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Identifying opportunities to add value to the New Zealand beef industry: a modelling approach

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ABSTRACT

A model of the New Zealand beef value chain, from conception to export, was constructed. The model is parameterised at the national level so that issues and opportunities within the beef industry can be examined at a high level by researchers and industry participants. Working with numerous key informants from throughout the beef industry, the researchers developed a conceptual model of the beef value chain and then constructed the model in a spreadsheet. The model is capable of modelling changes in farm practice, market situations and the industry structure. This model and a range of scenarios have been demonstrated to a range of beef industry participants facilitating considerable debate. To illustrate the power and value of the model in evaluating change and facilitating debate within the beef sector, three scenarios are presented and compared with the *status quo*.

Keywords: value chain; scenario evaluation; beef; model.

INTRODUCTION

New Zealand's (NZ's) beef industry produces approximately 580,000 tonnes of beef per year, about 80% of which is exported, with approximately 70% of this beef destined for the North American grinding (manufacturing) market. At present, around 60% of beef cattle originate from the dairy industry. Beef cows produce 1.1 million calves (heifers or steers) per year for the prime beef market. In addition, 0.4 to 0.6 million of the 3.3 million calves produced by the dairy industry, predominantly Friesian or beef-sired dairy cross bulls, are retained for the manufacturing beef market. Cull dairy cows also contribute significantly to this market. Improved efficiencies, and changing management strategies to better link the dairy and beef industries, have the potential to provide benefits along the whole beef value chain. However, it is difficult to objectively assess and quantify these.

The objective of this research was to develop a predictive model to identify and quantify the long-run impacts of different strategies on NZ beef producers, processors and exporters. This model is useful in helping identify where the greatest impacts for future research and development and/or enhanced industry relationships might be likely to occur. The outputs of the model are analyses of different scenarios and recommendations based on these analyses for industry strategy and investment. This paper presents several such scenarios. The model could also become a useful tool for assessing future research projects.

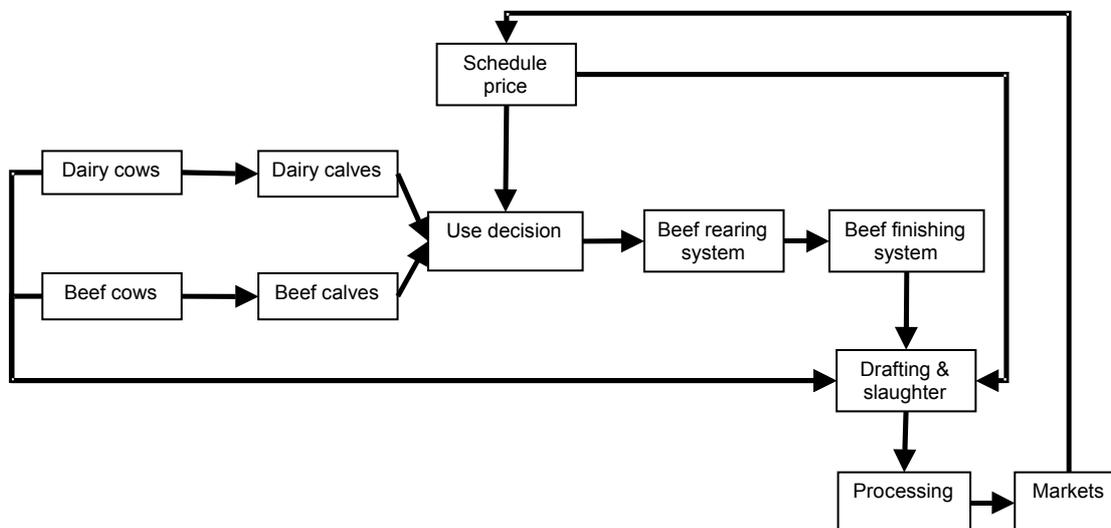
METHOD

The first stage of the project was to define the range of possible issues, problems and questions that the project sponsors might want answered. Stage 2 was the development of a conceptual model of the beef and dairy industries using workshops with key informants for the industries. Stage 3 involved the development and

construction of a systems dynamic model to describe the NZ beef industry, including the relevant components of the dairy industry that are integrated with the beef industry. The model was developed in Microsoft Excel to ensure transparency and accessibility. The model includes all aspects of the beef industry, at a national level, from the farm to the export market (Figure 1) and runs for 20 years on a quarterly basis to predict long-run changes. The model incorporated 318 classes of growing cattle (age, sex, end-use, breed, age and feeding system factors – i.e. 27 classes x 3 age groups of steers; 39 classes x 3 age groups of bulls; 36 classes x 2 age groups of heifers; 12 classes x 3 age groups of cows and 12 classes of calves). These groups of cattle progressed through the model in sequential steps from conception through to slaughter and then on through to market. The model was parameterised at the national level (see Smeaton, McDermott & Dooley (2004) for complete details of the model construction and assumptions) and any given parameter(s) (e.g. weaning rate, proportion of natural mating used in dairy herds) could be changed for evaluating a scenario. The model could also be re-parameterised at a lower level evaluating regional or company catchment scenarios although this has not been tested yet.

Means and standardised variances in live weight (Wake *et al.*, 1999) described the population of cattle in each class. Cattle in each class grew at average long-run growth rates (Smeaton, 2003) calculated for each quarter. Feed consumption (Geenty & Rattray, 1987) was then calculated for each quarter for the different classes of cattle. The model calculated the number of cattle from each class to slaughter in each period. The five functions used to calculate slaughter numbers (one for the slaughter of each of cows, bulls, steers, heifers and calves) were determined by analysing time series data (for at least 8 years, up to and including 2001) for numbers of cattle on hand, moisture deficit days (a proxy for feed available), time of year and slaughter prices. Other variables such as

FIGURE 1: Conceptual model of the New Zealand beef industry at a national level. This conceptual model shows the flows and feedback loops used in the model.



milk price and carcass weight were also considered in the analysis but they did not add to the accuracy or reliability of predictions. The heaviest animals in the various classes were drafted for slaughter until a cut-off weight is reached such that the calculated numbers (predicted by the least squares regressions above) were killed (Barr & Sherrill, 1989). Estimated meat cuts from these animals are then allocated to the most valuable markets first (volumes and prices of beef cuts exported were provided by Meat New Zealand). Average market prices are calculated and then fed back into the model as a ‘fair’ schedule price (i.e. excludes price components such as procurement premiums). The cost of feed consumed was assumed to be \$0.09/kg DM based upon an analysis of farm survey statistics (Meat and Wool Innovation, 2002).

The outputs of the model include total FOB revenue, production and processing costs, net value (where, net value = total FOB revenue – cost of production – cost of processing), fair schedule prices, on-farm returns, slaughter numbers and weights, beef production by cuts (loins, secondary and processing) and feed consumption.

To validate the model, predictions made by the model were compared to historical holdout data. Several functions were then refined and the model re-run to confirm that it did reflect reality. Several scenarios were then run and presented to industry for feedback, after which the model was further refined. Three further scenarios were then run to study the effects of interactions and feedbacks along the value chain, and to identify those parts of the value chain that were most sensitive to changes. These scenarios are presented below.

Description of scenarios

Three scenarios were modelled. The first two scenarios represent the introduction of innovations or new practices on farms while the third scenario represents a shift in the market situation.

1. Scenario 1: More beef x dairy calves. The number of dairy cows mated to beef sires was increased from the current level of 19% to 38%, a level at which most of the surplus reproductive capacity in dairy herds was being used for producing beef-cross calves. The number of bobby calves predicted by the model to be slaughtered was reduced by 25% to reflect the higher retention of calves with beef-type attributes (Smeaton *et al.*, 2004).
2. Scenario 2: Improved beef cow productivity due to (1) pregnancy rates rising by 5% (from 90% to 95%); (2) reduction in calf losses at and soon after calving by 2.5% (from 10% to 7.5% of calves born); (3) a 30% reduction in the use of early maturing sire breeds and (4) a commensurate increase in the use of late maturing sire breeds relative to status quo.
3. Scenario 3: Changes in NZ’s United States of America (USA) beef quota volumes. This case involved two scenarios – (a) increasing the USA beef quota by 50% from the current 213,402 tonnes per annum to 320,000 tonnes and (b) reducing the quota by 50% to 106,000 tonnes per annum (McDermott *et al.*, 2004).

RESULTS AND DISCUSSION

Beef value chain model

Least squares regression analysis using 8 to 13

TABLE 1: Variables contributing significantly ($P < 0.05$) to the slaughter functions (number or proportion of cattle slaughtered within each quarter) for each of the five classes of cattle.

	Price	Number on hand	Number slaughtered previous period	Feed	Feed previous period	Season	R ²
Bulls		✓	✓	✓			0.90
Steers	✓	✓		✓	✓		0.90
Heifers				✓	✓		0.82
Cows		✓				✓	0.96
Calves	✓	✓					0.93

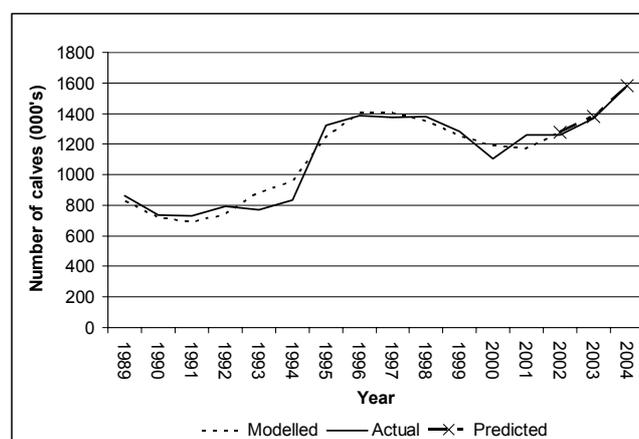
years historic data (by quarter) was used to derive functions for predicting the numbers of bulls, steers, heifers, cows and calves slaughtered in each quarter. Price, numbers on hand, number slaughtered in the previous quarter, and quarter (season) were used to predict slaughter number. Table 1 shows the inputs used in the slaughter function to predict the numbers of cattle to be slaughtered for each class. The slaughter functions for bulls, steers, heifers, cows and calves were all capable of predicting slaughter numbers relative to actual with a high level of accuracy ($R^2 > 0.90$ in most cases, see Table 1).

Figure 2 provides an example of the validation of the slaughter functions comparing the model's predictions with historical holdout data.

Predicted outcomes of the scenarios

Based upon 2001 market prices, the beef industry earns \$2,254 million FOB per annum. Table 2 shows the predicted long-run impacts on revenue, value, feed requirements and slaughter numbers for the three scenarios described above.

Increasing the number of dairy-beef cross progeny (Scenario 1, Table 2) is expected to generate extra revenue of \$220m per annum. This 10% increase in revenue translates into an additional \$182m in net

FIGURE 2: Numbers of bobby calves slaughtered between 1989 and 2004. The model was fitted to data from 1989 to 2001, and the model's bobby calf slaughter function was then used to predict actual slaughter numbers for 2002/2004.**TABLE 2:** Predicted long-run impacts on numbers of animals killed and prices received for the three scenarios compared with the *status quo* situation.

Scenario:	<i>Status quo</i>	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b
Total industry returns (\$NZm)	2254	2474	2375	2315	2103
Total farm gate returns (\$NZm)	2070	2296	2190	2128	1923
Net value to industry (\$NZm)	1266	1448	1358	1300	1147
Total feed eaten (mT dry matter)	11.0	11.4	11.3	11.3	10.6
Steer slaughter numbers (000s)	525	530	578	522	524
Bull slaughter numbers (000s)	656	955	596	670	584
Heifer slaughter numbers (000s)	410	454	622	410	410
Cow slaughter numbers (000s)	851	851	801	851	851
Total slaughter numbers (000s)	2442	2790	2595	2453	2369
Number of bobby calves (000s)	1562	1190	1554	1545	1642

value to the beef industry (14%), potentially shared by the various participants along the dairy-beef value chain including dairy farmers, calf rearers, finishers and processors. Calf retention (both bulls and heifers) is the key driver of this increase. A modest improvement to beef cow systems including increased pregnancy and calf survival rates, and wider use of late-maturing sires (Scenario 2) is expected to offer \$121m in additional revenue. This improvement would contribute an extra \$92m net value per annum. Increasing the size of the USA beef quota (Scenario 3a) has only a small impact on revenue and net value, increases of \$58m and \$34m respectively. These increases are relatively small because most of the processing grade beef produced in NZ is exported to the USA. For example, approximately 87% of processing grade bull beef and 75% of processing grade cow beef goes to the USA. This illustrates the importance of the USA manufacturing beef market with respect to volumes exported and prices received, but suggests that the current quota is sufficient provided production of manufacturing beef remains at or close to current levels. If the number of cull dairy cows increased, the benefit of an expanded quota would also increase. However, decreasing the size of the USA beef quota by 50% (Scenario 3b) is predicted to have a significant negative impact on the total revenue earned (decreases by 7% to \$1923m) and on net value which is expected to decrease by \$119m (9%). Fewer dairy calves would be retained for finishing as bulls while other cattle numbers are unlikely to increase to compensate. However, other enterprises would replace bull finishing and balance some of the lost beef revenue. Cull dairy cattle returns also decline due to lower prices in alternative markets.

Although feed requirements increased for three of these scenarios, the increases were only small (no greater than 3.6%). We expect that these increases would be automatically achieved through improved pasture utilisation without significant cost to other enterprises on farms.

This model has also been used to model structural changes to the NZ beef industry such as higher land prices (raising the cost of feed) (McDermott *et al.*, 2004).

CONCLUSIONS

We have developed a model that faithfully describes the NZ beef value chain. The three scenarios presented in this paper demonstrated the integrative capacity of the model and the learning opportunities the model offers our beef industry and provides confidence about the benefits of making changes. These scenarios represent the introduction of new technologies and practices on farms (Scenarios 1 and 2) and changes in market situations (Scenario 3), and the results from the model are presented to encourage debate about the future shape and direction of the NZ beef industry and investment in helping to ensure these changes occur. Structural changes to the NZ beef industry such as higher land prices could also be modelled. This value

chain model allows participants in the NZ beef industry to understand the impacts that changes in farm practice, markets and industry structure are likely to have on the industry at a national level. It provides a robust framework that facilitates discussion amongst industry leaders and the opportunity to explore ideas and strategies as to where investments should be made, where potential lies and threats exist in order to secure a sustainable, profitable future for NZ beef farmers and processors.

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