A Model of the New Zealand Beef Value Chain

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EXTENDED ABSTRACT

New Zealand'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 manufacturing market. Around 65% of beef cattle originate from the dairy industry. Beef cows produce 1.1 million calves (killed as 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, changing management strategies and better linkages between 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.

A dynamic simulation model was developed to identify and quantify the impacts of different strategies on efficiency and integration between the dairy and beef sectors for New Zealand's beef producers, processors and exporters. This model can be used to assist with future industry planning at the national level. Expected model outputs are analyses of different scenarios and recommendations based on these analyses for industry strategy and investment.

Industry issues and questions to be answered by the project were defined, and a conceptual model of the beef and dairy industries was developed through workshops with key informants in the industries. A Microsoft Excel spreadsheet model was developed to describe the New Zealand beef industry and its integration with the dairy industry from the farm to the export market. This model runs for 20 years on a quarterly basis to predict long-run changes. The model incorporates 318 classes (age, sex, end-use, breed and feeding system factors) of growing cattle which move though the model in sequential time steps. Standardised liveweight variances were used to describe each cattle class. Five functions were derived to predict the slaughter of each of cows, bulls, steers, heifers and calves. Numbers slaughtered were predicted using numbers on hand, moisture deficit days (a proxy for feed available), time of year and slaughter prices. The heaviest animals in the various classes were drafted for slaughter until a cut-off weight was reached, at a point where the predicted numbers of animals are slaughtered. Meat cuts from these animals were then allocated to the most valuable markets first. Average market prices were calculated and then fed back into the model to help predict slaughter numbers.

The model was validated against historical data, refined and 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. The model was run for several scenarios 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.

Three scenarios run were: (1) higher or lower land prices (affecting the cost of feed); (2) more beef x dairy calves (from an increase in artificial insemination with beef semen in the dairy industry leading to retention of more calves from the dairy industry with beef-type attributes); and (3) introgression of a set of genes that lead to better feed conversion efficiency.

Results demonstrated that significant opportunities do exist for the beef industry to improve total returns, while some policies could be quite costly to the industry. Model benefits include: (a) identifying where the greatest impacts for future research and development, and enhanced industry relationships might occur; (b) assisting in assessing future research projects; (c) enhancing learning by model users and industry people through thinking about why particular outcomes might have occurred; and (d) identifying areas where information is inadequate or unavailable.

1. INTRODUCTION

New Zealand's beef industry produces approximately 580,000 tonnes of beef per year. About 80% of this beef is exported, with approximately 70% of this beef destined for the North American manufacturing market. Currently, 35% of cattle slaughtered originate from the beef industry with the remaining 65% coming from the dairy industry (Beeby 2003). Beef cows produce 1.1 million calves 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 cows also contribute substantial volumes of beef to this market (Beeby 2003). Improved efficiencies, changing management strategies, and improved linkages between 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 benefits. A dynamic simulation model was developed to identify and quantify the likely impacts of change on New Zealand's beef producers, processors and exporters. This model can explore the impacts of technologies or practice changes, changes in New Zealand's beef marketplaces and changes to the structure of the beef and dairy industries. This paper will describe the model and its development. Three scenarios will be described to demonstrate the usefulness of the model for evaluating future research or industry changes. The usefulness of the model will be discussed.

2. DEVELOPMENT OF THE MODEL

There were three stages in the development of the model (1) discussion with industry to identify issues that they thought a model cold be used to address; (2) development of a conceptual model; and (3) development of a systems simulation model. Model development has been partly described by McDermott et al. (2005a., 2005b.) but is expanded in this paper.

The first stage of the project defined the range of possible issues, problems and questions that the project sponsors (then Meat and Wool Innovation, now Meat & Wool NZ) wanted answered. These primarily fitted into three categories: the impacts at a national level of changes in (a) technology or practices, (b) markets and (c) industry structure.

Stage 2 was the development of a conceptual model of the beef and dairy industries using three workshops and three interviews with key informants from these industries. This conceptual model formed the basis for progression to Stage 3. A mentor group was involved with the project. Four meetings were held with the mentor group throughout stages 2 and 3 to advise and provide feedback on model development.

Stage 3 was the development and construction of a systems dynamic model in Microsoft Excel, to describe the New Zealand beef industry, including the components of the dairy industry that are integrated with the beef industry. The model includes all aspects of the beef industry, at a national level, from the farm to the export market (Figure 1).

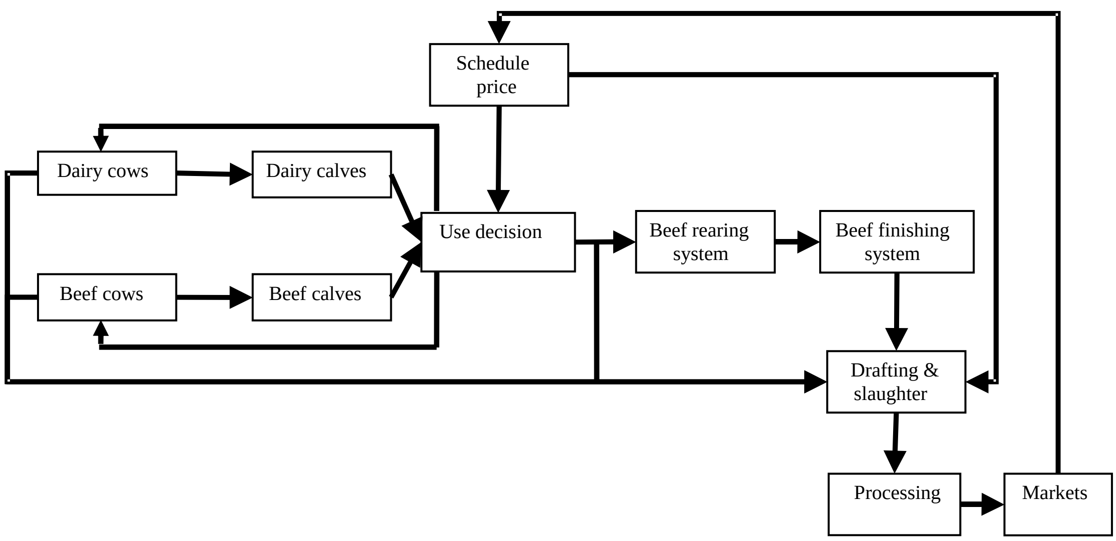

Figure 1. A conceptual model of the New Zealand Beef Industry at a national level (from McDermott et al. 2005b.). This conceptual model shows flows and feedback loops used in the model.

The model runs for 20 years on a quarterly basis to predict long-run changes. The model was parameterised at the national level (see Smeaton et al. (2004) for complete details of the model construction and assumptions). Therefore, all parameters are aggregate or national averages (many parameters are described by means and standardised variances) and as such, no attempt is made to reflect decision making at an individual farmer level. Data for model parameterisation was sourced from industry publications, industry bodies (e.g., Meat New Zealand), and industry experts. A large number of assumptions were made by experts familiar with the industry because published data were often unavailable or considered inaccurate. Any given parameter(s) (e.g. weaning rate, proportion of natural mating used in dairy herds) can be changed for evaluating a scenario.

The model incorporated 318 classes of cattle by age, sex, end-use (e.g., herd replacements, beef finishing), breed, and feeding system – i.e., 27 classes x 3 age groups of steers; 36 classes x 2 age groups of heifers; 39 classes x 3 age groups of bulls; 12 classes x 3 age groups of cows and 12 classes of calves). A closed system was assumed. All animals remained accounted for until they were slaughtered or died otherwise (i.e., losses). This is appropriate at a national level in New Zealand where there are few international animal transfers.

Means and standardised variances in liveweight (Wake et al. 1999) described the weights of the cattle population 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) using least squares regression. Numbers of cattle on hand, moisture deficit days (MDD, a proxy for feed available), time of year, milk price, carcass weight and slaughter prices were considered (Table 1). Those variables that were non-significant or did not add to the accuracy or reliability of the predictions were excluded from the functions in the model. The equation was tested against holdout data for 2002 to 2004. Figure 2 shows the prediction on bobby calves killed against actual values, for the fitted model and historical holdout data.

The heaviest animals in the various classes were drafted for slaughter until a cut-off weight was reached such that the calculated numbers (predicted by the least squares regressions described above) were killed (Barr & Sherrill 1989). This is shown diagrammatically in Figure 3.

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 cattle classes (from McDermott et al. 2005b.). Non-significant variables were excluded from the functions in the model. * P<0.05, NS not significant, - not tested.

	Price (NZ$)	Number on hand	Number slaughtered previous period	Feed (MDD)	Feed in previous period (MDD)	Milk price	Carcass weight	Season	R^2
Bulls	NS	*	*	*	NS	NS	NS	NS	0.90
Steers	*	*	NS	*	*	-	NS	NS	0.90
Heifers	NS	NS	NS	*	*	-	NS	NS	0.82
Cows	NS	*	NS	NS	NS	NS	-	*	0.96
Calves	*	*	-	-	-	NS	-	-	0.93

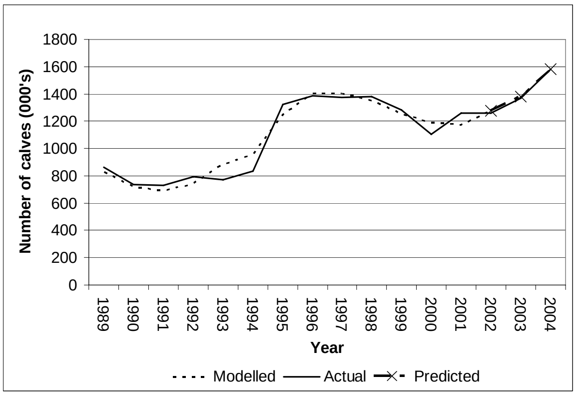

Figure 2: Numbers of bobby calves slaughtered between 1989 and 2004. The model was fitted to data from 1989 to 2001, and the model's bobby calf slaughter function was then used to predict actual slaughter numbers for 2002-2004.

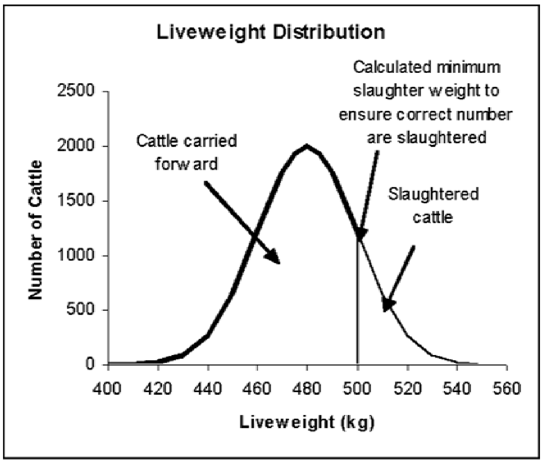

Figure 3: Diagram demonstrating cut-off liveweights for cattle slaughtered.

At slaughter, carcasses are broken into three cut types; loins, secondary cuts and processing cuts, at different ratios depending upon sex and breed. This creates 12 types of beef from slaughtered heifers, steers, bulls and cows. The 12 types of beef are then distributed across a range of 16 different markets: chilled or frozen for seven regions (US, Canada, Japan, Korea, Taiwan, Rest of Asia, Rest of World) and a remainder region "Other", which included the New Zealand domestic market, to capture beef produced over and above 2001/2002 export sales volumes. 2001/2002 price FOB (free on board, i.e., loaded onto a ship in a New Zealand port) and volume data were obtained from Meat NZ to construct demand profiles for each of these 14 export markets (Meat NZ unpublished data), and the estimated beef cuts were allocated to the most valuable markets first.

These prices were adjusted downwards to reflect the most recent full meat production year, 2003/2004, and to ensure the average FOB prices calculated in the model were similar to the actual average FOB prices reported by Davison (2005). Similarly, numbers of cattle slaughtered and the volumes of different types of beef cuts produced were compared with industry data (Meat NZ unpublished data) to ensure the model was faithfully representing the status quo situation (2003/2004). Average market prices were 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 12c/kg DM based upon an analysis of farm survey statistics (Meat and Wool Innovation 2004).

The model calculates net value created. This is derived from FOB returns less processing costs less production costs. At 2003/2004 prices, the net value created by the New Zealand beef industry was $793m.

3. SCENARIO ANALYSIS

Three scenarios were modeled. The first scenario represents a structural change that is occurring within the beef industry in New Zealand, while the second and third scenarios represent the introduction of a new practice and a new technology onto farms. Beef breeding cow numbers and bobby calf retentions were adjusted to ensure total feed consumption remained similar to the status quo situation.

The first scenario considered the threat to ongoing value creation from the beef industry in its current form because of increasing land prices and the associated cost of feed. In 2003/2004, the average value of typical beef producing land in New Zealand was approximately $7000/ha (estimated from Meat & Wool Innovation 2004). The sensitivity of net value creation from the beef industry was tested against a higher land price of $9500/ha and a lower land price $4500/ha (revised from the 2001/2002 example in McDermott et al. 2004). These scenarios relate to feed costs for pasture of 12c/kg DM, 15c/kg DM and 9c/kg DM, respectively. Higher land price (and therefore feed cost) reduces returns to the beef industry by $300m to $487m. Should land prices return to levels similar to 2001/2002 ($4500/ha), an additional $305m of value would be created. Increasing land price is realistic given the two- to three-fold increase in land prices over the past five years, the decline in sheep and beef farm profitability over the past 25 years (now below 2%, Davison 2005) and the disassociation of land prices with returns from farming (Davison 2005). The large reductions in value creation suggest that one of four things may happen: (a) land use will change away from beef production, (b) large step-changing technologies are required to substantively improve beef production efficiencies in terms of growth rate and stock turnover (reducing time to slaughter and thus maintenance feeding costs) (c) beef prices need to substantively increase or (d) land prices need to decline, which we consider unlikely to happen.

The second scenario described the more widespread use of beef sires in the dairy industry (McDermott et al. 2005b.). The number of dairy cows mated to beef sires was increased from the current level of 19% to 29%, at which half of the currently surplus reproductive capacity in dairy herds is being used for producing beef-cross calves. The number of bobby calves predicted by the model to be slaughtered was reduced by 10% to reflect the higher retention of calves with beef-type attributes for rearing (Smeaton et al. 2004). Increasing the number and quality of beef type animals produced from the dairy industry appears to be a highly valuable opportunity resulting in an additional $57m in net value to the beef industry (increase of 7.2%), 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) and the greater efficiency of these cattle classes (relative to steers) are the key drivers of this increase. This suggests a substantial opportunity exists for dairy farmers, calf rearers, beef finishers and processors to co-ordinate to produce a supply of dairy x beef calves and finished cattle for the beef industry.

The third scenario described the introduction of a set of genes into the beef herd to improve feed conversion efficiency. The feed conversion of beef cattle was assumed to increase through the introduction of a set of net feed intake genes into half of the country's beef herds. A 5% reduction in the amount of feed to produce a given amount of liveweight (for beef progeny only) was assumed (Morris pers. comm.) based upon indications from the feed efficiency research currently carried out at the Beef Co-operative Research Centre III in Australia. The analysis suggested that the same number of cattle could be reared and finished while consuming 2% less pasture across a year. This feed could be used to either finish more cattle or feed alternative livestock classes to generate additional revenue. Feeding more beef cattle (beef cow herd grows slightly to supply more calves) results in $7m additional revenue and a $7m increase in net value.

4. MODEL USE AND FUTURE DEVELOPMENTS

The model can integrate changes in technology and structure with known aggregate behaviour to provide an indication of the likely outcomes at the national level of these changes. This type of industry analysis cannot reliably be undertaken using a simple multiplicative cost benefit approach because it is difficult, if not impossible, to include the numerous and often complex systems interactions.

The participation of industry people in model development and testing, and the model developers' considerable beef industry knowledge contributed to the successful development of this model, and to industry interest in the model. The fact that a large number of parameters can be changed, and the ease with which these parameters can be changed, makes the model flexible in its ability to model beef industry scenarios. The three scenarios presented in this paper demonstrated the integrative capacity of the beef value chain model and the learning opportunities the model offers New Zealand's beef industry.

Identification of the reasons for the impacts of any parameter changes, and consideration of the implications of these changes requires careful interpretation of the results by someone familiar with the beef industry. An unexpected benefit identified during model development was the learning by model users and industry people through thinking about why particular outcomes might have occurred for each scenario and the factors that might be contributing to those outcomes.

This value chain model allows participants in the New Zealand 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 New Zealand beef farmers and processors. Several users of the model are already working with farmers, processors and Meat and Wool NZ for this purpose. It is hoped that these industry participants will continue to use the model to obtain an objective assessment of the likely impacts of changes and to guide their decision-making.

A considerable number of assumptions from those familiar with the industry were required during model development and another benefit from this research was the identification of areas where current information was inadequate or unavailable, thus requiring future research. One of the keys to maximising the future usefulness of this model will be maintaining the accuracy of various industry parameters, prices and market sizes. This will ensure that farmers and processors can relate directly to results from the model and that the results accurately reflect the likely outcomes at that time. There is potential to develop the model further to represent regions or supply catchments. This would require the identification of parameters and functions to represent these regions or supply catchments.

5. ACKNOWLEDGMENTS

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