLD over-the-hooks (OTH) price. With many different classes of cattle slaughtered, the OTH price seems to best represent the market that covers the majority of grainfed beef. Bullocks with a hot standard carcass weight (HSCW) of 300kg and optimal fat score three and four was chosen, as beef exported to Japan is longer fed and therefore has higher carcass weights. This class was chosen over other possibilities including bullocks grainfed for 100 days, export steers HSCW over 280 kg optimal FS three and four, export steers HSCW 220-280 kg optimal FS three and four, and export steers HSCW 180-220 kg optimal

FS three and four. Correlations were carried out on the class choices available, and these showed that all classes were highly correlated and therefore would all be good indicators. Monthly data were obtained from both the MLA and the National Livestock Reporting Service (NLRS) and quarterly averages calculated.

The second indicator for fed cattle price was for chilled beef export cuts. Data sets were available for chilled grassfed, shortfed fullset, longfed fullset, chilled striploin, cubed roll, and tenderloin. The decision of which indicator to use was based on correlations among the classes. Shortfed and longfed fullsets would have been the preferable indicator as they give a better indication of the export price of beef into Japan . There were few observations available for these data sets however so they were excluded. Chilled striploin is used in the study as it is has the highest correlation with the shortfed and longfed fullsets. These prices were taken from MLA. They were given weekly, and were converted into average quarterly prices for this study.

Monthly numbers on feed in the US were obtained from the United States Department of Agriculture (USDA) website (USDA 2001), for the seven major beef producing states in the US . Data for the mid-quarter month were used.

Japanese imports of beef were the most difficult variable to compile a quarterly data set for. A restricted set of monthly data were found in *The Meat Statistics in Japan* published by the Japanese Ministry of Agriculture, Forestry and Fisheries (LIB, MAFF 1998, 2000). These figures were converted into quarterly data for the purpose of the analysis.

The study covers the period from the second quarter in 1991 to the first quarter in 2001, giving 41 potential observations. Importantly, 22 quarters are covered by the most recent and hopefully more reliable feedlot survey procedures. However, where the Japanese import variable was included, the number of observations was only 26. Critical one-tail t values are 1.68 (5%) and 1.30 (10%) for most equations, and 1.71 and 1.32 respectively for equations where the Japanese import variable was included. The significance of the seasonal dummy variables was assessed using two-tailed tests.

## 5. Results

The two sets of models described above - numbers on feed models, and destination models - were estimated using regression procedures in the TSP econometrics program [3] .

### 5.1 Numbers on Feed Models

Four equations were jointly estimated to explain variation in numbers on feed in all Australian feedlots and in Queensland , New South Wales and Victoria, separately (Table 1a). This has been done to allow for the different feedlot structures, capacities, and availability of inputs in each state. This segregation allows for a more precise analysis of the industry in each state as well as providing output for Australia as a whole.

TABLE 1a: NUMBERS ON FEED EQUATIONS - 3SLS ESTIMATES

| STATE | LAGGEDCAPA-CITY | LAGGEDPRICE OF FEED | LAGGED PRICE OF FEEDER CATTLE | LAGGED PRICE OF FED CATTLE | LAGGED DEPEND. VARIABLE | Q1 | Q2 | Q3 | R 2 | DH | DW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.523 | -0.785 | 0.156 | 1.743 | - | 48.10 | 78.21 | 36.86 | 0.90 | | 1.96 |

**significant at the 5% level, * significant at the 10% level, 1-tail test for the capacity, price and other economic variables, 2-tail test for the seasonal dummy variables, n=29.

The R 2 value for the total equation shows that 90 per cent of variation in numbers on feed in Australia is explained by the tested variables.  The figures for QLD and NSW are also high, however only 63 per cent of variation in numbers on feed is explained in VIC.  Autocorrelation, as measured by the DW and/or DH statistics, does not seem to be a problem in any equation.

In any cell in the tables relating to an explanatory variable, the first value is the estimated regression coefficient, the second value is the estimated t-value with an indication of level of statistical significance, and the third value is the estimated elasticity value (see the discussion below). As feedlot capacity increases it would be expected that numbers on feed would follow this trend.  This pattern is confirmed in Australia , QLD and NSW, where capacity was significant and had a positive influence on numbers on feed.  For example, in Australia as a whole it was found that an increase in feedlot capacity of 1000 head will lead to numbers on feed increasing by 523 head two quarters later.

The two main inputs into feedlotting, feeder cattle and feed, had differing effects amongst the states.  In QLD and in Australia as a whole, feed price was significant while in NSW and VIC the variable approached significance at the 10 per cent level.  For example, in QLD a $10/tonne increase in the price of sorghum will lead to a decrease of numbers on feed by 4430 head.  Similarly numbers on feed in Australia as a whole will decrease by 7850 head. However, the price of feeder steers was not significant in any of the equations.

The price of fed cattle is the most significant factor influencing numbers on feed in feedlots in NSW and QLD and across Australia .  This substantiates preliminary findings by Coddington (1997).  Across Australia , a $0.10/kg rise in the price of fed cattle will result in an additional 17430 head placed on feed.

Numbers placed on feed in the US , Japanese imports, the survey dummy variable and a lagged dependent variable (except in VIC), were not significant. There was however significant seasonal variation in all equations. Generally, on a quarterly basis, numbers on feed are higher in the first nine months of the year than in the last three months.

## 5.2 Destination Models

The domestic and Japanese market destination model results are shown in Table 2a.  Numbers placed on feed in the US, Japanese imports, the survey dummy variable or a lagged dependent variable played no role in determining placements of cattle destined for the domestic market, and were subsequently deleted from the final model.  The R 2 value was high at 0.82 however the DW statistic was measured at 1.17, in the indeterminate range, and therefore it cannot be confirmed that autocorrelation is absent from the model. However an AR1 correction was not significant, so it is likely that it is not a problem.

TABLE 2a: DESTINATION EQUATION - 3SLS ESTIMATES

| MARKET | LAGGED CAPACITY | LAGGED PRICE OF FEED | LAGGED PRICE OF FEEDER CATTLE | LAGGED PRICE OF FED CATTLE | LAGGED JAPANESE IMPORTS | Q1 | Q2 | Q3 | R 2 | DW |
|---|---|---|---|---|---|---|---|---|---|---|
| DOMESTIC | 0.398 | -1.037 | 0.252 | 0.319 | - | 58.27 | 32.32 | 18.69 | 0.82 | 1.17 |
| | 5.19 ** | -5.88 ** | 1.00 | 2.62 ** | - | 4.40 ** | 2.23** | 1.28 | | |

**significant at the 5% level, * significant at the 10% level, 1-tail test for the capacity, price and other economic variables, 2-tail test for the seasonal dummy variables, n=29.

The price of feeder cattle was not significant, but all remaining variables tested were significant. The results suggest that a capacity increase of 1000 head will lead to an increase in cattle destined for the domestic market of 398 head; a $10/tonne decrease in the price of feed will increase domestic numbers on feed by 10370; and a $0.10/kg rise in the price of fed cattle will increase cattle on feed destined for the domestic market by 3190 head. Japanese imports would be expected to have a notable influence on numbers destined for the Japanese market. However when tested (Table 2a) this variable was very insignificant. It therefore can be concluded that the assumption made that price does not truly represent the market situation for Japanese beef exports does not hold. The price of fed cattle was the most significant factor influencing numbers destined for the Japanese market, with numbers increasing by 11540 head for every $0.10/kg rise in the price of fed cattle. Capacity had a similar impact as in the domestic destination equation, but neither the price of feed nor the price of feeder cattle was significant (and correctly signed) in determining numbers destined for the Japanese market.

While there were significant seasonal influences in the domestic equation, none were evident in the Japanese destination equation (because of the length of time cattle for this market have to remain in the feedlot).

## 5.3 Discussion of Results

As mentioned above, elasticities were estimated for the significant coefficients (at the 10 per cent level) in each of the equations. Long-run elasticities were calculated where lagged dependent variables were significant.

The elasticity of numbers on feed with respect to capacity show the elasticities are around one for Australia as a whole and for NSW, while that for QLD was quite inelastic. These differences highlight the difference in industry structure and availability of inputs between states and the flexibility that exists to increase numbers on feed as space becomes available. Elasticities calculated for numbers on feed with respect to the two major inputs, that is the price of feed and the price of feeder steers, were inelastic, and not significantly different from zero, respectively. A given percentage change in the price of feed will have a significantly lesser percentage change in numbers on feed. These calculated elasticity values are in accord with previous findings for feed grain, but contrary for feeder cattle. In preliminary research, Coddington (1997) found an elastic response to feeder cattle prices, while Buffier and Freebairn (1975) found cattle prices had a more important effect on the number of cattle placed on feedlots for similar percentage movements in cattle and grain prices. The increasing inelasticity of the two inputs is most likely due to the continuing commercialisation of the feedlot industry over recent years. Contracts are used much more extensively in the industry and therefore a significant degree of risk can be taken out of feeding cattle over required time periods. Further, it is well documented that there is a significant degree of foreign investment in the Australian feedlot industry with supply chains linked through to Japanese meat processing and trading firms. Finally, opportunity feedlots, a significant component of the Buffier and Freebairn (1975) sample, are not included in the current survey.

Elasticities with respect to the price of fed cattle were generally around one or a little elastic, which confirms the results found by Coddington (1997) and by Buffier and Freebairn (1975). This is an expected result as this variable had the most influence on decisions to invest in numbers on feed.

When numbers on feed for particular end markets are examined, some major differences arise. The elasticities of numbers on feed for the domestic market with respect to capacity, feed cost and fed cattle price are all elastic, indicating that there is a substantial degree of flexibility in this sector of the industry to be able to respond to market signals. Thus excess capacity can be quickly allocated to domestic feeding when grain is relatively cheap and/or fed cattle prices are relatively high. The elasticities of numbers on feed for the Japanese market are very similar to the aggregate numbers on feed elasticities.

## 6. Conclusions

The supply of grainfed beef has been extremely variable since the emergence of the feedlot industry in Australia . One aim of this study has been to analyse the economic factors that influence variability in investment and output in this industry. Economic models were developed to analyse the effects the chosen variables had on numbers on feed, and on the different destinations for grainfed beef. The other aim was to calculate supply response elasticities for the feedlot sector so as to fill some information gaps for undertaking empirical evaluations of the returns from beef industry R&D investments.

The results obtained were much more inelastic compared to those of Buffier and Freebairn (1975) and slightly more inelastic compared to the initial set of estimates by Coddington (1997). The elasticity results reflect the changes that have occurred in the feedlot industry since its emergence and in recent years. Feedlots have become larger with a significant level of foreign investment in the industry. The use of contracts for grain and contracts for supplying grainfed beef has also become used to a much greater extent. The implication of these results for R&D studies is that the feedlot sector may be able to more easily appropriate the benefits of cost reducing technologies than had been expected from the early studies (Zhao *et al.* 2001).

Throughout the results it was found that the price of fed cattle plays the largest role in influencing decisions to place cattle on feed, while the price of feed is the major input affecting utilisation over the price of feeder steers. It was also found that the price of feeder steers plays a lesser role in the decision making than previously thought.

Numbers placed on feed in the US and growth in the Japanese import market for beef did not impact significantly on decisions made in the Australian feedlot industry, which may suggest the Australian industry is growing more independent of US and Japanese market influences.

From a technical modelling perspective, future work could involve:

- more sophisticated checking and modelling of the dynamics of these decisions (perhaps based on the sorts of model outlined in Aadland and Bailey (2001));
- a closer look at the importance of supply response to risk (Antonovitz and Green 1980);
- updating the data set to better account for the influence of the current drought; and
- the use of a formal profit function framework to take better account of the jointness of many of the feedlot utilisation and destination decisions and the restrictions that economic theory would suggest applies to such decisions (including restrictions on the signs of estimated coefficients).

A related technical implication of the results reported here is that the feedlot sector may be more appropriately modelled as using a combination of specialised and non-specialised resources (see for example Zhao *et al.* 2003).

## 7. References


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APPENDIX

TABLE 1b: NUMBERS ON FEED EQUATIONS - OLS ESTIMATES

| STATE | CAPACITY | PRICE OF FEED | PRICE OF FEEDER CATTLE | PRICE OF FED CATTLE | LAGGED DEPENDENT VARIABLE | Q1 | Q2 | Q3 | R2 | DH | DW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.603 | -0.560 | 0.244 | 2.017 | - | 34.15 | 75.47 | 42.07 | 0.93 | - | 1.91 |
| TOTAL | 17.49 ** | -2.89 ** | 1.06 | 8.18 ** | - | 2.38 ** | 5.09 ** | 2.87 ** | | | |
| | 0.94 | -0.21 | 0.12 | 1.01 | | | | | | | |
| | 0.638 | -0.246 | -0.008 | 0.691 | - | 10.27 | 17.88 | 4.75 | 0.86 | - | 1.63 |
| NSW | 12.68 ** | -2.50 ** | -0.07 | 4.86 ** | - | 1.31 | 2.27 ** | 0.60 | | | |
| | 0.98 | -0.26 | | 0.96 | | | | | | | |
| | 0.493 | -0.206 | -0.023 | 1.122 | - | -0.297 | 31.11 | 35.75 | 0.87 | - | 1.54 |
| QLD | 10.22 ** | -1.59 * | -0.14 | 7.50 ** | - | -0.03 | 3.23 ** | 3.77 ** | | | |
| | 0.73 | -0.16 | | 1.15 | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.095 | -0.009 | 0.040 | 0.042 | 0.518 | 8.40 | 8.04 | -5.52 | 0.61 | 1.37 | - |
| VIC | 0.82 | -0.22 | 0.84 | 0.71 | 3.22 ** | 2.69 ** | 2.36 ** | -1.44 | | | |

**significant at the 5% level, * significant at the 10% level, 1-tail test for the capacity, price and other economic variables,

2-tail test for the seasonal dummy variables, n=41.

TABLE 1c: NUMBERS ON FEED EQUATIONS - 2SLS ESTIMATES

| STATE | CAPACITY | PRICE OF FEED | PRICE OF FEEDER CATTLE | PRICE OF FED CATTLE | LAGGED DEPENDENT VARIABLE | Q1 | Q2 | Q3 | R2 | DH | DW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.546 | -0.789 | 0.203 | 1.743 | - | 48.12 | 78.55 | 37.52 | 0.90 | | 1.99 |
| TOTAL | 4.82 ** | -2.06 ** | 0.66 | 3.77 ** | - | 2.65 ** | 4.15 ** | 1.90 * | | | |
| | 0.91 | -0.30 | | 0.81 | | | | | | | |
| | 0.798 | -0.123 | 0.015 | 0.850 | - | 10.80 | 9.73 | 0.95 | 0.83 | | 1.55 |
| NSW | 3.36 ** | -0.41 | 0.11 | 2.89 ** | - | 1.11 | 0.96 | 0.09 | | | |
| | 1.30 | | | 1.09 | | | | | | | |
| | 0.370 | -0.472 | -0.058 | 0.791 | - | 5.56 | 39.98 | 38.22 | 0.85 | | 1.81 |
| QLD | 3.48 ** | -2.49 ** | -0.30 | 3.40 ** | - | 0.52 | 3.55 ** | 3.38 ** | | | |
| | 0.59 | -0.37 | | 0.75 | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | -0.571 | -0.144 | -0.033 | -0.087 | 0.590 | 7.79 | 4.84 | -12.84 | 0.55 | 1.37 | - |
| VIC | -1.73 | -1.52* | -0.48 | -0.75 | 2.34** | 1.72 * | 0.89 | -1.99 * | | | |
| | | -0.75 | | | | | | | | | |

n=29.

TABLE 2b: DESTINATION EQUATION - OLS ESTIMATES

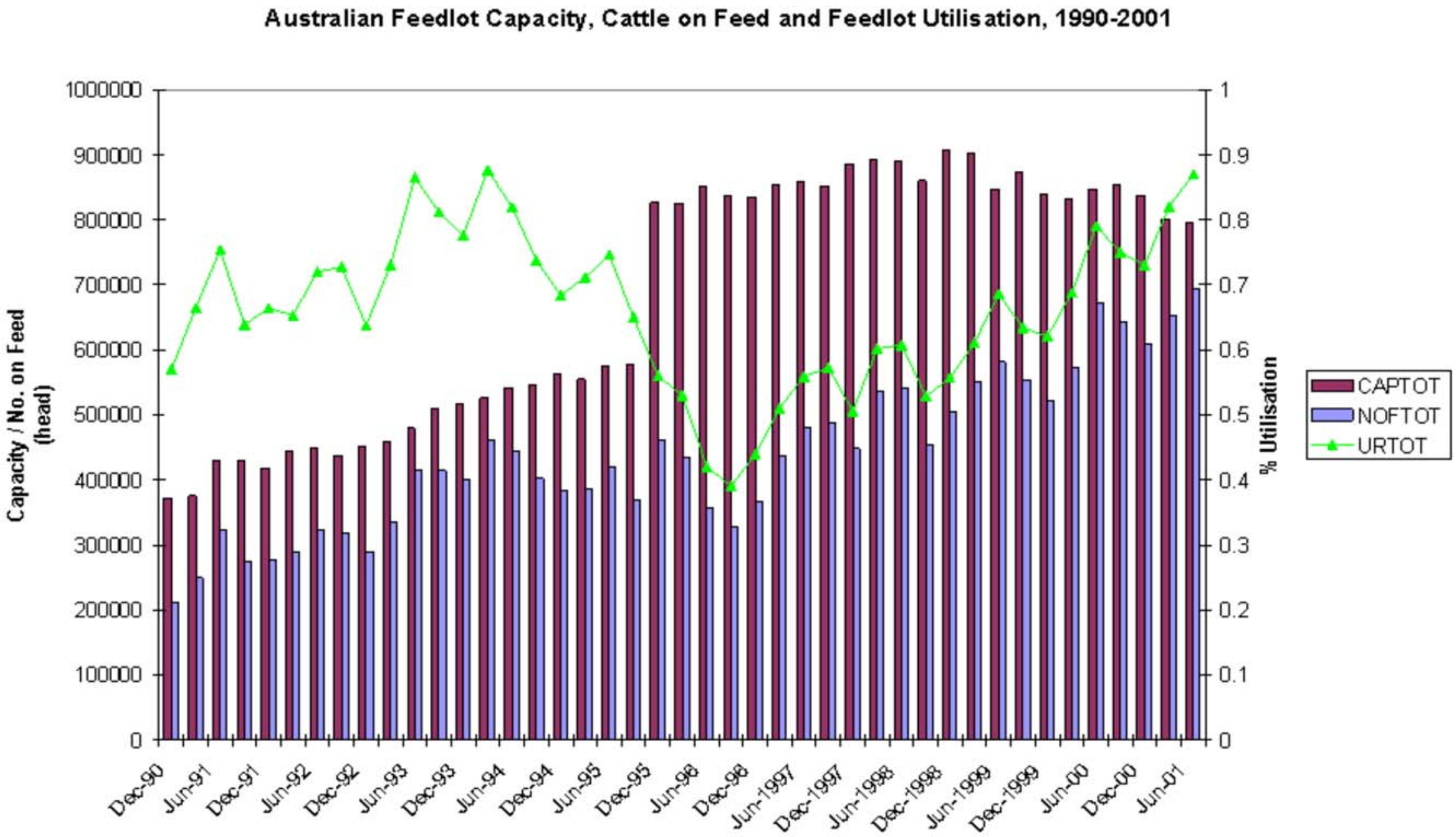
| | CAPACITY | PRICE OF FEED | PRICE OF FEEDER CATTLE | PRICE OF FED CATTLE | JAPANESE IMPORTS | Q1 | Q2 | Q3 | R2 | DW |
|---|---|---|---|---|---|---|---|---|---|---|
| DOMESTIC | 0.380 | -0.865 | 0.150 | 0.347 | - | 45.09 | 17.22 | 5.78 | 0.85 | 1.46 |
| | 9.51 ** | -6.08 ** | 0.77 | 2.86 ** | - | 3.42 ** | 1.24 | 0.43 | | |
| | 1.97 | -1.10 | | 1.26 | | | | | | |
| JAPAN | 0.367 | -0.199 | 0.320 | 0.951 | 0.255 | | | | 0.80 | 1.70 |
| | 5.02 ** | -0.82 | 1.47 * | 3.21 ** | 1.24 | | | | | |
| | 0.98 | | 0.20 | 0.71 | 0.14 | | | | | |

n=41 for Domestic, n=29 for Japan

TABLE 2b: DESTINATION EQUATION - 2SLS ESTIMATES

| | CAPACITY | PRICE OF FEED | PRICE OF FEEDER CATTLE | PRICE OF FED CATTLE | JAPANESE IMPORTS | Q1 | Q2 | Q3 | R2 | DW |
|---|---|---|---|---|---|---|---|---|---|---|

n=29.

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[2] The focus in this paper is numbers on feed and destination of fed cattle. See Griffith *et al.* (2002) for preliminary estimates of feedlot capacity equations.

[3] The results reported here are obtained using a regression method called three-stage least squares (3SLS). We use this method for two reasons: (a) to account for the possible joint decisions on where to place cattle on feed and/or on which market to feed for; and (b) to account for the fact that the explanatory variable "feedlot capacity" is really influenced by the same factors as numbers on feed (ie it is simultaneously determined). Results from simpler methods such as ordinary least squares (OLS) and two-stage least squares (2SLS) are given in the Appendix for interested readers. Further, the results for models with price ratios are not reported because in general they did not provide as high a level of explanation and there was a greater incidence of signs contrary to prior expectations.