Management Science in the New Zealand Dairy Industry: A managerial perspective

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Abstract

We examine the historical relation of logistics to strategy in the NZ dairy industry, with special emphasis on OR/MS applications. We review the various ways in which efficiency has been realized in logistics in the industry (mostly through recourse to OR/MS). We especially dwell on how the structure (e.g., operating mechanisms) of the NZ dairy industry has supported and/or hindered the focus on supply chain efficiency.

1 Introduction

The dairy industry plays a very important role in New Zealand's economy. The New Zealand Dairy Board (NZDB), the industry's statutory export arm, generated export earnings of NZD 4.8 billion for the year ended 31 May 1999, which represented 23% of New Zealand's total export revenue[1]. In achieving this, the dairy industry appears to have been operating in a very cost-efficient manner. The industry as a whole has focused on cost minimisation as a means of remaining competitive in a global market that has, however, experienced declining commodity prices.

The subject of this paper is the relationship of logistics to company strategy in the New Zealand dairy industry, with an emphasis on OR/MS applications. (Our interpretation of logistics is quite broad, verging on the integrative management of the end-to-end supply chain; thus, in this paper, 'logistics' subsumes, for instance, production and operations planning as well.) The central thesis is that the New Zealand dairy industry would appear to have realised a strategic focus on cost innovation with regard to logistics. The strategy of cost leadership may not have been explicitly chosen, but might have evolved at least to some extent from the payment system used by the New Zealand Dairy Board (NZDB). To an extent, the perspective adopted herein is historical; the payment system as considered in this paper was superseded in June 1998 by a different model, and sweeping changes are afoot in the structure of the industry.

The thesis is supported with a discussion of the cost models that determine the payouts to the dairy companies; a consideration of cost innovation with regard to logistics in the dairy

[1] http://www.nzmilk.co.nz/cgi-bin/publish/pages/page/20064

industry; and the factors (e.g., ownership structure) that have encouraged/inhibited this innovation.

The paper is laid out as follows. §2 briefly describes the New Zealand dairy industry. §3 describes the development and purpose of the cost models that have been used by the NZDB to determine payouts to dairy companies. §4 dwells on how the strategy of cost leadership is reflected in logistics, and focuses especially on OR/MS applications. §5 examines how the payment system, the co-operative ownership of dairy companies, and the high level of vertical integration in the industry have furthered and/or hindered the industry's ability to realise total cost savings with regard to logistics.

2 Dairy Industry Summary

Below we present an abbreviated description of the dairy industry; the interested reader is referred to [13] for more details.

New Zealand's temperate climate and fertile soils combine to provide New Zealand dairy farmers with some of the best conditions for farming in the world [15]. These favourable natural conditions are complemented by efficient production techniques, making New Zealand dairy farmers highly competitive in the global market [4]. However, New Zealand's natural advantage is offset to some degree by the seasonal nature of production. Processing capacity is under-utilised during winter and hence average production costs increase.

The New Zealand dairy industry has always paid particular attention to efficiency and productivity. Milk production increased by 80% between 1936 and 1993, while the number of cows increased by just 20% over the same period [15]. The rationalisation of processing companies has transpired since 1917, if not earlier.[2] At the beginning of the 1998/99 season, only nine co-operatives remained - four in the North Island and five in the South Island[3]. At the time of writing (October, 99), only eight remain.

The NZDB has till now a statutory monopoly over the export of dairy products established by the Dairy Board Act (1961). Processing companies can export independently of the NZDB if they obtain a license from the Dairy Board. Licenses are mostly granted for products that the NZDB has little interest in developing and for markets where the products will not come into direct competition with other products exported by the Dairy Board. Approximately 180 approved licenses prevailed as of mid-1999.

The rationale for the statutory power of the NZDB is that through a single-desk seller, the dairy industry as a whole can compete more effectively with large industry players such as Nestle on the international market. The NZDB's statutory powers are likely to be removed by the government in the near future; however, the single-desk marketing philosophy may still prevail.

The New Zealand dairy industry has developed into a highly vertically integrated, farmer-owned, co-operative structure. The producers, who are mostly family-owned farm units, supply their co-operatively owned processing factories with milk. Following the Dairy Board Amendment Act (1996), non-transferable shares in the NZDB have been issued to the co-operatives on the basis of the total milk solids supplied by them. The NZDB purchases

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[2] http://www.kiwidairies.co.nz/profile_historymore.htm

[3] http://www.nzmilk.co.nz/facts/figures-industry.html

the products from the processing companies and sells them overseas through its extensive marketing network.

The co-operative ownership structure of the dairy factories is problematic in some respects. For instance, a dairy company's actions are governed in large part by the demands of the company's members, as a result of which, a co-op may not always act in the best interests of the industry, taken as a whole. A good example of the adverse impact of co-operative ownership in the dairy industry is the agreement that a dairy company will accept all the milk that is supplied by its member-suppliers [15]. This may not be in the best interests of the company as processing capacity might be at its peak and transport costs will be incurred to find another processor who can deal with the extra volume. Alternatively, milk collection capacity might be constraining, resulting in diseconomies of scale.

3 Payment System

The co-operative ownership and the vertical integration of the industry have led to the development of a unique system for establishing payouts to farmers. The following discussion of the structure and purpose of the payment system, as it existed in the early to mid 1990s, draws upon [25], as also [6], [14], and [15].

3.1 Structure and Purpose of the Payment System

The payment system was developed by the NZDB to distribute the export earnings as fairly as possible among the processing companies. The export earnings less expense incurred by the NZDB were distributed to the processing companies on a cost-reimbursement basis.

The payment system could offer differentials or penalties to processing companies to encourage certain product mixes. Hence, the NZDB used the system to exert some influence over the product mix. This effect was limited however by regulations that ensured the NZDB had to buy everything the processing companies could make of certain product types. Products the NZDB was required to buy are known as "standard products," of which there is one or at most a few in each product class: salted butter; cheddar cheese; particular grades of skim milk powder; casein; and caseinate [25].

Once the processing companies received their payment from the NZDB, they made a payout to the farmer based on the kilograms of milksolids provided by him/her. The system of payments encouraged increased milk production by the farmers as a means of earning more money. John Storey, a former NZDB chairman, has said that a move should be made to a system where co-operatives pay less for marginal milk production beyond their commercial need [24]. This would help to strengthen the market signals to farmers.

3.2 The Cost Models

The standard cost models were first established by the NZDB in 1987 and existed in the same conceptual form until June 1998 when the commercial pricing model replaced them. Engineers and accountants belonging to the NZDB developed the models. A cost model was developed for every product that was made by the processing companies. The models included all the costs associated with producing particular products, collection of milk, administration, and capital investment. These costs were estimated as 'industry averages' for the manufacture of particular products. The models were updated regularly to reflect

technological advances and other changes in the industry. In essence, each model represented a single manufacturing site that made just the one product.

On the basis of the models used to estimate production costs for each product, the NZDB "reimbursed" the co-operatives according to the amounts of the various products supplied by them. The payout per kilogram of each product to each processor was therefore standard. Any surplus that the board earned was paid out to the processing companies on the basis of milksolids provided. The ability of a co-operative to pass on a larger payout to the farmer was determined by how efficient it was; if the co-op could produce the goods cheaper than the average as calculated by the model, then it could pass on the surplus to its supplying farmers.

3.3 Potential Problems with the Payment System

As noted earlier, the payment system encourages the farmers to produce more milk to earn more money. This can be problematic in the face of capacity shortfalls.

The use of the standard cost models has been blamed for stifling innovation (especially new product development) in the industry. The cost model implied that the best way for processing companies to achieve higher gains than presently, was to focus on becoming more efficient than the hypothetical factory underlying the cost model, a strategy that has been commonly referred to in the industry as "beating the model". This usually entailed a focus on producing large runs of bulk goods, whilst foregoing shorter runs of niche products, such as spreadable butter and aerosol creams.

In the past, competition between dairy companies also increased the pressure to achieve payouts to farmers that were at least equal, if not larger, than those offered by adjoining processing companies. If a dairy company could not match the payout in its local vicinity, it ran the risk of losing suppliers to higher paying processing co-operatives [15].

4 Efficiency Gains in Logistics in the Dairy Industry

A company that is focused on cost leadership needs to take advantage of economies of scale to the extent possible [21], [22]. Economies of scale need to be exploited in transportation, warehousing, purchasing, and production.

The dairy companies and the New Zealand dairy industry as a whole appear to have largely successfully configured their supply chains to support a cost leadership strategy. Below we describe by turn the various initiatives undertaken in the industry with regard to efficiencies in logistics.

4.1 Mergers and Centralisation of Processing

In 1994, several dairy companies commissioned an Industry Efficiency Improvement Study (IEIS) carried out by the Boston Consulting Group. This resulted in the setting up of an industry committee to look at ways of capturing the efficiencies identified by the report, which called for a rationalisation of the then-15 co-operatives to only four co-op dairy companies. As a result, the committee initiated the Business Development Project (BDP).

The industry's cost-driven payment system has acted "as a direct incentive for companies to achieve greater economies of scale by taking over other co-ops and securing larger milk flows" [14]. In fact, in 1998, the then-chairman of the NZDB commented that the payment system had served the industry extremely well, acting as a driver for manufacturing

efficiency [12]; mergers of co-operatives have greatly helped reduce overall manufacturing costs by creating greater economies of scale than previously.

The 1990s witnessed a spate of mergers as well as the emergence of mega-processing sites. However, the number of dairy companies had been declining even before then - the cost model payment system, the IEIS, and the Act of 1996 may have only accelerated the process.

As larger processors have developed, mergers are now providing a way of reducing product mix risk. A large plant focused solely on producing one type of product exposes itself to fluctuations in demand for that product. It makes sense for a large processor of milk powder to merge with a large processor of cheese. By doing this they reduce each other's product mix risk.

4.2 Optimal Production and Operations Planning

Centralisation of processing represents a long-run measure of the dairy co-ops to increase profitability by beating the cost model and by optimising the product-mix. In contrast, the co-ops have also planned production in the short to medium-term optimally, with reference to the payment system, by recourse to optimisation models and decision support software. Thus, beginning in 1977, the now-defunct Department of Scientific and Industrial Research developed and implemented an integer linear programming approach to help the NZCDC, the New Zealand Co-operative Dairy Company (which is part of the NZDG, the New Zealand Dairy Group of companies), plan its short- and medium-term production [2]. Profitability was gauged with reference to the Board's system of bonus and penalty payments, which supplemented a set of product prices that were based on average industry yields and production costs, as well as a basic milkfat price for the farmer. (At the time, milkfats, and not milksolids, was the basis of payment to farmers.) Company management was also furnished with decision support regarding the allocation of milk in the various farming regions to the NZCDC's factories as well as the diversion of by-products between factories for further processing.

Much more recently, the NZDB has used a constraint-oriented-reasoning (COR) optimisation model to develop a monthly optimum production plan for the (up to) two billion litres that has to be processed and sold on a month-by-month basis as one of nine possible milk product categories [5]. The model takes into account plant capacities, milk volume and composition, process options, market demand, finished goods requirements, storage capacities, and transport and storage costs.

It should be noted that optimal operations planning, as described above, subsumes both cost control and revenue maximisation.

4.3 Tanker Routing

A major cost in the dairy industry is the collection of the milk from the dairy farms. The careful management of collection costs has become even more important as the processing sites have become increasingly centralised. Milk has to be collected from farther away and timeliness is all-important, as it is a perishable product. Kiwi Co-operative Dairies noted that a record milk volume in the 1997/98 season resulted in a shortfall in tanker capacity and delayed milk pickup [10].

Extensive attention has been paid to tanker routing, allocation, and scheduling to reduce costs and to improve efficiency in the dairy industry. Recent examples of work carried out in New Zealand dairy companies to improve transport efficiency and reduce costs are reported in [1], [8]. The East Tamaki Dairy Co-op pioneered the use of a neural networking software system for milk tanker scheduling.

4.4 Finished Goods Distribution

Owing directly to the use of the cost models and the averaging effect that they had on the industry, some dairy companies would send products to ports farther away than was necessary (refer [23] for details) and increase their payouts to farmers thereby. To correct this anomaly, as part of its ongoing Supply Chain Optimisation programme, which is being undertaken within the BDP, the NZDB carried out a warehousing and port rationalisation study in the South Island. The study identified substantial savings that could arise if produce from the eight manufacturing sites in the South Island was exported through three ports instead of the five being used at the time. The study predicted that "... storage and inland transport cost savings of up to NZD 4.2 million (31%) against 1997/98 costs can be achieved by exporting South Island product through only three ports." [7]. At the time of this writing (October, 99), a similar study is underway for the North Island.

5 On the Industry's Ability to Realise Efficiency Gains in Logistics

The preceding section outlined a variety of ways by which the NZ dairy industry has realised efficiencies in logistics. We now discuss how the structure (e.g., operating mechanisms) of the NZ dairy industry has supported and/or hindered the industry's ability to consistently realise efficiency gains in logistics.

Prior to such a discussion, we need to clarify a simple, yet important concept, namely that of 'total cost.' The total cost concept requires organisations to adopt a systems viewpoint towards the constituent activities in the supply chain and to minimize the 'total cost' of these activities rather than the costs of individual activities in piecemeal fashion. If one attempts to control transportation, warehousing, inventory costs, etc., within budgets developed independently and individually for these activities, one will likely not be minimising the *total* costs of these activities, which are interdependent [21].

Such cost trade-offs are widely manifest in the NZ dairy industry. The centralisation of processing naturally results in a greater cost of milk collection, but economies of scale in production outweigh the same. Likewise, the rationalisation of ports (and warehousing) in the South Island, from five to three, increases the cost of haulage of finished goods from the eight manufacturing sites to the ports, but the benefits of consolidation more than offset the increased cost of transport.

An interesting example of cost trade-offs in the dairy industry is the introduction by Kiwi Co-op Dairies of larger milk storage tanks (milk fridges) than previously, in remote dairy farms. This initiative on the part of the Dairies results in overall cost savings in transport by enabling less frequent pickups of milk from farms by road tankers. The Co-op replaced farm storage tanks and most refrigeration units, and the only costs to the concerned farmers were that for larger foundations and roof extensions if the tanks were housed indoors rather than outdoors.

We now examine the influence of each of three features of the dairy industry on its ability to realise efficiency gains in logistics. These are the payment system; the co-operative ownership structures in the industry; and the vertically integrated nature of the industry.

5.1 The Payment System

Whilst the key to managing the logistics function is total cost analysis, the relevant cost information is needed to conduct such an analysis. "If knowledgeable trade-offs are to be made, management must be able to account for the costs of each component and to explain how changes in each cost contribute to total costs" [11]. This in turn reflects the cliché, 'if you cannot measure it, you cannot manage it.' A key reason why firms have been unable to reap the full benefit of integrated logistics management and the total cost concept is the lack of accurate cost data [11].

The cost models developed by the NZDB appear to play a vital role in providing the information required for making total-cost decisions. The models are very detailed and incorporate all aspects of logistics and operations. The models provide information on a product basis that cuts across functional boundaries.

By having to participate in the industry cost surveys, the individual co-ops are forced to better measure their own costs, which in turn facilitates better tracking and management of the same. The repeated, as opposed to one-off, nature of the surveys meant that the information on costs was updated regularly, which has been deemed important if total cost decisions are to be made successfully [3]. The regular updating of the models also required the dairy companies to continually improve their performance.

The payment system had not always encouraged system-wide efficiency, however. An obvious example, which was mentioned in the preceding section, is the sending of boxes to ports that were farther away than necessary.

5.2 Co-operative Ownership

The co-operative ownership of the dairy companies would appear to be a double-edged sword with regard to the implementation of the total cost concept. On the one hand, it encourages a systems viewpoint towards supply chain optimisation, while on the other, it can protract the actualisation of such a viewpoint. Below, we clarify this point through examples.

The enhancement of the capacity of milk storage tanks on farms by Kiwi Co-op is a good example of how the co-operative structure facilitates the realisation of system-wide savings. Kiwi Co-op covered the majority of costs involved in that exercise. Each farmer, acting alone (or in the language of game theory, 'non-co-operatively'), would probably have been better off *not* upgrading the capacity of the milk tanks in his/her farm (an instance of the well known 'prisoner's dilemma'), but in sum, farmers would have stood to lose by acting non-co-operatively. Instead, the co-op is able to leverage the capital investment to the benefit of *all* farmers, each of whom stands to gain by any efficiency that is realised through the installation of larger storage tanks.

The co-operative structure facilitates a systems viewpoint in another respect as well. Total cost savings are elusive unless a manager or group becomes directly responsible for the two or more interacting functions that might offer a total cost savings [3]. By having one group of people – the management of the co-operative - responsible for the production,

collection, and processing of the milk, as well as the outbound distribution of finished product, total system-wide benefits can be achieved.

However, the co-operative structure, when taken with the regulated nature of the industry, has some disadvantages. Due to the co-operative ownership, farmers have a high degree of involvement in decision-making. Several rounds of discussions with farmers are required before change can be initiated. This has been highlighted as a hindrance to change.

Another impediment to change is the need for the industry to approach Parliament for any changes to its commercial arrangements.

5.3 Vertical Integration

A high level of vertical integration or partnering in the supply chain enables organisations to realise benefits in supply chain logistics that could not be achieved by acting on their own [21]. Cavinato notes that advantages such as joint R&D and closer management co-ordination in production and logistics flows can accrue from strong supply chain relationships [3]. The NZDB spends around NZD 4-10 Million per annum on projects that improve manufacturing efficiency. Such investment pays for itself several times over; for example, the benefits from the IEIS were projected to be worth NZD 200 million a year.

For a strategy of cost leadership, the locus of planning should be staff, i.e., analysts who serve an advisory role [22]. The NZDB has several divisions that serve in a staff capacity (e.g., the Benchmarking Unit, the Supply Chain Optimisation section, etc.). The Board employs engineers and accountants who have developed the standard cost models, KPI's for internal benchmarking, etc. Once again, each co-op, acting alone, could ill afford such planning staff.

The dairy industry with a high level of vertical integration is able to make decisions that yield benefits for the entire supply chain. An example of this activity is the Supply Chain Optimisation programme initiated by the NZDB. The knowledge that supply chain efficiencies will be passed on to the farmer-suppliers would provide the Board additional incentive to engage in supply chain R&D. The study was possible precisely because of the highly integrated nature of the industry. If the co-ops undertook the distribution of finished product independently of each other, then each co-op might export product through the port(s) nearest to its manufacturing sites. This would increase overall system costs owing to the duplication of assets such as coolstores.

Another example of NZDB-led initiatives that benefit the entire supply chain is the global information technology package commonly referred to as the "cow-to-customer" project [9]. The project will eliminate many non-value-adding activities in the supply chain, such as the duplication of order processing; a major goal of the project is to be able to pass on orders from the consumer directly to the dairy factory, which then fills the order.

6 Conclusion

It would appear that in the main, the dairy industry has realised efficiency gains with regard to logistics. Table 1 identifies the way(s) in which supply chain efficiency in the industry is facilitated and/or thwarted by each of three factors: the payment system (and the closely related internal benchmarking programme of the NZDB); the co-operative ownership structure; and the vertically integrated nature of the industry.

In 1998, probably in the wake of historically low commodity prices in the global marketplace, the NZDB openly expressed a dual focus on efficiency and the addition of high value. The modified 'commercial pricing' model is designed to reward companies that produce more innovative products. It is likely that this model will exert considerable influence on the behaviour of the dairy companies and serve as a 'control lever,' just as its predecessors, the standard cost models, did.

Factor	**Supply chain efficiency**	
	Furtherance	*Inhibition*
Payment system/ Internal benchmarking	• Assistance to the co-ops in measuring, tracking, and managing supply chain costs. • Positive incentives for the co-ops to continuously improve their operations.	• Encouragement of non-systemic actions by co-ops (e.g., the shipping of boxes to far-off ports). • Incentives for farmers to supply more milk than less milk - possibly even beyond the co-op's capacity for collection and/or processing, resulting in diseconomies of scale.
Co-operative ownership	• Avoidance of the 'prisoner's dilemma.' • Unitary management of inter-related supply chain activities.	• The protracted process of mergers. • The need to process all of the milk supplied by farmers.
Vertical integration	• Positive incentive for supply chain efficiency improvements to be instigated by the Board since they are passed on to farmers and not to middlepersons. • Leveraged investment into supply chain R&D for system-wide improvements (e.g., the Supply Chain Optimisation programme). • Centralised personnel (e.g., engineers and accountants) in a staff (advisory) role. • Installation of a global IT system (GISP) to remove non-value-adding activities in order processing worldwide.	

Table 1. Factors that have furthered and/or inhibited supply chain efficiency in the NZ dairy industry.

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