A model of the New Zealand beef value chain: evaluating opportunities

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Abstract
A model of the New Zealand beef value chain, from conception to export, was constructed. The model was 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. The model is capable of modelling changes in farm practice, market situations and the industry structure. To illustrate the integrative power and value of the model in evaluating change within the beef sector, three scenarios are presented and compared to the status quo: changes in land price; wider use of beef semen in the dairy industry; and introduction of a gene to improve net feed intake. From the three scenarios presented, it is apparent that land price dominates the ability of the NZ beef industry to create value in the long-run. Although behaviour, practices and technologies can contribute to overcoming this factor, such changes will need to be substantive – incremental improvements will not be sufficient. This model provides the basis for facilitating debate on the future of NZ's beef industry and how to ensure long-run profitability.
Keywords: beef industry, scenario evaluation, beef systems, value chain model

Introduction
New Zealand's beef industry produces approximately 580000 tonnes of beef/yr, about 80% of which is exported, with approximately 70% of this beef destined for the North American manufacturing market. At present, around 65% of beef cattle originate from the dairy industry (Beeby 2003). Beef cows produce 1.1 m calves/yr for the prime beef market. In addition, 0.4 to 0.6 m of the 3.3 m 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, 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, due to the complexities of the beef systems and value chains, 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 change on NZ beef producers, processors and exporters. The changes this model was developed to cope with were technologies or practice changes, changes in NZ's beef marketplaces and changes to the structure of the beef and dairy industries. The results of scenarios evaluated using this model will be used to help identify where the greatest impacts for future research and development lie, substantial threats to the profitability and or financial sustainability of the beef industry in NZ, the benefits different industry strategies may have and where enhanced industry relationships might be likely to create value.

This paper provides a brief description of the model and then presents several scenarios and illustrates how the model could become a useful tool for assessing future research projects. The first scenario considers 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 (scenario 1); the second scenario describes one of the more promising opportunities identified through use of the model, the more widespread use of beef sires in the dairy industry (scenario 2, revised from that previously reported in McDermott *et al.* (2005)) and the third scenario describes the introduction of a gene into the beef herd to improve net feed intake (scenario 3).

Method
The development of the model has been partly described by McDermott *et al*. (2005), but is repeated and expanded here for convenience. The first stage of the project was to define the range of possible issues, problems and questions that the project sponsors (then Meat and Wool Innovation, now Meat & Wool NZ) might want 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 workshops with key informants for the industries. This conceptual model formed the basis for progression to Stage 3, which 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 includes all aspects of the beef industry, at a national level, from the farm to the export market (Figure 1 (McDermott *et al.* 2005)) and runs for 20 years on a quarterly basis to predict long-run changes. The model was parameterised at the national level (see Smeaton *et*

Figure 1 The conceptual model of the NZ beef industry at a national level (McDermott *et al.* 2005). This conceptual model shows the flows and feedback loops used in the model.

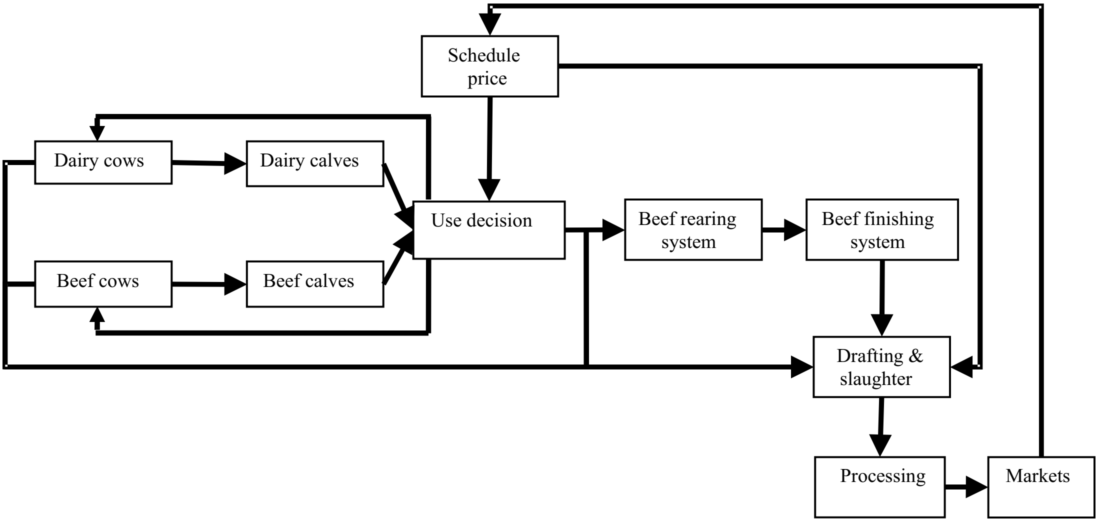


Table 1: Variables contributing significantly (P<0.05) to the slaughter functions (number or proportion of cattle slaughtered within each quarter) for each of the five classes of cattle (adapted from McDermott *et al.* 2005). Those variables not significant were excluded from the functions in the model. * P<0.05, NS not significant, – not tested.

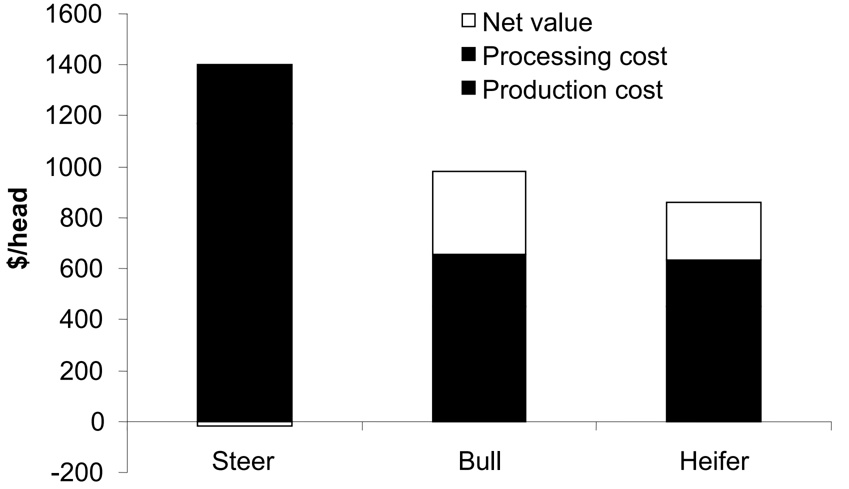
	Price	Number on hand	Number slaughtered previous period	Feed	Feed previous period	Milk price	Carcass weight	Season	R^2
Bulls	NS	*	*	*	NS	NS	NS	NS	0.90
Steers	*	*	NS	*	*	-	NS	NS	0.90
Heifers	NS	NS	NS	*	*	-	NS	NS	0.82
Cows	NS	*	NS	NS	NS	NS	-	*	0.96
Calves	*	*	-	-	-	NS	-	-	0.93

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. 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 incorporated 318 classes of cattle (age, sex, end-use, breed, and feeding system factors – 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). Means and standardised variances in liveweight (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 (Table 1). 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).

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

Figure 2 Comparison of cost of production, cost of processing and net value on a per head basis between average steers, bulls and heifers slaughtered across a year.



(US, Canada, Japan, Korea, Taiwan, Rest of Asia, Rest of World) and a remainder region "Other", which included the NZ domestic market, to capture beef produced over and above 2001/2002 export sales volumes. 2001/2002 price and volume data was obtained from Meat NZ to construct demand profiles for each of these 14 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 (free on board, i.e. loaded onto a ship in a NZ port) calculated in the model were similar to the actual average FOB prices reported by Davison (2005). 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.

To validate the model, predictions made by the model were compared to historical holdout data (see McDermott *et al.* (2005) Figure 2 for an example of these comparisons).

Description of scenarios

Three scenarios were modelled. The first scenario represents a structural change that is occurring within the beef industry in NZ, while the second and third scenarios represent the introduction of a new practice and a new technology on farms.

1. Scenario 1: In 2003/2004, the average value of typical beef producing land in NZ 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 (Scenario 1a) and a lower land price $4500/ha (Scenario 1b) similar to those in 2001/2002 (revised from McDermott *et al.* 2004).
2. Scenario 2: More beef x dairy calves. This is a refinement of the same scenario reported by McDermott *et al.* (2005). The number of dairy cows mated to beef sires was increased from the current level of 19% to 29%, a level at which half of the currently 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 10% to reflect the higher retention for rearing of calves with beef-type attributes (Scenario 2a) (Smeaton *et al.* 2004). As a revision of the scenario reported by McDermott *et al.* (2005), this scenario was also tested against no change in the breeds of sires used by dairy farmers but still increasing the retention of calves for rearing (Scenario 2b).
3. Scenario 3: Net feed intake gene. The feed conversion of beef cattle was assumed to increase through the introduction of a net feed intake gene into half of NZ'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.

Beef breeding cow numbers and bobby calf retentions were adjusted to ensure total feed consumption remained similar to the status quo situation.

Results and discussion

Based upon 2003/2004 market prices, the beef industry

Table 2 Predicted long-run impacts on numbers of animals killed and prices received for the three scenarios compared with the status quo situation, using 2003/2004 prices and parameters.

Scenario	Status quo	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b	Scenario 3
Total industry returns ($NZm)	2013	2013	2013	2066	2076	2020
Net Value to Industry ($NZm)	793	487	1098	850	852	800
Excluding cull dairy cows	408	102	713	465	467	415
Total feed eaten (mT dry matter)	10.17	10.17	10.17	10.13	10.20	10.17
Steer slaughter numbers (000s)	527	527	527	520	506	531
Bull slaughter numbers (000s)	639	639	639	706	799	639
Heifer slaughter numbers (000s)	303	303	303	379	296	302
Cow slaughter numbers (000s)	886	882	882	880	866	882
Total slaughter numbers (000s)	2358	2350	2350	2485	2467	2350
Number of bobby calves (000s)	1706	1706	1706	1531	1529	1706

earns $2013m FOB per annum. Table 2 shows the predicted long-run impacts on revenue, value, feed requirements and slaughter numbers of the three scenarios described above.

At 2003/2004 prices, the net value created by the NZ beef industry was $793m. At the same time, the average value of typical beef producing land was $7000/ha. If the average land price was to increase to $9500/ha, driving up the average cost of feed on an average beef farm from 12c/kg DM to 15c/kg DM, approximately $300m of value is eroded from the industry, down to $487m (Scenario 1a). Should land prices return to levels similar to 2001/2002 of $4500/ha, reducing the average cost of feed on an average beef farm to 9c/kg DM, the beef industry would create an additional $300m of value (Scenario 1b). This first scenario is entirely feasible given the two- to three-fold increase in land prices over the past five years, while the second illustrates where the industry has moved from in just three years. Sheep and beef farm profitability (rate of return on capital) has steadily declined over the past 25 years and is now below 2% (Davison 2005). Davison (2005) also showed how land prices are now disassociated with returns from farming; using 1990-1991 as a base index year, land prices in 2004-2005 are five times 1990-91 levels while profit/ha is just two and a half times higher. Further, the beef schedule has only increased by 21% during this same period from 257c/kg to 310c/kg (Meat & Wool NZ Economic Service 2005). The large reductions in value creation suggest that one of four things will or need to 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, highly unlikely in our opinion.

Increasing the number and quality of beef type animals produced from the dairy industry appears to be a highly valuable opportunity (Scenario 2a, Table 1) as described by McDermott *et al.* (2005). In this scenario, surplus reproductive capacity in the dairy industry was mated to beef sires and the progeny retention rate increased (10% less bobby calves slaughtered per annum). An additional $53m in revenue could be generated (revised from McDermott *et al*. 2005). This 2.6% increase in revenue translates into 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 (Figure 2). The comparison where more calves are retained but the genetic make-up of progeny remains unchanged from the status quo (Scenario 2b) is much less likely because the model is already accurately predicting aggregate behaviour and a similar priced market must be found for nearly 100000 more bulls. Thus, the $2m difference is likely to be reversed and be substantive. If dairy farmers, calf rearers, beef finishers and processors are able to co-ordinate to produce a supply of dairy x beef calves and finished cattle, there is a substantial opportunity for the beef industry. Oliver & McDermott (2005) found that a premium for beef-cross calves of $30-$50/hd would be sufficient to encourage dairy farmers to use more beef genetics across their dairy herds. This finding supports one of the underlying assumptions in this scenario, the increased retention of 4-day-old calves for finishing.

The third scenario considered the introduction of a gene to improve net fed intake into the beef herd. 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 net value.

Although total feed demand was adjusted to be similar to the status quo situation, the adjustments to beef cow numbers was only small (less than 1%) and the seasonality of this demand remained essentially unchanged. The authors expect that these increases would be readily achieved without significant cost to other enterprises on farms.

This value chain model allows participants in the NZ beef industry (to date Meat and Wool NZ, Beef Council, researchers and numerous farmer groups) 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. However, one of the keys to maximising the 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 recent information is fully utilised.

Conclusion

This 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 to include the numerous and often complex systems interactions. The three scenarios presented in this paper demonstrated the integrative capacity of the beef value chain model and the learning opportunities the model offers our beef industry, and provides confidence about the benefits of making changes. The first scenario showed the tenuous situation the NZ beef industry finds itself when viewed from the value creation perspective, suggesting that either land use will change away from beef production or a paradigm shift is required in the way that we produce beef, incremental gains simply will not be good enough. The second and third scenarios represent how the introduction of different practices and behaviours, and new technologies, on farms can achieve improvements and lift value creation.

These and other results from the model will encourage debate about the future shape and direction of the NZ beef industry and investment in helping to ensure these changes occur. Considering the three scenarios presented, it is apparent that land price dominates the ability of the NZ beef industry to create value in the long-run. Behaviour, practices and technologies can however contribute to mitigating against this trend.

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